PRECAMBRIAN EVOLUTION OF THE AMAZONIAN REGION

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GEOLOGICAL EVOLUTION AND EVALUATION OF RECENT GEOCHRONOLOGICAL DATA IN AMAZONIAN CRATON

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INTRODUCTION

During the last five years in Amazonian craton, there has been much progress in the geochronology thanks to the efforts of the IGCP Project 204 activity. Several institutions were evolved in this research, such as: the geochronological. Research Center of University of São Paulo, the Isotopic Geochemistry Laboratory of University of Pará, the Department of Earth Sciences of University of Oxford, the Z.W.O Laboratorium Voor Isotopen-Geologie of Amsterdam, the Universities of New Hampshire and Kansas in the U.S.A.

In regard to the Amazonian Craton, at present, somethink like 3 thousand age determinations are available on different methodologies. Many of them are already published in the specialized literature. Most of these data are related to the Rb-Sr and Pb-Pb in whole rock analyses and K-Ar in minerals, but some U-Pb were performed in zircons. In addition, few Sm-Nd age determinatibns have been carried out on the recent years. On the other hand some geochronological maps have been already made for the precambrian areas of Brazil, Bolívia, Suriname and Colombia. These represent the actual level of regional geochronological knowledge of the region.

GEOLOGICAL SETTING

The Amazonian Craton, as described by Cordani and Brito Neves (1982) is a very large unit, which acted as a stable foreland in Late Proterozoic times, for a marginal belt named Paraguai - Araguaia (Fig. 1). In a few words, that unit is composed by an ancient "cratonic" domain (the Central Amazonian Province) which is surrounded by mo-

bile belts of Early to Middle Proterozoic ages: Maroni-Itacaiunas, Rio Negro-Juruena, Rondonian and Sunsás.

The Central Amazonian Province was submitted to platform conditions for long time. Unfolded and unmetamorphosed volcanic - sedimentary sequences, (in the interval of 1.9-1.0 GA), demonstrate the long duration of the cratonic conditions of the area.

The sedimentary deposits unconformably overlie the acid to intermediary volcanism in the Central Amazonian domain. They are related to the Roraima Group which occurs extensivelly in Brazil, Venezuela and Guiana, and the Gorotire, Rio Fresco and Beneficente groups, that appears in the southern part of the Amazonian craton. These sediments are exposed mainly as "mesas", with gentle dips except near to block faults or intrusions. These units include orthoquartzites, arkoses, conglomerates, minor shales and jasperoid tuffs. Middle Proterozoic dikes and extensive sills of continental tholleite type cut the sedimentary covers.

The Carajás area in the southeastern sector of the Central Amazonian Province, are made up by Archaean granite - greenstone terranes and high-grade metamorphic rocks. The basement complex includes generally orthogneiss, migmatites, granites, granodiorites, adamelites, diorites and tonalites, but minor occurrences of metassediments and metabasic and ultrabasic rocks have been reported also. The associated supracrustals correspond to the Grão Pará Group, which forms a broad synclinorium with N-NW trending axis. This low grade metamorphic sequence is made up by a metavolcanic unit, BIFs and a clastic sequences also. The general geologic scenary of the Central-Amazonian Province is completed by the development of an important plutonism of post-tectonic and anorogenic characteristics.

The Central Amazonian Province is bounded to the north and to the northeast by the Maroni-Itacaiunas mobile belt. However, towards the southeast the limits between those geotectonic units are still preliminary and they need further confirmation. The belt shows a large extension of area, along the French Guiana, Suriname, Guyana, and parts of Brazil (Amapá, Roraima, Pará) and Venezuela.

The Early Proterozoic Maroni-Itacaiunas belt exhibits a strong petrological and structural coherence. In a broad view, the geotectonic unit can be subdivided into a granulite and gneissic terrane with Archaean protoliths (The Imataca Complex, in Venezuela and Cupixi area in Amapá), and a Early Proterozoic (2.2-1.9 Ga.) granite-greenstone terrane, and the so-called Central Guiana Granulitic belt.

The pre-existent basement occurs as nuclei along the mobile belt extension. Most of these fragments is made up of granulitic rocks, partially reworked during the Transamazonic cycle (2.25-1.9 Ga.). The geochronological studies performed on these remnants demonstrate the subordinated ensialic character of the Maroni-Itacaiúnas mobile belt, although the majority of its crust appears to be originated through mantle-derived processes during the lower Proterozoic time.

The mobile belt comprises a large portion of supracrustal rocks identified as metavolcanic and metassedimentary sequences, metamorphosed at the greenschist to amphibolite facies, and intensily deformed (Carichapo-Pastora, Barama-Mazaruni, Orapu, Bonidoro and possibly part of the Vila Nova Groups). The nature, composition and evolution of these rocks have lead some authors to consider them as Early Proterozoic greenstone belts (e.g. Gibbs, 1980).

Towards the west, the Maroni-Itacaiúnas belt is truncated by the structural trends of the so-called Rio Negro-Juruena mobile belt (Tassinari, 1981) of Middle Proterozoic age (1.75-1.6 Ga.). This unit is composed predominantly of granitic to granodioritic rocks, many of which exhibiting gneissic structure. There are gneisses, migmatites, granodiorites and tonalites.

Metamorphism in general took place in the amphibolite facies although granulite facies assemblages have been reported. The dominant structural trend is NW-SE, but in some areas a NE-SW overprint has been observed.

Associated to the evolution of the Rio Negro - Juruena belt is the acid,to intermediary volcanism and granites (Teles Pires type volcano-plutonism. They are respectively of 1.65 and 1.5 GA. ages. In turn the undeformed volcanic cover is overlied by the Beneficente Group (1.6-1.4 GA), which is composed of marine clastics, locally including

limestones

Rapakivi granites, alkaline ring complexes and basic magmatism occurred during the time interval 1.45-1.40 GA within the province. They have been interpreted as the cratogenic activity of the mobile belt. The evolution of the Rio Negro-Juruena mobile belt was recently proposed by Tassinari (1981),based on geochronological studies, including Sr and Pb isotopic evidences. Indeed the geological control, the coherent structural trends and age measurements are consistent with a possible origin for this belt by the development of a mantle derived magmatic arc. (Fig. 2)

The Rondonian and Sunsás mobile belts are the youngest geotectonic unit of the Amazonian Craton's evolution. Their histories belong to the Middle Proterozoic (1.55-1.30 GA and 1.25-1.0 GA, respectively). The both mobile belts show strong overprint structures and are of clear ensialic character.

The whole geographic domain includes nuclei of exposed older basement, such as in Bolivia (Lomas Maneches granulitic area)and in Brazil (Ituxi and Jauru areas). The basement complexes of those provinces includes many kinds of migmatites and great volume of granitic to granodioritic rocks, mainly metamorphosed to amphibolite facies (Teixeira and Tassinari 1984, and Litherland and Bloonfield,1981).

Low grade supracrustal sequences and underformed sedimentary covers (age around 1.4 and 1.1. GA.) have been identified in special within the Rondonian belt. On the other hand the Sunsas orogenic cycle has been recently reported as comprising the erosion of rocks of older cycles, the deposition of the clastic sequences and the subsequent deformation and metamorphism accompanied by granitic activities (Litherland et al. 1986).

In terms of the available geochronological data of the Amazonia the general proposed evolution is characterized by reworking of continental crust with associated activity of syn, late and post-tectonic granites. In special, two main cratogenic granitic activities occurred in the area, at 1.25 GA and 0.95 GA. They are interpreted as the

final stage of the evolutionary processes of the Rondonian and Sunsás belts, respectively.

DISCUSSION

In the Central Amazonian Province, the most recent published geochronological studies are related to the Serra dos Carajás area. Archean ages were obtained on the granite-greenstone terranes and on the high-grade metamorphic rocks.

Rb-Sr age measurements of 2,640 ± 40 MA. (I.R.= 0.7009) for the Rio Maria granitoids, and of 2,480 ± 40 MA. (I.R.= 0.7072) for the Itacaiúnas river gneisses, near Serra dos Carajás, were reported by Montalvão et al. (1984) the correspondent K-Ar cooling age pattern for that region are on the time interval 2.6-2.2 GA. In addition, U-Pb analyses from rhyolites in the Grão Pará Group (metavolcanic sequences BIFs and clastic sequence) indicated that volcanism and iron deposition occurred 2,758 ± 39 MA. ago (Wirth et al., 1986). As reported by those authors, the U-Pb results are in concordance with Rb-Sr age of 2,687 ± 54 MA. for the metabasalts.

Radiometric determinations are also available for some granitic bodies in Central Amazonian province. This is the case of the Carajás type granite with an age of 1,820 ± 56 MA. by U-Pb zircon method (Wirth et al, op. cit.), the Pitinga granite with 1689 ± 19 MA. Rb-Sr whole rock isochron age (Macambira et al., 1987) and the Jamon body with 1601 ± 21 MA. Rb-Sr whole rock isochron age also (Dall'Agnol 1984). In general, it can be pointed out that the stocks and batholiths that spread out in the entire cratonic domain indicate radiometric ages in the interval 1.9-1.3 GA. (Tassinari et al., 1985).

In regard to the Maroni-Itacaiúnas province the available radiometric date is very complete including U-Pb, Rb-Sr, Sm- Nd, Pb-Pb and K-Ar analyses. Representative studies have been carried out in French Guiana, Guyana and in Roraima and Amapá Brazilian territories. In general, there is a remarkable concordant geochronological pattern along the entire domain of the belt; demonstrating that the its evolution took place during a major event; the Transamazonian oro

geny (2.2-1.9 GA.).

The most recent representative radiometric results are reported for rocks from the French Guiana, as summarized below:

Unit	Rocks	Isochron Ages (GA.)	Isotopic Parameters
L'Ile de Cayenne	Migmatites	Rb-Sr = 2.0	i.r. 0,7018
Guyanais Type	Syn-Tect. Granite	Pb-Pb = 2.1	u_1 = 8,095
		Rb-Sr = 2.0	i.r.= 0,7020
Paramacã	Volcanic Sedimentary Sequence	Sm-Nd = 2.1	E_{Nd}= + 2,1
		Rb-Sr = 2.0	i.r.= 0,7024
Caraibe Type	Post-Tect. Granite	Rb-Sr = 1.9	i.r.= 0,7024
	General K-Ar cooling pattern around 1.8-1.9 GA.		

* Teixeira et al. (1985).

** Gruau et al. (1985).

Rb-Sr whole rock isochron of granulitic from Roraima (Brazil) yielded an age of 1,908 ± 48 MA. with a inicial ratio of 0.7005 (Lima et al, 1986). These rocks correspond to the extension of the Central Guiana granulitic belt. In Suriname, high metamorphic rocks of the Fallawatra Group have been dated also (Priem et al. 1978; Tassinari, unpublished data), with the results in the range 2.2-2.0 GA. Moreover, Othman et al. (1984) reported Nd model ages on granulites from the Barkuis region (2.3 GA.) as well as on the Kanaku granulites (2.2 GA). In Venezuela, new U-Pb and Rb-Sr radiometric analyses were performed on medium to high grade gneisses and granitoids from the Amazonas territory (Gaudette et al., 1985). The results are slighty younger and are consistent with a regional metamorphism followed by intrusions, during the period 1860-1760 MA..

In a broad sense, most of the available data are in concordance with some U-Pb zircon ages in Guiana, where the felsic volcanics of the Barama-Mazaruni Supergroup indicated on age of 2.25 Ga. (Gibbs, 1980).

As prior described, pre-existent remnants of basement rocks within the Maroni-Itacaiúnas belt has been identified. They con

sist generally of high grade polimetamorphic terranes, such as the Imataca Complex in Venezuela, and the Cupixi and Tumucumaque areas in Brazil.

Archaean radiometric ages have been first reported for the Imataca banded gneisses by Montgomery and Hurley (1978). More recently Rb-Sr geochronological studies were reported by Lima et al. (1981) on the tonalitic and trondjemitic rocks from Cupixi area with an age of 2,860 ± 60 MA. (I.R.= 0,7025), although the granulitic rocks from the Tumucumaque area yielded an younger isochron age, of 2,450 ± 74 MA. (I.R. = 0,7063).

The most recent radiometric published results of the Rio Negro-Juruena province are concentrated in the Pico da Neblina region (northwestern sector) and in the Aripuanã region (southeastern sector). They were performed by Rb-Sr and Pb-Pb whole rock methods, as well as by the U-Pb zircon method. A summary of these data were presented by Tassinari et al. (1986):

Location	Rocks	Ages (Ma.)	Isotopic Parameters
Papuri and Uapes Rivers	biotite-titanite granitoids	Rb-Sr= 1698 ± 27	i.r. = 0,7030
		Pb-Pb= 1630 ±100	u_1 = 8,16
		U-Pb = 1709 ± 17 (zircons)	
		U-Pb = 1521 ± 30	
Aripuanã River area	granite-gneisses	Rb-Sr = 1700 ± 21	i.r.= 0,7048
		Pb-Pb = 1672 ± 90	u_1 = 8.24
Pontes e Lacerda area	granite-gneisses	Pb-Pb = 1717 ±115	u_1 = 8,10
Quatro Marcos area	gneisses	Rb-Sr = 1670 ± 46	i.r.= 0,7035

The Sr and Pb isotopic parameters are suggestive that these rocks constitute a new continental crust formed from magmatic precursor which was originated in the upper mantle at about 1700 - 1650 MA. or shortly before.

During the last six years intense geochronological studies have been carried out by different methodologies (Rb-Sr, Pb-Pb, K-Ar) on rocks from selected areas of the Rondonian and Sunsás provinces.

These data interpreted together with the prior available radiometric results make possible a better understanding of the main metamorphic events occurred during the Middle Proterozoic. In general, the ensialic character of the evolution is demonstrated, with identification of remnants of at least 1.7 GA. old within the both belts, although subordinated mantle derived material has been suggested. Moreover, two periods of granitic plutonism is well defined. The main geochronological results of the Rondonian province are summarizes below.

Province	Location	Rocks	Ages (MA.)	Isotope	Parameters
Rondonian	Ituxi area	Granulites	Rb-Sr 1,515 ± 28	I.R.	0.707
Rondonian	Abunã - area	Granite-Gneisses	Rb-Sr 1,520 ± 24	I.R.	0.705
Rondonian	Ariquemes	Granite-Gneisses	Rb-Sr 1,440 ± 21	I.R.	0.705
Rondonian	La Junta - Diamantina	Syntectonic granites	Rb-Sr 1,375 ± 80 Rb-Sr 1,391 ± 70	I.R. I.R.	0,7052 0,7004
Rondonian	Lomas Manaches	Granulites	Rb-Sr = 1960		

Based on the available data the main metamorphic phases of the Rondonian belt occurred between 1.55-1.40 GA. and the Post-Tectonic plutonism took place between 1.4 and 1.3 GA. ago. On the other hand the age of the Sunsás Orogeny is defined by Rb-Sr and K-Ar dating on both synkinematic and post-kinematic phases giving on orvall span of around 1000-950 MA. for the orogeny (Litherland et al., 1986).

Finally, in terms of new geochronological data over the Amazonian Craton, Nd and Sr provenance studies were carried out in sediments from the Amazon river and its tributaries (Goldstein et al. 1985). The results are potentially of interest because they show that the Transamazonian orogeny was a period of major crustal addition in the area of the Guiana shield.

This study represents a future good perspective to the understanding of the age provinces within the craton. In addition the improvements of new geochronological clean labs in Brazil will result in further high quality research on the precambrian rocks from the Amazonian region.

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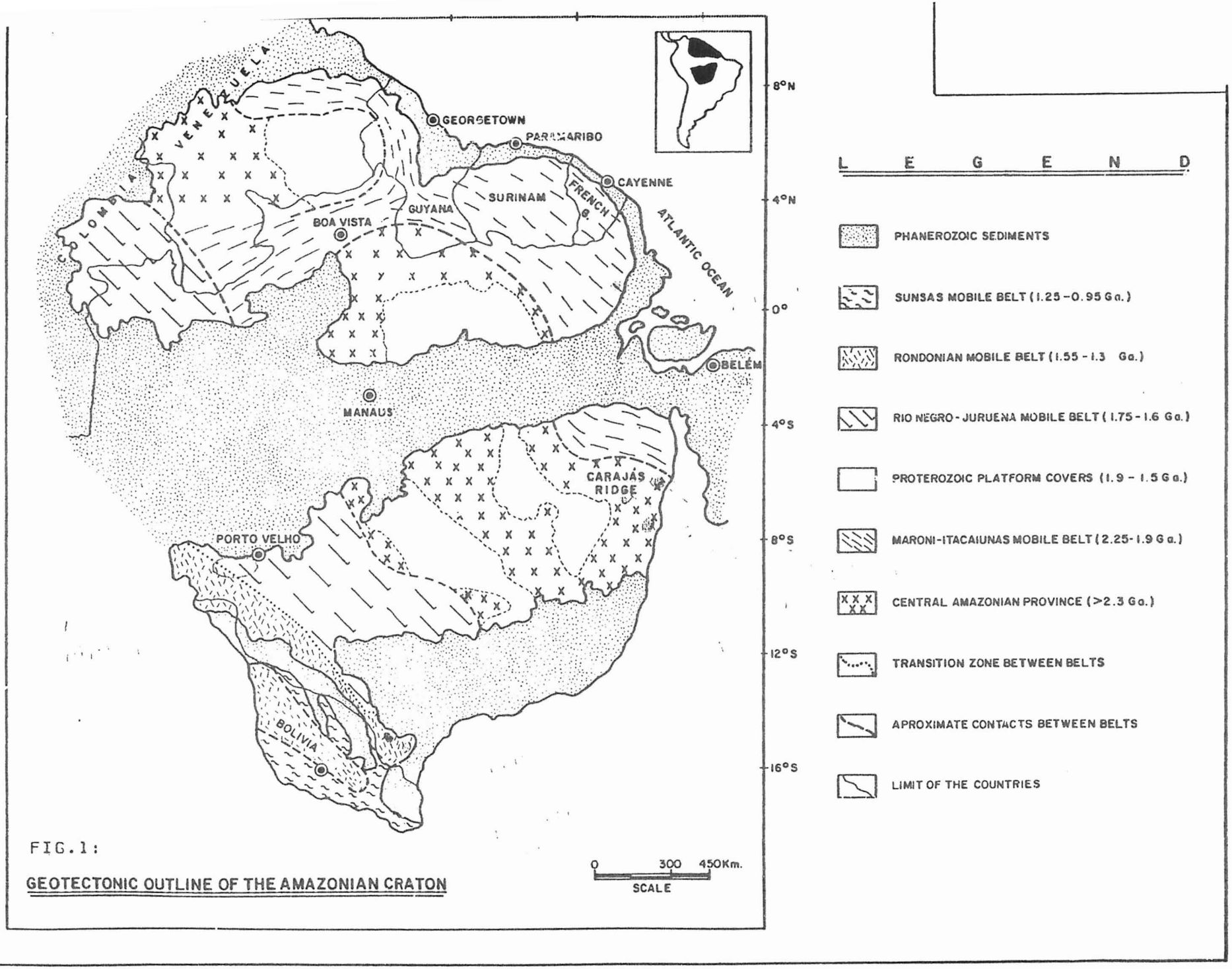

FIG.1:

GEOTECTONIC OUTLINE OF THE AMAZONIAN CRATON

LEGEND

FIG.2:

- CONTINENTAL CRUST
  - I – L. MANECHES/JAURU
  - II – CENTRAL AMAZONIAN
  - III – RIO NEGRO - JURUENA
- OCEANIC CRUST
- GRANITES
- SEDIMENTATION