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THE ALTO RIBEIRA MAGMATIC ARC (PARANA STATE-SOUTHERN BRAZIL): GEOCHEMICAL AND ISOTOPIC EVIDENCE OF MAGMATIC FOCUS MIGRATION AND ITS TECTONIC IMPLICATIONS

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The present location of the geological units which comprise the Precambrian of the south-southeastern part of the Ribeira fold belt in Paraná State, Brazil, is the result of a series of superposed tectono-metamorphic events. During this evolution, and especially at the end of the Neoproterozoic, between 640 and 550 Ma, an important crustal accretion event within the Brasiliano Megacycle was responsible for the generation of the Alto Ribeira magmatic arc (ARMA). This arc is now represented by a large volume of granitic rocks amongst which the Cunhaporanga (CPB) and Três Córregos (TCB) granitic batholiths stand out.

The SSE part of the Ribeira belt forms an long, NE strip with a mainly NE trend, formed by deformed middle to upper crustal rocks, metamorphosed in greenschist to amphibolite facies (Basei *et.al.*1992; Fiori, 1993; Hackspacher *et.al.* 1997; Campanha & Sadowski 1999). These rocks are intruded by the Neoprtoerozoic CPB, TCB and the Agudos Grandes batholith, and many granite stocks.

The CPB and TCB are elongated bodies with NE-SW major axes which occur north and south, respectively, of the Itaiacoca metavolcano-sedimentary sequence. Together, they occupy about 6,500 km^2 (Fig. 1). The southeastern contact between the CPB and the Itaiacoca country rocks is intrusive, while the northwestern contact of the BCT with this group is tectonic, represented by the Itapirapuã shear zone. Its contact with rocks of the Água Clara Formation of the Açungui Group is intrusive (Fig. 1).

The mineral assemblages in the rocks of the two main batholiths are typically calc-alkaline. The CPB is more homogeneous, being mainly composed of porphyritic to inequigranular, isotropic monzogranite which are accompanied by rare granodiorite. The TCB is more heterogeneous, and includes undeformed or deformed quartz monzonite, granodiorite and monzogranite, as well as rare tonalite and syenogranite (Fig. 1).

The rocks of the CPB (with 65 – 73% SiO_2) and the TCB (60-76% SiO_2) are meta- to weakly per-aluminous in the case of the CPB, and predominantly meta-aluminous in the case of the TCB. Both batholiths are calc-alkaline. The main chemical contrast between the two batholiths, reflecting the different modal compositions, is in the behavior of the alkali elements, the CPB being more potassic and less sodic, while the TCB is more sodic and less potassic (Fig. 2)

Conventional multi-grain U-Pb (zircon) dating of the crystallization age of batholiths is complex where inherited zircons are present. Nevertheless, a short time interval for the intrusion of the CPB at about 590 Ma has been inferred from the $^{207}Pb/^{206}Pb$ and $^{238}U/^{206}Pb$ ages (Fig. 3 A, B, C; Prazeres Filho, 2000). In contrast, the intrusion of the TCB took place over a much longer time interval. Tonalite and granodiorite were intruded at 636±3 and 633±3 Ma, respectively (upper intercept ages: Fig. 3 D,E), while quartz monzonite was intruded at 604±4 Ma (concordant - Fig. 3 F). This age is confirmed by Gimenez Filho et. al. (2000).

It is important to note that the isotopic memory retained in many zircon fractions points, through the upper intercept ages, to paleoproterozoic source rocks for both batholiths.

Six titanite fractions from granites of both batholiths yielded U-Pb ages between 570 and 550 Ma. These ages are ~30Ma younger than the youngest U-Pb (zircon) ages. As an alternative to a prolonged cooling history, we interpret these younger ages as the consequence of a regional thermal event which affected both batholiths. The action of such an event has already been discussed by Machado et al. (1996) for the central part of the Ribeira belt.

The Nd, Sr and Pb isotopic data obtained by Reis Neto (1994) and Prazeres Filho (2000) suggest that the granitic magmas were produced from different paleoproterozoic continental crustal source rocks, supporting the deduction from U-Pb (zircon) data. Different Nd T_{DM} ages are inferred for CPB (1.8-2.0 Ga) and TCB (2.2-2.4 Ga). $\varepsilon Nd_{(t=600\ Ma)}$ values are highly negative (-11 to –13 for CPB and –17 to –19 for TCB). $(^{87}Sr/^{86}Sr)_{i\ (t=600\ Ma)}$ values are systematically higher than 0.709 (Fig. 4 A, B), while Pb isotopic compositions favor an upper crustal source for CPB, and a lower crustal source for TCB (Fig. 4C).

The geochemical, isotopical and geochronological differences between the two batholiths are a result of the northwestwards movement of the ARMA, a response to continuous northwestwards subduction of an oceanic plate, towards the Paranapanema block (Quintas, 1995), under a paleoproterozoic continental margin. The 570-550 Ma thermal event registered by the U-Pb dating of titanites could represent the age of collision between the Paranapanema and Curitiba blocks, which is also revealed by the intrusion ages of the Cerne and Morro Grande granite plutons at 560 Ma (Prazeres Filho, 2000).

In this way the isotopic behavior of the ARMA is different from that proposed for other Brazilian neoproterozoic magmatic arcs, such as those of western Goiás State (Pimentel et al., 1996), and of Bom Jardim, Rio Grande do Sul (Leite et al., 1998), where juvenile addition predominates, with neoproterozoic Nd T_{DM} ages and positive εNd values. On the other hand, the ARMA is similar to other magmatic arcs of SE Brazil, such as Piên (Harara, 1996) and Florianópolis (Basei, 2000), where crustal reworking predominated.

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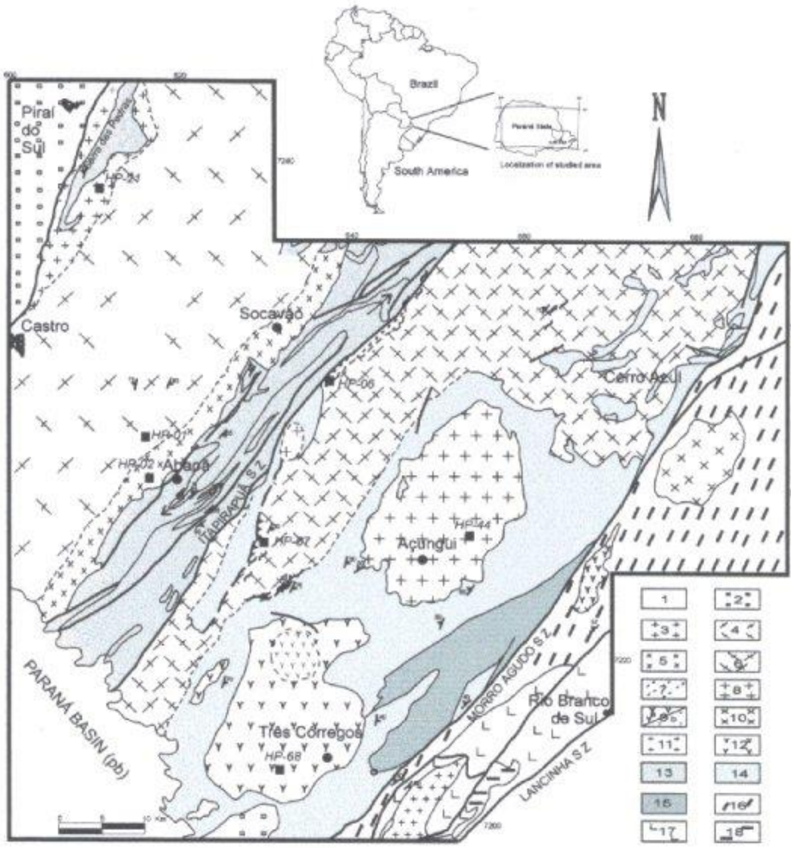


Figure 1 - The Southern part of Ribeira Belt (Paraná State- SE Brazil). Paraná Basin (1) - Neoproterozoic/Cambrian extensional basins(2) - Alto Ribeira Magmatic Arc: CPB, biotite-monzogranites(3) - porphyritic biotite monzogranites(4) - hornblende, biotite-monzo to granodiorites(5); TCB, hornblende, biotite monzo to granodiorites deformed or not(6) - hornblende, biotite tonalites(7) - hornblende, biotite quartzo monzonites(8) - inequigranular to porphyritic biotite, hornblende monzogranites(9a) and biotite syenogranites granites(9b); Granitics Stocks: Morro Grande(10) - Cerne(11) - Piedade(12); Itaiacoca Group(13) - Açungui Group: Agua Clara Formation(14) - Antinha Formation(15) - Votuverava Formation(16) - Betara Formation(17); Granitic Basement Nuclei(18).

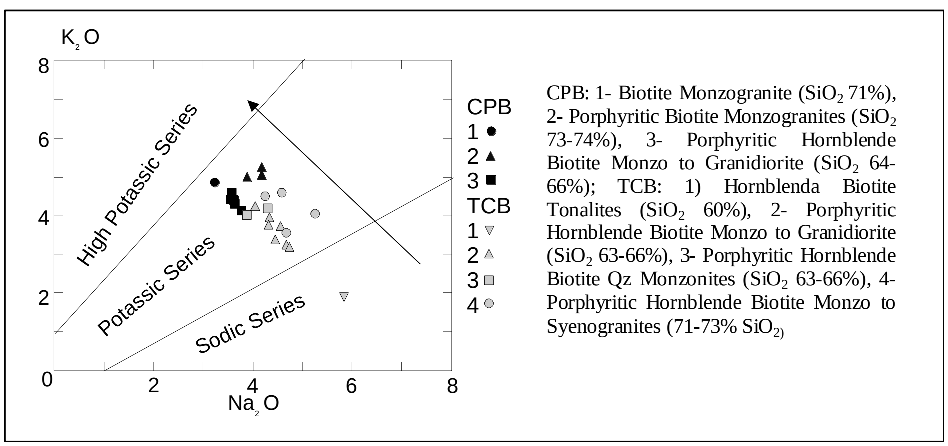


Figure 2 – Na2O vs K20 diagram for Cunaporanga Granitic Batholit and Três Córregos Granitic Batholit

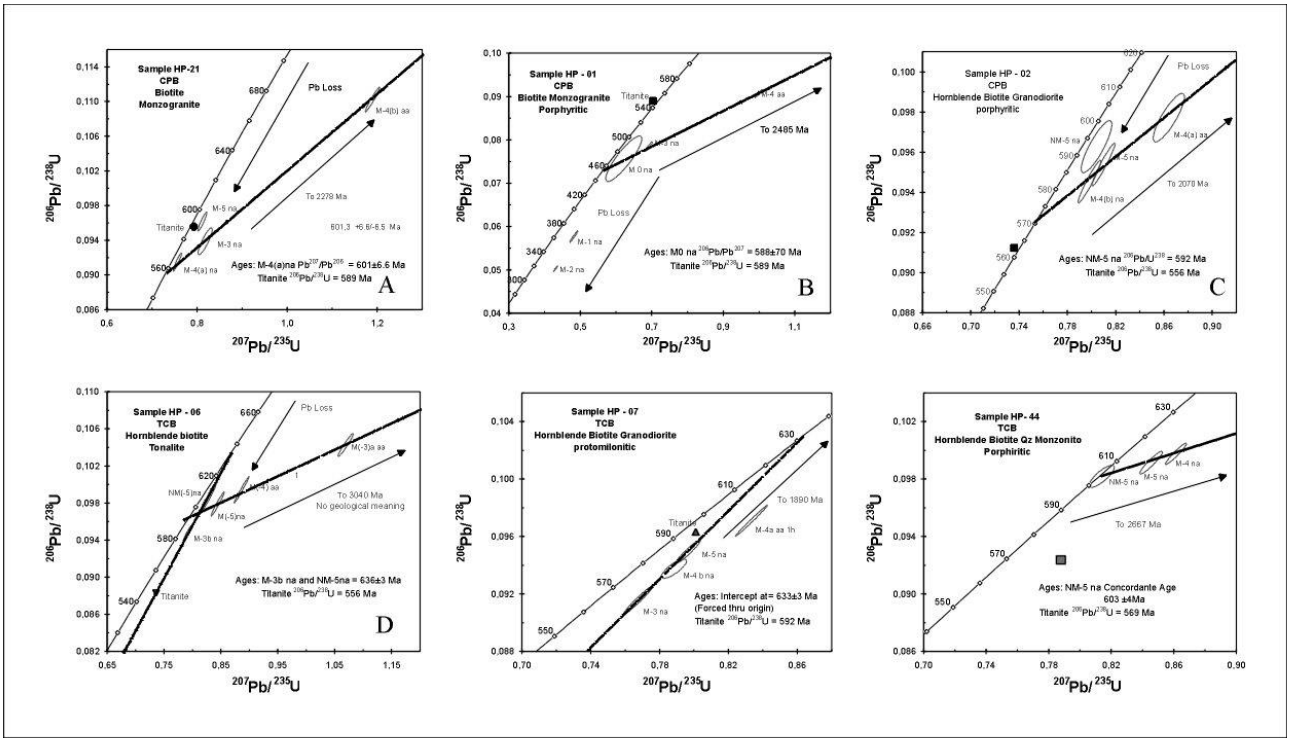
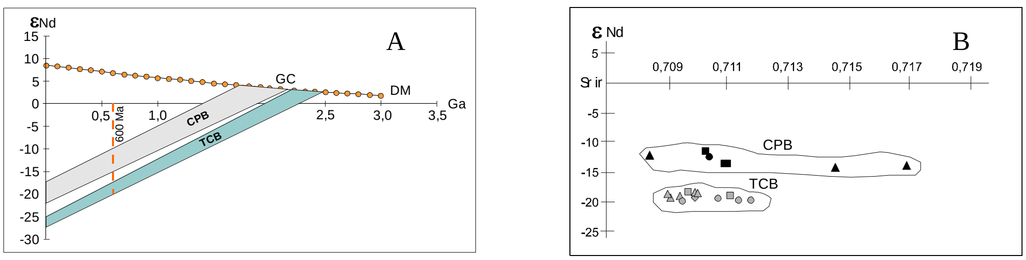
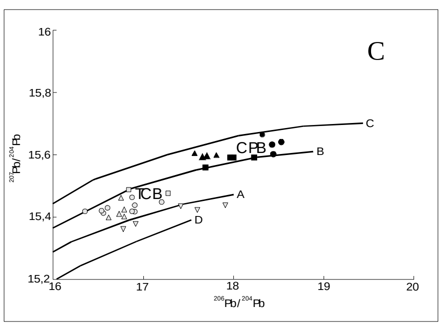


Figure 3 – U-Pb zircons and titanites concordia diagrams from CPB and TCB. U-Pb zircons and titanite concordia diagram for Cunhaporanga Granitic Batholit (CPB), diagrams A, B and C and Três Córregos Batholit (TCB), diagrams D, E, F and G.





A – Nd isotopic evolution for the CPB and TCB.
B – Intial $^{87}Sr/^{86}Sr$ vs εNd (t=600Ma) for CPB and TCB litologies.
C – Plumbotectonic for CPB and TCB litologies, (A- Mantle; B- Orogene; C- Upper Crust; D- Lower Crust, after Zartman and Doe, 1981)

Figure 4 – Nd, Sr and Pb isotopic composition for Cunhaporanga Granitic Batholit and Três Córregos Granitic Batholith