U-Th-Pb (EPMA) MONAZITE AND ZIRCON Pb-Pb GEOCHRONOLOGY OF THE TRANSAMAZONIAN HIGH-GRADE METAMORPHISM IN THE ARCHEAN AMAPÁ BLOCK (BRAZIL), SOUTHEASTERN GUIANA SHIELD

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INTRODUCTION

The eastern portion of the Guiana Shield, in South America, consists of an exceptionally large Paleoproterozoic belt, named Maroni-Itacaiúnas Province (Tassinari and Macambira, 2004), in which the evolution took place during the Transamazonian orogenic cycle (2.26-1.95 Ga), and that matches with the Eburnean orogen in West African Craton (Feybesse and Milési, 1994; Ledru et al., 1994). Despite the coherent Paleoproterozoic geochronological pattern of this belt, two major Archean domains have been documented in its northwestern and southeastern portions, the Imataca Block, in Venezuela, and the Amapá Block, in the north of Brazil (Figs. 1, 2A).

The basement assemblage from the southwestern portion of the Amapá Block is constituted by several granulitic-gneissic metamorphic complexes, which present Paleo- to Neoarchean zircon ages (>3.0 to 2.60 Ga) for their igneous precursors (Rosa-Costa et al., 2003, in press; Klein et al., 2003), and also includes Neoarchean charnockitic plutons dated between 2.65 and 2.60 Ga (Ricci et al., 2002; Rosa-Costa et al., in press). The Transamazonian overprinting in Archean rocks is testified by the emplacement of several syn- to late-orogenic granitic plutons with ages ranging from 2.22 Ga to 2.03 Ga, and Nd isotope signatures pointing to an origin by reworking of Archean crust (Rosa-Costa et al., 2003, in press).

The undoubted Paleoproterozoic reworking of the Archean basement, point to a polymetamorphic evolution for the southwestern portion of the Amapá Block. The purpose of this study is to constrain the age of the regional high-grade event that affected the Archean rocks, through the U-Th-Pb and Pb-Pb dating of monazite and zircon, respectively, and to determinate whether the high-grade metamorphism is related to Transamazonian or to an oldest Archean event, or both.

REGIONAL GEOLOGICAL BACKGROUND

The Archean basement assemblage of the southwestern portion of the Amapá Block includes: 1) granulitic orthogneisses (mainly enderbitic and charnockitic banded gneisses) that have their igneous protoliths dated at about 2.8 Ga (Rosa-Costa et al., 2003, in press); 2) undated mesoperthite and/or clinopyroxene-bearing granitic orthogneisses, metamorphosed under amphibolite-granulite transition facies; 3) undated paraderived granulites; 4) amphibolite-facies grey gneisses (mainly tonalitic and granodioritic), which have igneous protoliths dated at about 2.65-2.60 Ga (Rosa-Costa et al., 2003, in press); and 5) several plutons of catazonal granitoids (charnockites, charnoenderbites and mesopertite-granites) dated between 2.65-2.60 Ga (Ricci et al., 2002; Rosa-Costa et al., in press), which supposedly mark the time of an Archean granulitic event. Migmatization is widespread in the basement rocks, and the occurrence of charnockitic leucossomes indicates that it also occurred under granulite-facies conditions. These basement complexes host several orogenic granitic plutons, dated at about 2.22 Ga, 2.18 Ga, 2.15 Ga, 2.05 Ga and 2.03 Ga (Rosa-Costa et al., 2003, in press). Post-orogenic plutonic magmatism is marked by the emplacement of 1.75 m.y. old A-type granitic plutons (Vasquez and Lafon, 2001).

Along the southwestern border of the Amapá Block an expressive supracrustal belt marks the boundary of this Archean block with the Carecuru Domain, a granitoid-greenstone terrane, developed in a magmatic arc setting, which was accreted to the southwestern border of the Archean block during the Transamazonian orogenesis (Rosa-Costa et al., in press). This Paleoproterozoic domain consists principally of calc-alkaline gneisses and granitoids, dated at 2.19-2.18 Ga and at 2.15-2.14 Ga, and of supracrustal sequences, constituted mainly by mafic metavolcanics. Several granitic plutons mark episodes of crustal reworking in the Carecuru Domain, being one of them dated at about 2.10 Ga. In addition, granulitic rocks with Archean precursors are registered within that domain, in an oval-shaped nucleus basically composed of granulitic gneisses dated at about 2.60 Ga (Rosa-Costa et al., 2003), which host 2.07 m.y. old charnockitic plutons (Rosa-Costa et al., in press).

GECHRONOLOGICAL STUDY

Three samples were selected for study and their location is shown in the figure 1. Monazite concentrates were extracted from two enderbitic gneisses (MV-27A and LT-214) and from a charnockitic leucossome (MV-27E). Zircon grains from this leucosome were also selected for dating.

The analyses on monazite grains were carried out on a CAMECA SX 50 electron probe micro-analyzer (EPMA), at laboratory of BRGM, France. Age calculations were done using the Isoplot program (Ludwig, 2004) and a Microsoft Excel add-in program for determining U-Th-Pb ages from EPMA measurements (Pommier et al., 2002), according to the procedure proposed by Cocherie and Albarede (2001). All the calculations were done at 2σ level.

The zircon geochronology was based on the Pb-evaporation method (Kober, 1986, 1987). The isotopic analyses were performed on a Finnigan MAT262 mass spectrometer, at the Laboratory Pará-Iso of the UFPA, Brazil. The zircon ages and the 2σ errors on the ages were calculated following Gaudette et al. (1998).

In the enderbitic gneiss LT-214, 138 U-Th-Pb EPMA measurements were obtained on 8 monazite grains and yielded individual ages ranging between 2156 and 2010 Ma. These ages are considered as representing an unimodal population, and an average weighted age of 2086 ± 3 Ma (MSWD = 1.6) was calculated (Fig. 2B).

Nine monazite grains from the enderbitic gneiss MV-27A furnished individual ages between 2026 and 2182 Ma, collected on 137 analytical points, providing an average weighted age of 2096 ± 6 Ma (MSWD = 1.6).

In the charnockitic leucosome MV-27E, six monazite grains gave individual ages varying between 1988 and 2179 Ma, yielding a weighted average age of 2087 ± 8 Ma (MSWD = 1.5). In addition, 7 zircon grains were analyzed and provided ages spreading between 2045 Ma and 2091 Ma, at the higher steps of temperature of 1500 and 1550 °C. A mean age of 2091 ± 5 Ma (USD = 2.6) was calculated from three oldest grains and is interpreted as the crystallization age of the charnockitic leucosome, which is in agreement with the monazite age of the same sample (Fig. 2B).

DISCUSSION

The monazite and zircon ages, which are similar within the errors, make unambiguous the existence of a tectono-thermal event at about 2.09 Ga affecting the Archean basement of the southwestern portion of the Amapá Block.

The closure temperature (Tc) of Th-U-Pb system in monazite has been largely accepted to be at least about 700-750 °C (Suzuki et al., 1994), and even higher than 750 °C (Copeland et al., 1988; Spear and Parrish, 1996; Bingen and Bremen, 1998; Braun et al., 1998). It has also been demonstrated that, the U-Pb system of monazite may be resetted by secondary replacement of newly grown monazite rather than by volume diffusion of Pb (De Wolf et al., 1993; Zhu et al., 1997). Consequently, if diffusive Pb loss is not a common process in monazites, a record of the prograde path of metamorphism and even of peak metamorphic conditions should be preserved.

Based on these considerations, we conclude that monazite ages from the studied granulites may be interpreted as growth ages and, consequently, provides a reliable estimate of the age of the granulite-facies metamorphism, occurred at about 2.09 Ga, which possibly reached temperatures of at least 750°C. The zircon and monazite ages of the charnockitic leucosome reinforce this interpretation, since elucidative field data indicate that this leucosome is product of in situ melting of the enderbitic gneiss MV-27A. Furthermore, the metamorphic mineral assemblage (orthopyroxene-bearing) of the leucosome strongly suggests that the migmatization event marks the time when peak metamorphic conditions were reached.

The Paleoproterozoic ages obtained in the investigated samples indicate that, if basement rocks from the Amapá Block were submitted to a high-grade event during Archean times, they were completely resetted during the Paleoproterozoic overprinting. Then, based on the current data, we can not establish any genetic or chronological relationship between the Neoarchean charnockitic magmatism and the granulitic rocks of the region, as previously suspected (Rosa-Costa et al., 2003)

The basement rocks from the southwestern part of the Amapá Block commonly exhibit pervasive NW-SE ductile foliation, dipping systematically 20-50° SW, and mineral lineation with low plunge predominantly to SW. This pattern is strongly disturbed along NW-SE transcurrent zones defined by steeply dipping mylonitic foliation and sub-horizontal lineation, marking the strike-slip movement. The structural features are coherent with a regime of oblique thrusting, with tectonic vergency from SW to NE. Apparently, the strike-slip zones development coincides with the final stages of the thrusting movement.

Structural field features strongly indicate that the granulitic metamorphism was contemporaneous to the development of the thrusting system. For instance, the leucosome MV-27E, presenting monazite and zircon ages about 2.09 Ga, occur in layers concordant to the foliation of the parental gneisses, MV-27A.

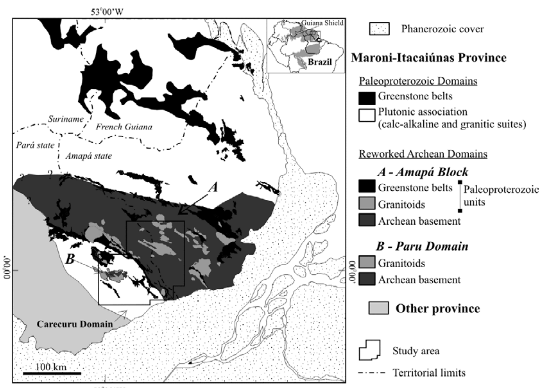

Figura 1 . Location of the Amapá Block in southeastern Guiana Shield.

The structural pattern of the southwestern of Amapá Block, which registers an evolution from an early tangential tectonics to a dominantly transcurrent tectonics, is classically described as evidence of collision tectonics and testifies the oblique character of the collision (Shackleton, 1986). The development of this structural framework coeval to regional granulite-facies metamorphism about 2.09 Ga, is consistent with palinpastic reconstructions involving Man and Guiana shields, which also evoke a collisional stage at about 2.1 Ga, resulting from the convergence of West African (Man Shield) and Amazonian Archean plates (Feybesse and

Milési, 1994; Ledru et al., 1994) that can be represented by the Amapá and Imataca blocks.

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RESUMO

O Bloco Amapá, sudeste do Escudo das Guianas, constitui um bloco arqueano envolvido em uma extensa faixa paleoproterozóica, cuja evolução principal ocorreu durante a Orogênese Transamazônica (2,26-1,95 Ga). Gnaisses granulíticos e um leucossoma charnoquítico da porção sudoeste do Bloco Amapá foram datados pelos métodos U-Th-Pb por microsonda eletrônica em monazita e Pb-Pb em zircão. As monazitas de um gnaisse enderbítico forneceram uma idade U-Th-Pb de 2086 ± 3 Ma MSWD = 1,6). Para um outro gnaisse enderbítico, as monazitas apresentaram uma idade de 2096 ± 6 Ma (MSWD = 1,6). As monazitas de um leucossoma charnoquítico forneceram uma idade U-Th-Pb de 2087 ± 8 Ma (MSWD = 1,5), enquanto que os zircões do mesmo leucossoma apresentaram uma idade Pb-Pb de 2091 ± 5 Ma (USD = 2,6). As idades obtidas nas monazitas podem ser interpretadas como idades de formação e, consequentemente, fornecem a idade do metamorfismo granulítico em torno de 2,09 Ga, o qual alcançou temperaturas de pelo menos 750°C. As idades em zircão e monazita do leucossoma charnoquítico, produto da fusão *in situ* do gnaisse enderbítico encaixante, reforçam essa interpretação e sugerem fortemente que o evento de fusão marca o momento em que o pico do metamorfismo foi alcançado. Os padrões estrutural e geocronológico da porção sudoeste do Bloco Amapá caracterizam um estágio colisional da orogênese Transamazônica, em torno de 2,10-2,09 Ga.

(A)

(B)

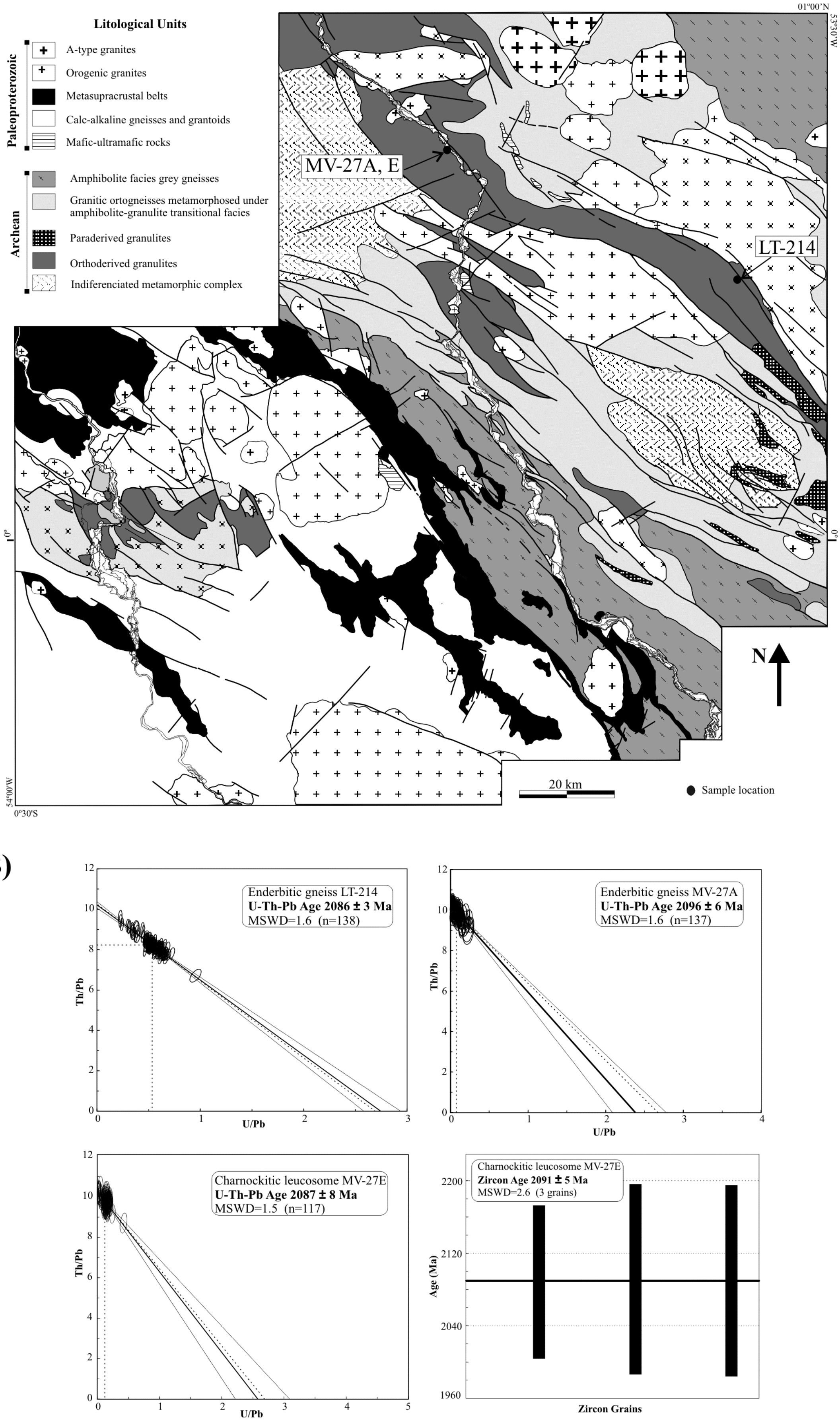

Figure 2. – (A) Geological map of the investigated area, based on Ricci et al. (2001); (B) Th/Pb vs. U/Pb diagrams for the dated monazites and Pb-evaporation diagram for the dated zircons.