Archean crustal evolution of the Imataca Complex, Amazonian Craton: Sm/Nd, Rb-Sr and U-Pb (SHRIMP) evidences.

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Introduction and geologic framework

Archean and Proterozoic events have played important role in the evolution of the Amazonian craton which tectonic stability took place at the end of the Late Mesoproterozoic (e.g. Tassinari et al. 2000). The regional geologic and structural features support the existence of six crustal provinces composed of specific plutonic-volcanic and sedimentary associations and coeval metamorphic rocks, all of them showing very coherent isotopic constrains. These provinces are: The oldest Central Amazonian province(> 2.53 Ga), The Maroni-Itacaiunas province (2.25/2.10 – 1.95Ga). This province toward the west exhibits tectonic contact with the Imataca Complex - a ENE-trending, fault-bounded block composed of high grade Archean rocks, The Ventuari-Tapajós (1.95-1.8 Ga) province: a major calc-alkaline plutonic-volcanic terrane(1.95-1.8 Ga), The Rio Negro-Juruena (1.8-1.55 Ga), Rondonian-San Ignácio (1.5-1.3 Ga) and Sunsás-Aguapeí (1.25-1.0 Ga) provinces.

The Imataca Complex (NW corner of the Guiana shield) comprises mostly medium- to high grade quartz-feldspathic paragneiss, exhibiting complex deformation (e.g. extensive mortar, augen, flaser and mylonitic textures), and are exposed as elongated and symmetrical domes (e.g. Sidder & Mendoza 1995). Calc-alkaline gray gneisses and granitoids of igneous protolith are also present in the Imataca Complex (IC), as well as dolomitic marbles, orthopyroxene and magnetite quartzites, and BIFs that include huge ore deposits of Algoma type. Moreover, migmatite injections and anatexis (devoid of metasedimentary components) are widespread in the western part of Complex, the largest migmatite mass centered in Cerro La Ceiba. During the Transamazonian orogeny (2.15-2.00 Ga) several granitoid plutons emplaced the IC crust (e.g. Gibbs & Barron, Sidder & Mendoza 1995). Transcurrent and thrust faults combined with isoclinal folds have also been important during the geologic evolution, mirrored by the Guri Fault System - a zone of multiple faulting, shearing and mylonitization, located along the southeastern edge of the IC. In a pre-Pangean reconstruction using paleomagnetic data from rocks of the IC and African counterpart, the Guri System is contiguous to the Sassandra (Ivory coast) and Zednes (Mauritaine) faults (Onstott & Hargraves, 1981; Caen-Vachete 1998).

This paper presents the first Sm/Nd whole rock and SHRIMP U-Pb zircon analyses of the Imataca Complex. Integrated interpretation of the new results with previous geochronology provide better understanding of the main mantle/differentiation events in this complex, giving new insights on paleotectonic correlations between the Amazonian and West Africa cratons, during the Archean and Late Paleoproterozoic.

Geochronologic background of the Imataca Complex

Radiometric studies performed in the IC during the 70 and 80 have led to the following assessments for the crustal evolution of the IC:

Rb-Sr and Pb whole rock analyses suggest that the protolith age of the IC goes back to at least 3100 Ma and might be as old as 3700-3400 Ma (Montgomery 1979). Early high grade metamorphism and igneous events represented by gneisses, migmatites (including La Ceiba), and granitoid rocks took place between 2800-2700 Ma ago (see Sidder & Mendoza 1995 for review). Rb/Sr whole rock analyses on thin-slab specimens of banded granulites yielded ages in the 2.02 1.90 Ga range ($^{87}Sr/^{86}Sr = 0.7404$). This age is interpreted to be a local, high grade metamorphism which in some places was accompanied deformation by shearing (Montgomery et al. 1977). This event is contemporary with the emplacement of the Encrucijada granite, as supported by the Rb/Sr whole rock isochron of 2190 Ma ($^{87}Sr/^{86}Sr = 0.7010$; data recalculated from Possadas & Kalliokoski 1967). Thereby a tectonic relationship with the Transamazonian orogeny can be established. Additional $^{40}Ar/^{39}Ar$ plateau ages on hornblende and biotite for the Encrucijada granite are 1970 and 1880 Ma, respectively, indicating its cooling took place shortly after emplacement (Onstott et al. 1989). The IC high grade gneisses have $^{40}Ar/^{39}Ar$ plateau dates on hornblende and biotites that vary from 1970 to 1760 Ma, recording the waning stages of the Transamazonian orogeny uplift and cooling. Additional 1.4 - 1.1 Ga ages on biotites and feldspars reveal that the IC central zone was isobarically cooled. These youngest dates are compatible with published K-Ar and Rb/Sr mineral dates on different rock units in the area, between 1.5 and 1.1 Ga (Onstott et al. 1989). From the above, the IC crust underwent further reactivation and thermal overprints during the Mesoproterozoic, thereby suggesting a tectonic relationship with the multi-orogen evolution of SW Amazonian craton, as well as with Southern Laurentia. Finally, U/Pb SHRIMP analyses (Arndt & Goldstein, unpublished data) on detrital zircons from sands of the Orinoco river along the western limit of the IC, show a wide age range (2.8 Ga, 2.0 - 0.9 Ga and 0.5 - 0.1 Ga), suggesting the polycyclic evolution of crustal sources.

Results and discussion

Twenty Sm-Nd whole rock analyses were performed on selected IC rocks. The Sm-Nd T_{DM} model ages are between 3.23 – 3.00 Ga and 2.90 – 2.80 Ga. This supports the assumption that

crustal accretion took place during two distinct Archean events whilst the geographic distribution of the ages suggest that some crust zonation might exist within the IC. Additional Nd evidence from two Late Archean plutons (2.50 Ga) indicates their derivation from mixtures between the lower crust and a subordinate juvenile component. Two high-grade metasedimentary rocks have T_{DM} crustal ages of 3.16 and 3.23 Ga, in agreement with the T_{DM} ages of the country rocks. A gray gneiss near the Guri dam yielded the oldest T_{DM} age of 3.41 Ga; however, we have not found any isotopic evidence that the protolith age of IC goes back to 3.70 Ga, as previously proposed.

Two Rb/Sr whole rock isochron ages on banded granulites are between 2.78 and 2.67 Ga, indicating the period of high grade partial melting in the IC. During this event migmatitic injection (La Ceiba) took place, in accordance with the calculated $\varepsilon_{Nd(2.78Ga)}$ values (+1.13 to – 4.93).

Additional U-Pb SHRIMP zircon analyses were undertaken on a banded garnet bearing granulite, as well as on the La Ceiba migmatite. The sample of a felsic component of granulite yielded some prismatic zircons, which display, in CL images, oscillatory zoning parallel to their exterior surfaces, core and rim structures. The analyses were of the dominant oscillatory zoned zircon and yielded a weighted mean $^{207}Pb/^{206}Pb$ date of 3229 ± 39 Ma (MSWD = 5.2). These dates point to an Archean age for the igneous protolith of granulite, in agreement with the Nd evidence. The La Ceiba sample gave a prismatic and subhedral zircons, which exhibit in CL images a dark homogeneous colour and oscillatory zones. All analyses yielded a ^{204}Pb corrected weighted mean $^{207}Pb/^{206}Pb$ date of 2787 ± 22 Ma (MSWD = 1.9). This age is in agreement with the oldest Rb/Sr whole rock isochron age (2.78 Ga) on the same rock, and confirm the Late Archean partial melting process in high-grade metamorphic conditions.

It is noteworthy that protoliths as old as 3.70 – 3.40 Ga, as previously suggested from conventional Pb-Pb studies on the IC granulites, were not confirmed by the new Sm/Nd and U-Pb study, and neither by unpublished U/Pb ion probe ages of detrital zircons from the Orinoco river sands.

Finally, additional Sm/Nd whole rock analyses were also performed on selected granitoid plutons of Transamazonian age.The Nd evidence coupled with geographic distribution of these intrusions point that the southern edge of the IC is more restricted than it has been postulated, as supported by their T_{DM} ages between 2.29 and 2.21 Ga, and positive $\varepsilon_{Nd\ (2.1Ga)}$ values (+3.05 to + 0.74). Moreover, there is isotopic evidence for a significant participation of Paleoproterozoic mantle-derived magma in the granite genesis. Nevertheless, two of these plutons that emplaced within the northern part of the IC yielded T_{DM} ages (2.95 and 2.85 Ga) and $\varepsilon_{Nd\ (2.10Ga)}$ values of – 4.20 and -4.93. Thereby they were mostly formed by remelting of the Archean crust (IC).

Concluding remarks

- New Sm-Nd analyses display coherent T_{DM} model ages, revealing that two major periods of crust generation took place in the IC: 3.23 - 3.00 Ga and 2.90 - 2.80 Ga.
- The Rb/Sr whole rock isochron ages between 2.78- 2.67 Ga constrain the period of of regional high grade metamorphism and migmatitic injection.
- The isotopic and petrologic evidences as well the tectonic features of the IC (e.g. faults, mylonites, isoclinal folding) support the interpretation that Imataca is an allochthonous block which was juxtaposed to the Maroni-Itacaiunas mobile belt during the Late Paleoproterozoic. Moreover, this scenario is in agreement with the contemporary geologic evolution in the West African craton, as previously suggested from radiometric ages and paleomagnetic data. Therefore the new geochronological data support the interpretation that a large tectonic unit grouping the Guiana shield (Northern Amazonian craton) and the West African counterpart did exist during Archean and Late Proterozoic.

References

Caen-Vachete M., 1988. Le craton ouest-africain et le bouclier guyanais: um seul craton au Protérozoiique inférieur? J. African Earth Sci., 7, 479-488.

Gibbs, A. K. & Barron, C. N., 1983. The Guiana Shield reviewed. Episodes, 2, 7-14.

Montgomery, C. W., 1979. Uranium-Lead Geochronology of the Archean Imataca Series, Venezuelan Guayana Shield. Contrib. Mineral. Petrol., 69, 167-176.

Montgomery, C. W., Hurley, P. M., Fairbairn, H. W. & Gaudette, H., E., 1977. Equilibrated domains and conbined Rb-Sr and U-Pb systematics in the history of a granulite. 21th Ann. Rep., Geochronology Lab., M.I.T., Cambridge, USA, 1-25.

Onstott, T. C. & Hargraves, R. B., 1981. Proterozoic transcurrent tectonics: palaeomagnetic evidence from Venezuela and Africa. Nature, 289, 131-136.

Onstott, T. C., Hall, C. M. & York, D., 1989. $^{40}Ar/^{39}Ar$ thermochronometry on the Imataca Complex, Venezuela. Precambrian Res., 42, 255-291.

Possadas, V. G. & Kalliokoski, J., 1967. Rb/Sr ages of the Encrucijada granite intrusive into the Imataca complex, Venezuela. Earth Planet. Sci. Lett., 2, 210-214.

Sidder, G. B. & Mendoza, V. S., 1995. Geology of the Venezuelan Guayana Shield and its relation to the Geology of the Entire Guayana Shield. U. S. Geological Survey Bull., 2124-B, 1-33. USA.

Tassinari, C. C. G., Bettencourt, J. S., Geraldes, M. C., Macambira, M. J. B. & Lafon, J. M., 2000. The Amazonian Craton. in *Tectonic Evolution of South America*, Cordani, U. G., Milani, E. J., Thomaz Filho, A. & Campos, D. A., eds., 41-96, 31st Int. Geological Congress, 2000.

Teixeira, W., 1990. The Proterozoic mafic dyke swarms and alkaline intrusions in the Amazonian Craton, South America, and their role in the tectonic evolution based on Rb-Sr, K-Ar and ^{40}Ar-^{39}Ar geochronology. in *Mafic Dykes and Emplacement Mechanisms*, Parker, A. P., Rickwood, P. C. & Tucker, D. H., eds., Publication 23, Int. Geol. Correlation Program Project 257, 285-294, A. A. Balkema.