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ARTICLE

SiO_2-saturated potassic alkaline magmatism in the central Amazonian Craton, southernmost Uatumã-Anauá Domain, NE Amazonas, Brazil

Magmatismo alcalino potássico saturado em SiO_2 na porção central do Cráton Amazônico, extremo sul do Domínio Uatumã-Anauá, NE do Amazonas, Brasil

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ABSTRACT: This paper approaches the record of SiO_2-saturated potassic alkaline magmatism of Castanhal Quartz Monzonite, Mapuera Suite, and Ladeira da Vovó Quartz Syenite. These samples are located near the Northern border of the Amazon Basin. Such rocks show $K_2O + 2 > Na_2O$ and $K_2O/Na_2O < 2$ values that confirm the potassic or shoshonitic character of these rocks. The Castanhal Quartz Monzonite contains less than 20% volume of quartz, which is also a characteristic of the shoshonitic or SiO_2-satured potassic alkaline A-type magma signature observed on geochemical plots. Listric faults, representing the rifting phase of Amazon Basin formation, emplaced and reworked Ladeira da Vovó Quartz Syenite, which caused its granophyric texture, probably during the Tonian period. A group of 21 zircon crystals was extracted from a hornblende quartz monzonite and yields an average age of 1872 ± 6 Ma (MSWD = 2.4). However, an additional zircon crystal yielded a Trans-Amazonian age of 2062 ± 17 Ma. These potassic alkaline rocks of Orosirian (1872 Ma) age may correspond to a post-collisional setting. Dominantly negative εHf_t values and Hf T_{DM} ages reveal a large contribution of a mafic crustal component from Mesoarchean to Neoarchean age (2.95 – 2.66 Ga), and a felsic crustal component from Neoarchean to later Siderian ages (2.51 – 2.34 Ga).

KEYWORDS: Silica saturation; Potassic alkaline magmatism; Mapuera Suite; Uatumã-Anauá Domain; Amazonian Craton.

RESUMO: *Este trabalho analisa o registro do magmatismo alcalino potássico saturado-SiO_2 do Quartzo-Monzonito Castanhal e do Quartzo-Sienito Ladeira da Vovó. Essas rochas estão localizadas próximas à borda norte da Bacia do Amazonas. As amostras mostram valores $K_2O + 2 > Na_2O$ e $K_2O/Na_2O < 2$, que confirmam o caráter alcalino potássico ou shoshonítico. O Quartzo Monzonito Castanhal contém menos de 20% de quartzo, o qual é também característico de rochas alcalinas potássicas, o que é confirmado nos diagramas geoquímicos. O Quartzo-Sienito Ladeira da Vovó foi alojado e retrabalhado em falhas lístricas, representantes da fase rifte da formação da Bacia do Amazonas, que causou sua proeminente textura granofírica (granófiro) provavelmente durante o período Toniano. Um grupo de 21 cristais de zircão foi extraído do hornblenda-quartzo-monzonito Castanhal e forneceu a idade média de 1872 ± 6 Ma (MSWD = 2,4), contudo um cristal adicional forneceu uma idade Transamazônica de 2062 ± 17 Ma. Essas rochas alcalino-potássicas de idade Orosiriana (1872 Ma) podem corresponder a um ambiente pós-colisional. Os valores negativos em εHf_t e as idades TDM Hf revelam grande contribuição de componentes crustais máficos Meso- a Neoarqueanos (2,95 – 2,66 Ga) e/ou componentes crustais félsicos Neoarquenos a Siderianos tardios (2,51 – 2,34 Ga).*

PALAVRAS-CHAVE: *Saturação em sílica; Magmatismo alcalino potássico; Suíte Mapuera; Domínio Uatumã-Anauá; Cráton Amazônico.*

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INTRODUCTION

There are still uncertainties about the origin and evolution of alkaline granitic magmas. The origin of alkaline magmas may be derived from various sources: mantle; lower crust; and magmas mixing from crustal and mantle sources.

However, some authors have concluded that alkaline granites are only formed in a continental rift setting (Barbarin 1999). Moreover, other authors have suggested that SiO_2-saturated alkaline granitoids were derived from a crustal source with pieces of evidence of a mantle component, largely rich in alkalis, that migrates along detachment faults, extending to the peridotitic mantle and to alkalis-enriched mantle plumes (Bonin 1990, Brown *et al*. 1992).

Systematic data on alkaline granitic magmatism into the Uatumã-Anauá Domain, Central-Northern Amazonian Craton (Fig. 1A and 1B), are restrict to Catrimâni and Água Boa regions, southeastern Roraima State (CPRM 2000). Oliveira *et al*. (1975) and Montalvão *et al*. (1975) reported SiO_2-insatured, nefeline-bearing alkaline granitoid rocks associated with Erepecuru Granite (1804 ± 69 Ma) and Cachorro Syenite (1479 ± 49 Ma), in addition to Mutum Syenite. Araújo *et al*. (1976) also individualized one alkaline stock and correlated it to Cachorro Syenite. K-Ar determination for a monzonite from the high curse of Uatumã River (Presidente Figueiredo district, NE Amazonas) yielded an average age of 803 ± 69 Ma (Montalvão *et al*. 1975). Younger ages were obtained to Catrimâni Syenite (180 ± 5 Ma, Salas & Santos 1974; 100 Ma, Montalvão *et al*. 1975), representing the youngest records of alkaline granitic rocks observed in the Uatumã-Anauá Domain (CPRM 2000). Studied alkaline granitoids crop out along BR-174 federal road and Castanhal dirty road, and they are located right at the boundary between sedimentary sequences of the Amazon Basin and Água Branca granites (Terra Preta Granite) and Iricoumé volcanites, southernmost Uatumã-Anauá Domain, southwestern Presidente Figueiredo district, and northeastern Amazonas State (Fig. 1C; Valério *et al*. 2009, 2012).

Moreover, this paper includes petrographic, whole-rock geochemical, *in-situ* U-Pb zircon geochronological and Hf isotope composition data upon the Castanhal Quartz Monzonite firstly, and field and petrographic features of the Ladeira da Vovó Quartz Syenite, secondly.

RESULTS AND DISCUSSION

The previously proposed models and geological observations have instigated the investigation of these Orosirian alkaline granitic rocks through this short communication paper. This paper includes Sar/Sipam radar and airborne geophysical images, because the access to the Castanhal stock was very difficult due to the dense forest and thick regolith mantle covering those rocks. Nevertheless, the samples of hornblende quartz monzonite display seriated texture and interpenetrative contacts between quartz and plagioclases (normally zoned). These rocks present less than 20% wt. of quartz or SiO_2-satured potassic alkaline A-type signatures. Another and intricate observation is related to a quartz syenite that shows a pervasive granophyric texture (granophyre). This sample was discovered along the listric faults, near the detachment fault. These listric faults served as conduit for emplacement and probably reworked this rock, which was observed in micro-faults, in the rifting stage of formation of the Amazon Basin (likely generated at Tonian period). According to Hibbard (1987), granophyric feature is originated by the simultaneous crystallization of the quartz, and K-feldspar started from a volatile-enriched eutectic mixture, mainly in shallow deep low-pressure areas and it is commonly associated with post-magmatism. Fenn (1986) declared that this texture is the result of premature cooling related to kinetic processes in borders of the feldspar crystals. However, Paterson *et al*. (1989) admitted that this type of texture could be produced in deformed granitoids in the solid state, instead of felsic liquids presence. As the quartz syenite recorded at least one pulse of the brittle deformation is cleaner to accept the Paterson's *et al*. (1989) model.

On the R1-R2 geochemical classification plot, the samples are falling in the quartz monzonite field (De la Roche *et al*. 1980, Fig. 2A). These hornblende quartz monzonites are alkaline and have intermediate to acid composition on the total alkalis-silica (TAS) plot (Cox *et al*. 1979, Fig. 2B), meta-luminous on the A/CNK-A/NK plot (Shand 1943, Fig. 2C) and are shoshonitic on the SiO_2 wt.% *versus* K_2O wt.% plot (Peccerilo & Taylor 1976, Fig. 2D). By magmatic differentiation, these rocks have evolved to SiO_2-supersaturated composition (quartz-alkali feldspar-plagioclase-feldspatoid – QAPF and TAS fields of Nardi 1991). These rocks show $K_2O + 2 > Na_2O$ and $K_2O/Na_2O < 2$ values that confirm their potassic alkaline or shoshonitic characteristics. Potassic SiO_2-saturated alkaline A-type granitic rocks are meta-luminous, and mainly occur in post-collisional, anorogenic and mature arc setting (Bonin 1990). However, their temporal and geographical associations with the SiO_2-supersatured subalkaline granites of the same area suggest a similar tectonic setting (post-collisional), which is confirmed on the Nb-Y and Ta-Yb plots (Pearce *et al*. 1984, Fig. 2E and 2F).

A group of 22 zircon crystals was selected for *in-situ* U-Pb zircon dating and extracted from a hornblende quartz monzonite of the Castanhal Quartz Monzonite, Mapuera Suite (sample CC-42). Zircon crystals show zoning, are

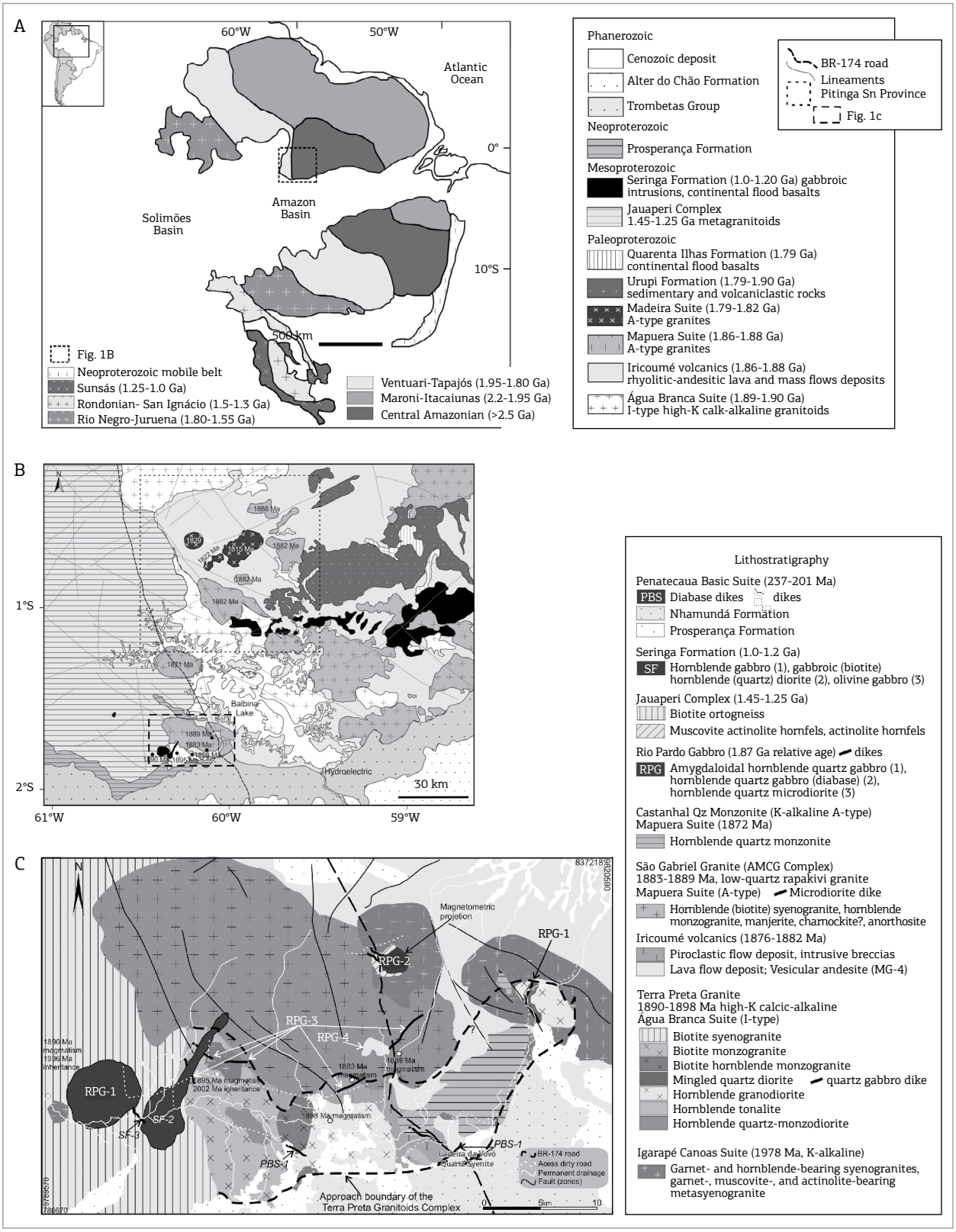

Figure 1. (A) Geochronological provinces of the Amazonian craton (Macambira *et al.* 2009). (B) Simplified geological map of the central Amazonian Craton, NE Amazonas State, central part of Ventuari-Tapajós and Western Central Amazonian provinces (in Valério *et al.* 2012, updated). (C) Geological map of the Southernmost Uatumã-Anauá Domain, central Amazonian craton. The compositional variation of granitoid and volcanic rocks and main fault zones has been obtained from integration of geological, petrography, geochemical, SAR/SIPAM remote sensing products and airborne geophysical data.

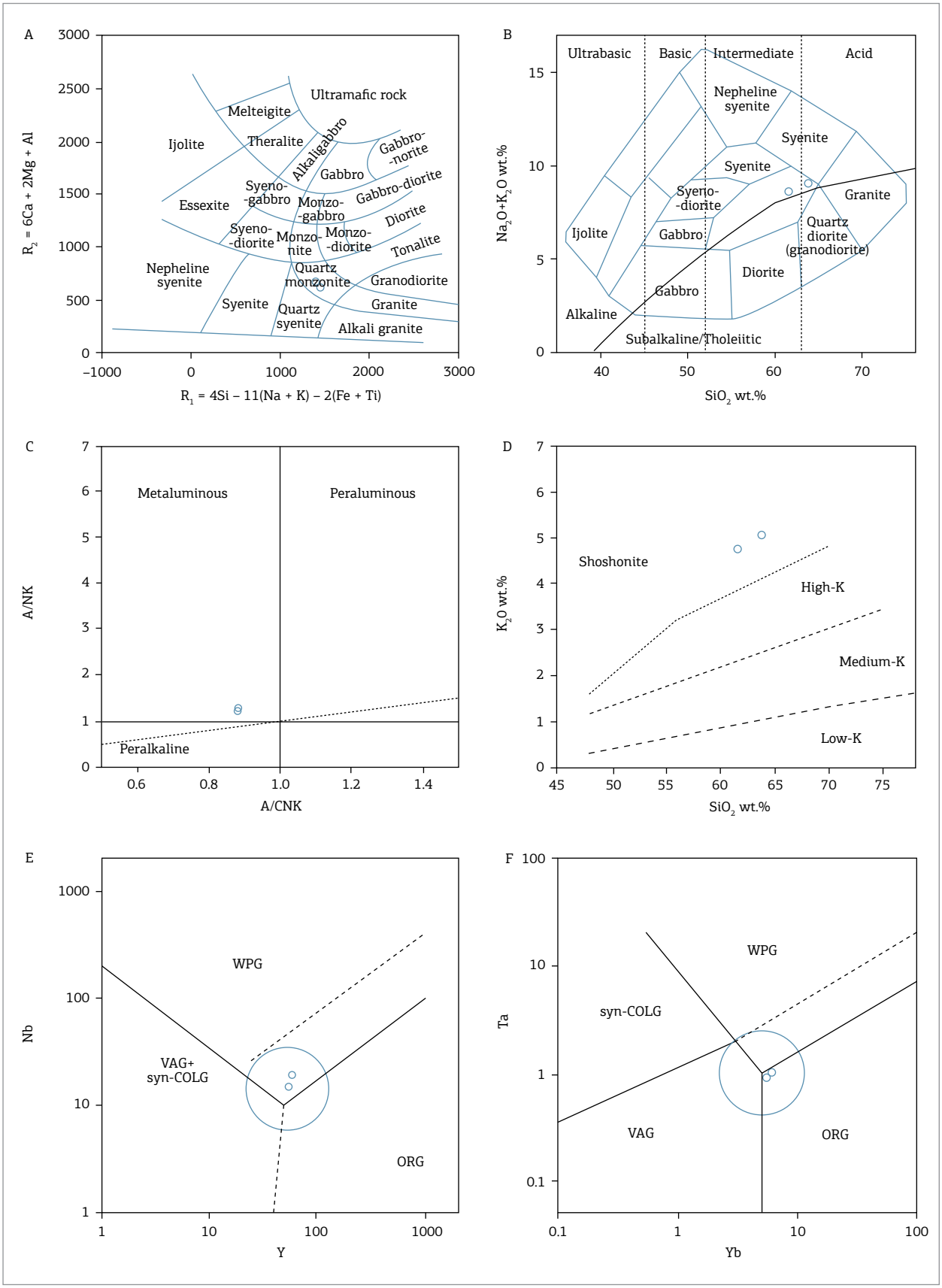

Figure 2. Geochemical classification plots. (A) R1-R2 plot (De la Roche *et al.* 1980). (B) TAS plot (Cox *et al.* 1979). (C) On the A/CNK-A/NK plot (Shand 1943). (D) SiO_2 wt.% versus K_2O wt.% plot (Peccerrilo & Taylor 1976). Tectonic setting plots by Pearce *et al.* (1984), Y-Nb (E) and Yb-Ta (F) plots; see field descriptions in Pearce *et al.* (1984).

slightly micro-fractured, and contain fluid inclusions of rounded shape. From this zircon set, 21 grains yielded an average age of 1872 ± 6 Ma (MSWD = 2.4) and one additional zircon crystal yielded a Trans-Amazonian age (2062 ± 17 Ma) (Fig. 3).

In-situ Lu-Hf analysis have been also driven on ten zircon crystals from the Castanhal hornblende quartz monzonite (Tab. 1). This set of zircon crystals yielded initial $^{176}Hf/^{177}Hf$ ratios ranging from 0.281527 to 0.281620, and their dominantly negative εHf_t values (between -2.2 and 1.1) imply the contribution of mafic crustal rocks ranging from 2.95 to 2.66 Ga (Mesoarchean–Neoarchean) and felsic crustal rocks varying between 2.51 and 2.34 Ga (Neoarchean-later Siderian) (Fig. 4).

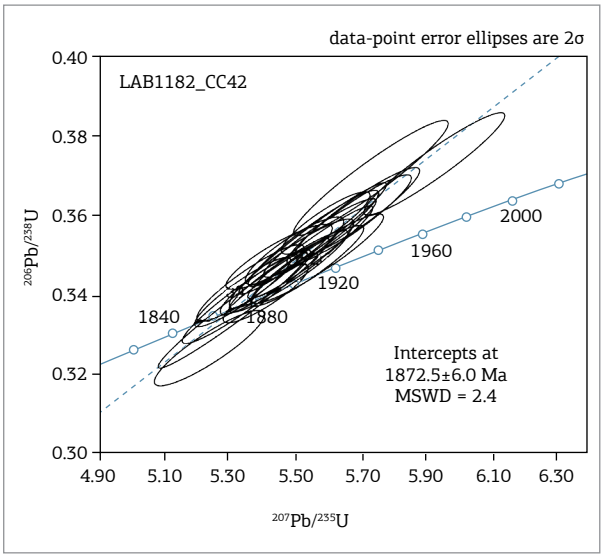

Figure 3. Discordia plot showing the upper intercept at 1872 Ma, crystallization age for hornblende quartz monzonite (CC-42) of the Castanhal Quartz Monzonite, Mapuera Suite.

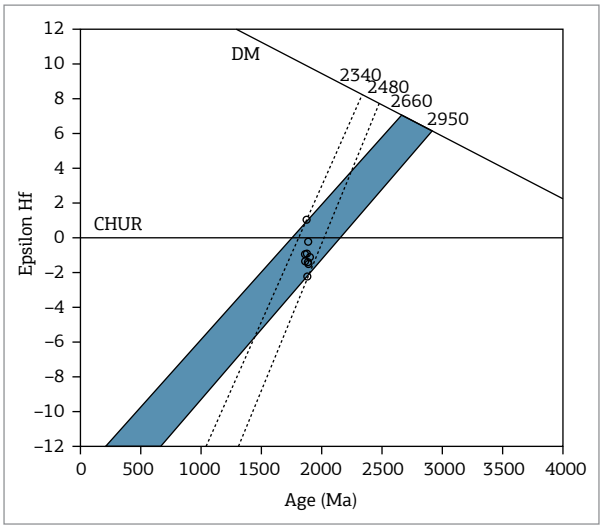

Figure 4. εHft versus age diagram for 10 zircon crystals from the hornblende quartz monzonite (CC-42) of the Castanhal Quartz Monzonite, Mapuera Suite. Mesoarchean to Neoarchean mafic crust sources and Neoarchean to later Siderian felsic crust sources.

Table 1. LA-MC-ICP-MS Lu–Hf analysis for sample CC-42 (hornblende quartz monzonite) of the Castanhal Quartz Monzonite, Mapuera Suite.

File Name	Sample/ spot	U-Pb Age (Ma)	±2σ	CHUR	DM	Sample (present-day ratios)				Sample (initial ratios)			DM model ages (Ga)	
				$^{176}Hf/^{177}Hf$ (t)	$^{176}Hf/^{177}Hf$ (t)	$^{176}Hf/^{177}Hf$	±2SE	$^{176}Lu/^{177}Hf$	±2SE	$^{176}Hf/^{177}Hf$ (t)	epsilon Hf (t)	±2SE	Mafic source	Felsic source
01	003-Z2. static.exp	1874	9.9	0.281589	0.281868	0.281573	0.000030	0.001296	0.000177	0.281527	-2.2	0.3	2.95	2.51
02	004-Z5. static.exp	1887	8.0	0.281580	0.281858	0.281565	0.000029	0.000741	0.000008	0.281538	-1.5	0.0	2.90	2.48
03	005-Z6. static.exp	1862	7.6	0.281597	0.281878	0.281589	0.000014	0.000856	0.000015	0.281559	-1.3	0.0	2.87	2.45
04	006-Z7. static.exp	1871	8.4	0.281590	0.281870	0.281665	0.000052	0.001271	0.000089	0.281620	1.1	0.1	2.66	2.34
05	007-Z11. static.exp	1872	7.5	0.281590	0.281870	0.281593	0.000026	0.000816	0.000008	0.281564	-0.9	0.0	2.84	2.44
06	008-Z13. static.exp	1893	8.4	0.281576	0.281854	0.281581	0.000039	0.001223	0.000040	0.281537	-1.4	0.1	2.90	2.48
07	009-Z14. static.exp	1858	9.1	0.281599	0.281881	0.281614	0.000039	0.001159	0.000027	0.281573	-0.9	0.0	2.83	2.43
08	010-Z16. static.exp	1894	12.6	0.281576	0.281854	0.281595	0.000045	0.001414	0.000012	0.281544	-1.1	0.0	2.87	2.47
09	011-Z20. static.exp	1881	11.2	0.281584	0.281863	0.281606	0.000029	0.000777	0.000006	0.281578	-0.2	0.0	2.78	2.41
10	012-Z22. static.exp	1878	7.6	0.281586	0.281865	0.281594	0.000031	0.001300	0.000028	0.281548	-1.4	0.0	2.88	2.47

CONCLUSIONS

In conclusion, SiO_2-saturated potassic alkaline A-type granites (hornblende quartz monzonite), composing the Castanhal Quartz Monzonite, Mapuera Suite, are meta-luminous and of Orosirian age (1872 Ma) generated in a post-collisional setting. The occurrence of the Ladeira da Vovó Quartz Syenite suggests it has been emplaced and reworked along listric faults, during the Tonian period, possibly (rifting phase of the Amazon Basin). Dominantly negative εHf_t values and Hf T_{DM} ages in zircon crystals from a hornblende quartz monzonite reveal a significant contribution of crustal material, including Mesoarchean to Neoarchean amphibolite and Neoarchean to later Siderian granulite.

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