

THE GEOLOGY OF SOUTH AMERICA

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Summary

The article deals with the geology and the geological evolution of the South American continent. The shield areas of the South American Platform, containing the cratonic regions surrounded by Neoproterozoic fold belts, consolidated during Late Proterozoic to Early Paleozoic times in contrast to the Patagonian Platform which mainly evolved during the Early Paleozoic, and has been tectono-thermally active up to the Cenozoic. The highest non-collisional mountain range of the world, the Andes, developed on the western continental margin of the plate, at least from the early Paleozoic on, and its evolution continues until today with active volcanism and seismicity due to continuous subduction of Pacific plates beneath the South American Plate. During the different tectonic regimes throughout time, four major tectono-sedimentary domains developed on the South American continent, which are discussed in the final chapter.

1. Introduction

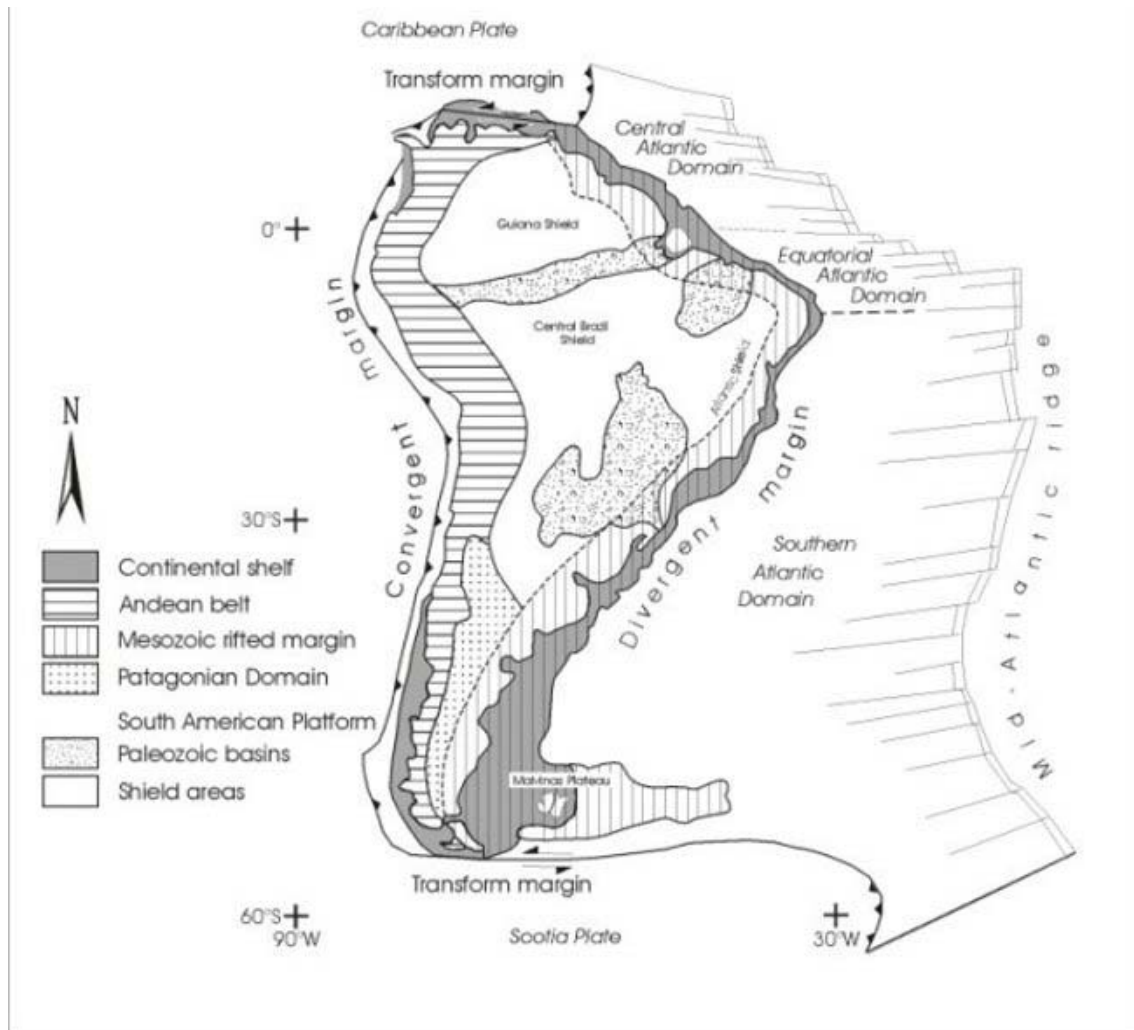


Figure 1: Major tectono-sedimentary provinces of the South American Plate, *modified after Milani and Thomaz Filho (2000)*

The South American Platform is mainly composed of metamorphic and igneous complexes of Archean/Proterozoic age and makes up the continental interior of South America. The Platform consolidated during Late Proterozoic to Early Paleozoic times in the course of the Brasiliano/Pan-African orogenic cycle during which the amalgamation of different continents and micro continents with closure of several ocean basins led to the formation of the Supercontinent Gondwana. Archean and Proterozoic rocks are exposed in three major shield areas within the framework of Neoproterozoic fold belts (Guiana, Central Brazil and Atlantic shields; Fig. 1). The western continental margin of the South American Plate developed at least since Neoproterozoic to Early Paleozoic times and constitutes a convergent margin, along which eastward subduction of Pacific oceanic plates beneath the South American Plate takes place. Through this process the Andean Chain, the highest non-collisional mountain range in the world, developed. The eastern margin of the South American Plate forms a more than 10 000 km long divergent margin, which developed as a result of the separation of the South American

plate and the African plate since the Mesozoic through the opening of the South Atlantic and the break up of Gondwana. The northern and southern margins of the South American Plate developed along transform faults in transcurrent tectonic regimes due to the collision of the South American Plate with the Caribbean and the Scotia plates (Fig. 1). The South American Plate reveals a long and complex geologic history, which will be reviewed in the following.

2. Cratonic Regions

2.1. The Amazonian Craton

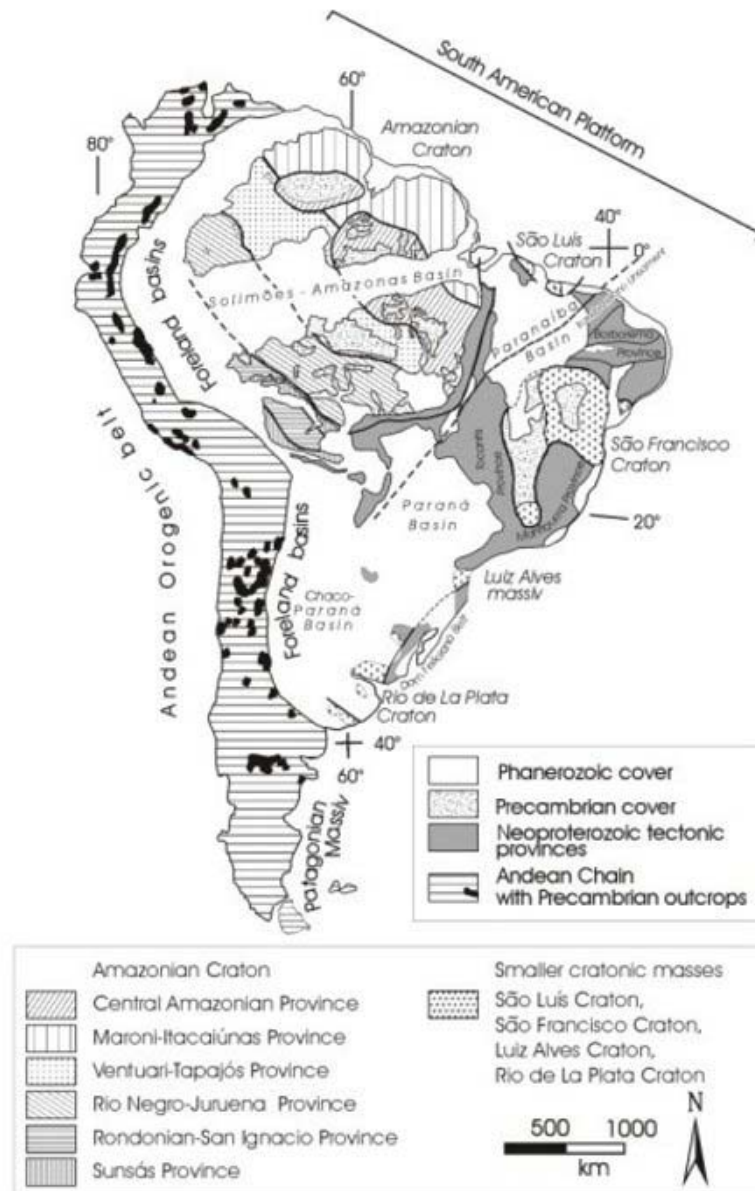


Figure 2: Geotectonic provinces of South America and the principal geologic units of the Amazonian Craton, *modified after Cordani et al. (2000)*

The Amazonian Craton, situated in the northern part of South America, is one of the largest cratonic areas of the world (about 430 000 km², Fig. 2). It includes parts of Brazil, French Guiana, Guyana Suriname, Venezuela, Colombia and Bolivia. To the west the craton is overlain by the Subandean basins and in the east and south it is flanked by Neoproterozoic orogenic belts (the Paraguay and Araguaia fold belts in Brazil and the Tucavaca Belt in Bolivia). The Paleozoic Solimões-Amazonas basin divides the Amazonian Craton into two Precambrian shields (the Guaporé Shield to the north and the Guiana shield to the south) which have been relatively stable since 1.0 Ga. Because of rich vegetation the geology of most parts of the Amazonian Craton is poorly known. Exceptions are some areas in the southwestern region of the craton like the Serra dos Carajás (which hosts important mineral deposits) and part of French Guiana where some comprehensive geological studies were carried out.

The Amazonian Craton can be divided into six major geochronological provinces (Fig. 2). **The Central Amazonian Province** (> 2.3 Ga) is composed of high grade terranes, granite-greenstone belt sequences, granitoids, ultramafic intrusions, gneiss, amphibolite, metavolcano-sedimentary sequences and mafic dykes and contains the oldest continental crust of the craton, which was not affected by the Transamazonian Orogeny during 2.2 -1.9 Ga (the Carajás-Iricoumé block and the Roraima block). Important mineral deposits like iron, copper, gold, manganese and nickel are found in the Carajás area. In the border zone of the stable Archean nucleus different Paleoproterozoic and Mesoproterozoic provinces developed. The **Maroni-Itacaiúnas Province** (2.25 – 1.95 Ga) to the east and north of the Central Amazonian Province consists mainly of metasedimentary and metavolcanic units associated with Paleoproterozoic granite-greenstone terranes (greenschist to amphibolite facies) as well as granulite facies rocks, gneiss-migmatite terranes and granitoid plutons. The **Ventuari-Tapajós Province** (1.95 – 1.8 Ga) to the west is mainly composed of calc-alkaline granitoids (e.g. Rapakivi granites), to a lesser content of calc-alkaline and alkaline acid to intermediate volcanic rocks and mafic dykes as well as a sedimentary platform cover. The **Rio Negro-Juruena Province** (1.8-1.55 Ga) includes volcano sedimentary sequences, felsic plutonic-gneiss and granitoids. Rift basins within the province are filled with continental platform molasse and marine sediments of Mesoproterozoic, Paleozoic and Mesozoic age. The **Rondonian-San Ignacio Province** (1.55-1.30 Ga) is composed of granite-migmatite terranes and granulitic rocks which contain scattered Paleoproterozoic granulitic inliers. Additionally metavolcano-sedimentary sequences, postorogenic and anorogenic intrusive rocks and sedimentary sequences associated with alkaline basalt flows are exposed. The youngest tectonic unit of the Amazonian Craton is the **Sunsás Province** (1.25-1.0 Ga) which consists of metavolcano-sedimentary sequences and granitoids and includes older terranes reworked between 1.3 and 1.0 Ga (Tassinari et al., 2000). Significant younger metamorphic and magmatic overprinting affected the Western Amazonian Craton on a much larger scale than the eastern part.

After Tassinari et al. (2000) the Archean protocraton was probably composed of independent micro continents (the Carajás-Iricoumé Block, the Roraima Block, the Imataca Block and the West Congo Cratonic Block in Africa). During amalgamation of the individual blocks between 2.2 and 1.95 Ga the Paleoproterozoic orogenic belts developed. Between 1.95 and 1.45 Ga accretion of juvenile Paleo-Mesoproterozoic continental crust took place on the western margin of the continent through the

development of different magmatic arcs (Ventuari-Tapajós, Rio Negro-Juruena and part of the Rondonian-San Ignacio Province). These arcs could be the result of subduction of oceanic lithosphere in the course of the collision of the Central Amazonian and Maroni-Itacaiúnas provinces against another continental mass. After Sadowski and Bettencourt (1996) the orogenic evolution of the Rondonian-San Ignacio and Sunsas provinces took place between 1.4 and 1.0 Ga due to continental collision between the Amazonian Craton and Laurentia.

2.2. The São Francisco Craton

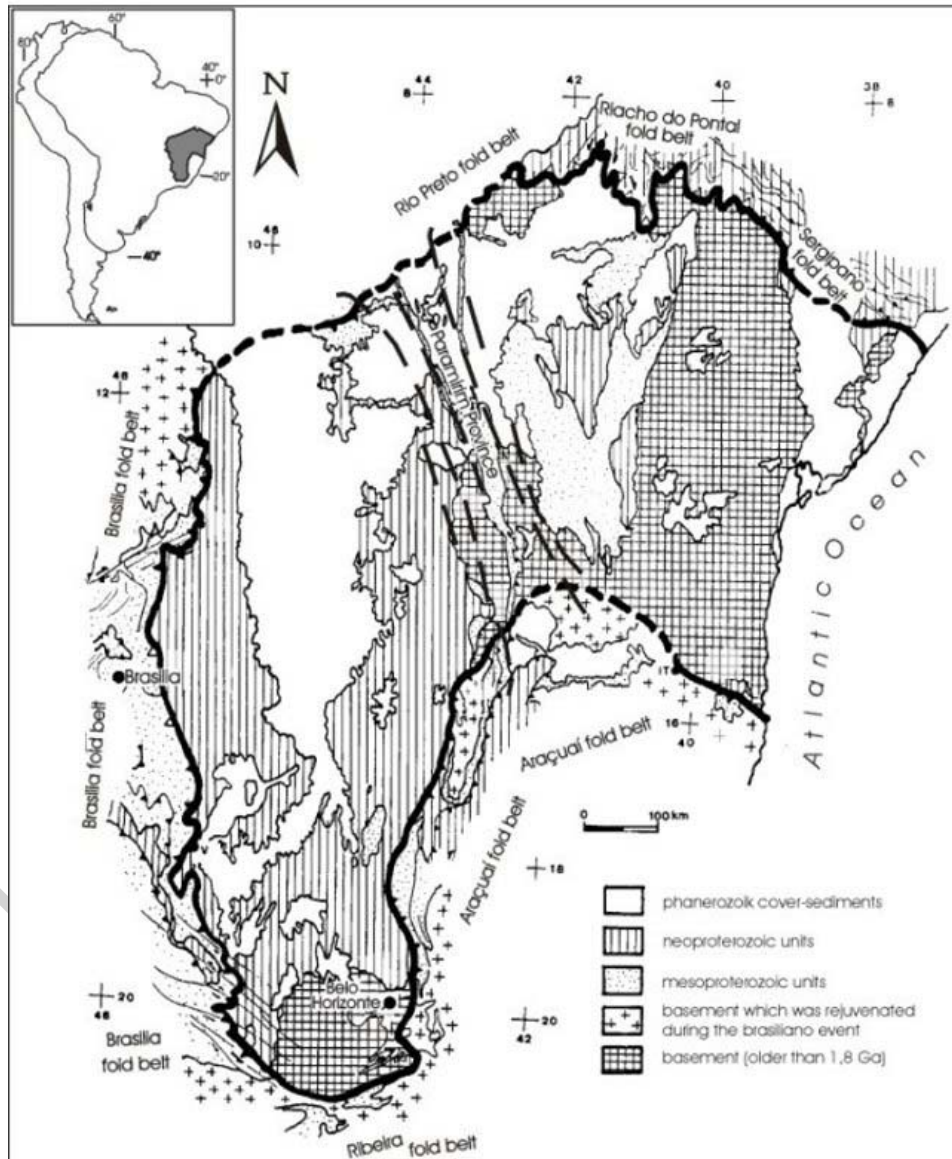


Figure 3: Principal geologic units of the São Francisco Craton, *modified after Alkmim et al. (1993)*

The São Francisco Craton is situated in the central-eastern part of Brazil (Bahia state and Minas Gerais state; Fig. 3) and represents one of the major shield areas in South

America. It is completely surrounded by Brasiliano/Panafrican fold belts. Archean and Paleoproterozoic basement is exposed in the N and NE (State of Bahia) as well as in the southern part of the craton (Minas Gerais state). In the central part of the craton additional Archean and Paleoproterozoic basement exposures occur, but these were tectonically reworked between 1.8 and 1.2 Ga. During this period an N-S elongated rift-thrust belt with grabens and basins developed, in which the Espinhaço Supergroup (Paleo to Mesoproterozoic) was deposited. Along a NNW-SSE axis of the craton the Paramirim polyphase province is distinguished (about 1.75 Ga; Cordani et al., 1992). The gneissic rocks and supracrustal sequences of the province were reworked and isotopically reset during the Brasiliano cycle. Large areas of the São Francisco Craton crystalline basement is partially covered by Neoproterozoic (Bambuí Group) and Phanerozoic sediments. The São Francisco Craton constitutes the northwestern extension of the Congo-Zaire Craton in Central Africa.

Archean and Paleoproterozoic basement

In the northern portion two stable Archean blocks are preserved: The Gavião Block and the Jequié Block, which constitute two different continental fragments that consolidated during the Transamazonian Orogeny. The **Gavião Block** represents the oldest well dated Archean crust of South America and consists of Early Archean TTG suites and greenstone belts evolved between 3.4 and 3.0 Ga. The **Jequié Block** consists mainly of 2.9-2.6 Ga old calc-alkaline charnockitic and enderbitic suites with subordinated tholeiitic volcanic rocks and chemical sediments. These two blocks are interpreted by Teixeira et al. (2000) as two independent proto-continentals during the Late Archean. During the Transamazonian orogenic collision (2.14-1.94 Ga) diachronic accretion of Archean and Paleoproterozoic terranes took place. The Contendas-Jacobina Lineament represents the major suture along which the subduction of the Gavião Block beneath the Jequié Block occurred. Another continental segment is the **Serrinha Block**, which probably represents an exotic continental segment extensively reworked during Paleoproterozoic. It consists of amphibolite facies orthogneiss and migmatite and constitutes the basement of the **Rio Itapicuru granite-greenstone belt**. During the Transamazonian collision different magmatic belts in-between the Archean blocks developed, like the **Salvador-Curaçá Belt**, the **Itabuna-Atlantic belt**, the **Contendas-Mirante Belt** and the **Jacobina-Mundo Novo Belt**. To the west of the Gavião Block the **Guanambi-Urandi Batholith**, consisting of monzonite, syenite and granite intrusions (2.06-2.0 Ga) is exposed. It is partly covered by Neoproterozoic sediments of the Bambuí Group (Teixeira et al, 2000).

The Archean terranes in the southern part of the craton are mainly composed of gneissic partly migmatized rocks, subordinated relicts of low-grade supracrustal rocks, greenstone belts, as well as granitoid plutons and mafic and mafic-ultramafic intrusions. The Archean and Paleoproterozoic basement can be subdivided after Teixeira et al., (1996) into three main metamorphic complexes: the **Belo Horizonte Complex**, the **Bonfim Complex** (containing the Quadrilátero Ferrífero, a granite-greenstone terrane which includes the Archean Rio das Velhas Greenstone Belt. The greenstone belt is overlain by the Proterozoic Minas Supergroup which hosts a thick Lake Superior-Type banded iron formation) and the **Campo Belo Complex**. The relationship of the different complexes is still under discussion; the limits are not well defined due to the polyphase

deformation and metamorphic overprint. The Archean complexes show a polyphase Archean evolution, with major events during 2860-2700 Ma, including reworking of established sialic crust with components up to 3380 Ma old. Late granites were injected between 2700-2600 Ma with subsequent stabilization of the Archean Crust (Teixeira et al., 1996). During the Transamazonian Orogeny (about 2.16-2.0 Ga) the **Mineiro Belt** developed at the margin of the Archean platform. It represents an arc-shaped collisional belt composed of granitoids and flysch deposits, as well as mafic dykes. Larger areas of the former Archean Platform are covered by Paleo to Mesoproterozoic sediments (Minas Supergroup) or are reworked and tied up in the Brasiliano framework surrounding the craton.

Cover Sequences

The Paleo-Meso Proterozoic **Espinhaço Supergroup** is a volcano sedimentary sequence intruded by granitic rocks, and is exposed in the Serra do Cabral, in the aulacogen of Espinhaço-Paramirim and in the Chapada Diamantina, in the State of Bahia. During the Espinhaço cycle (about 1.8-1.2 Ga) a North-South trending intracratonic rift-thrust belt with elongated grabens and basins evolved, which became the site of deposits of the Espinhaço Supergroup. The volcano-sedimentary sequence includes the Chapada Diamantina Group which hosts important diamond deposits. The **BambuÍ group** (or São Francisco Supergroup) is a widespread Neoproterozoic platform cover (pelitic and carbonate sediments), which was deposited during the latest events of the Brasiliano cycle. It covers the western portion of the craton, as well as parts of the Brasília, Sergipano and Araçuaí fold belts, and is partly affected by the tectonic movements of the Brasiliano cycle.

2.3. The São Luís Craton

The São Luís Craton is located at the central northern border of the South American Platform (Fig. 4) and is considered as a small fragment of the West Africa Craton.

Due to deep weathering and poor exposures little work has yet been done on the small cratonic fragment. Additionally the cratonic area is extensively covered by sediments of the Paleozoic Parnaíba Basin, as well as by sediments of smaller meso-cenozoic basins. The basement is exposed in small massifs and consists of tonalite and trondhjemite with emplacement ages between 2.2-2.1 Ga (Sadowski, 2000) as well as greenstone inliers intruded by late K-granite.

After Brito Neves & Cordani (1991) the fragment remained attached to South America when Africa and South America separated and the Equatorial Atlantic basin was formed during Mesoproterozoic times. The cratonic fragment can be correlated with the Liberian and Eburnean provinces (2.2-2.0 Ga) of the West Africa Craton. During Neoproterozoic times the Gurupi Mobile Belt developed at the south-western border of the São Luís Craton, which can most probably be correlated with the rock sequences of the Rokelides and Pharosides formations in West Africa (Sadowski, 2000).

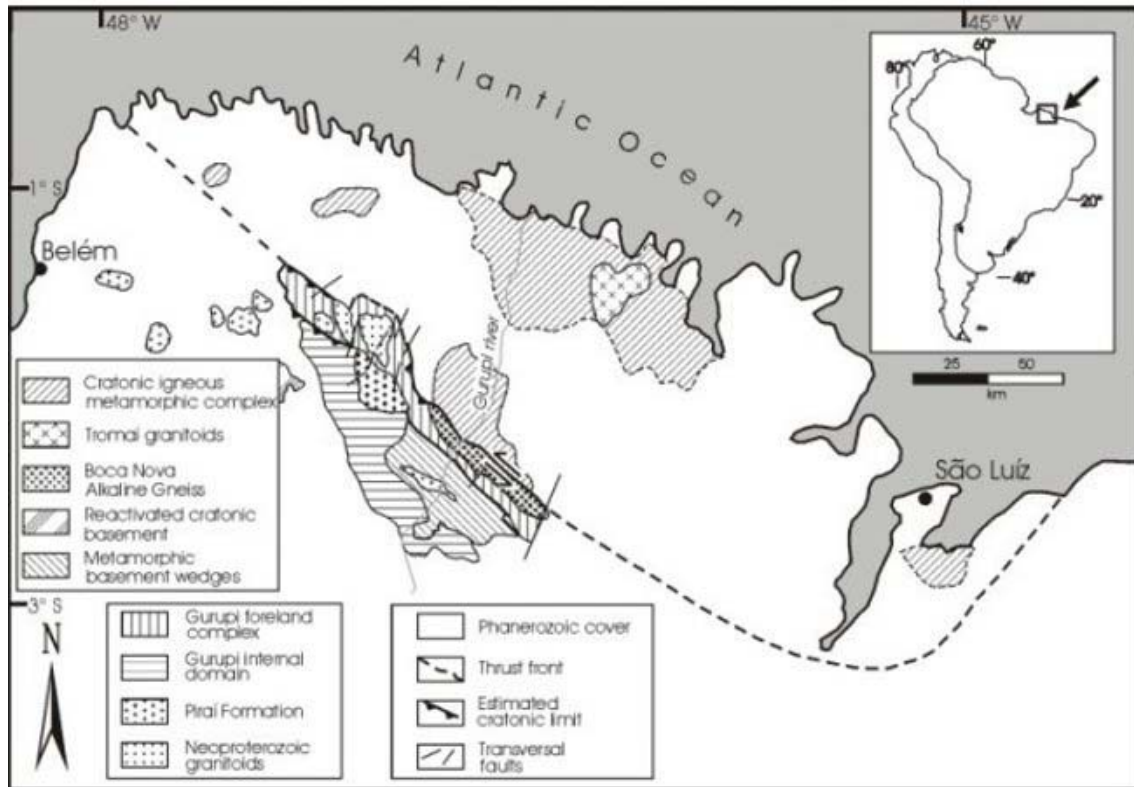


Figure 4: Geologic outline of the São Luís Craton and the Gurupi Fold Belt, *modified after Sadowski (2000)*

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Biographical Sketch

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