World Geomorphological Landscapes

Bianca Carvalho Vieira
André Augusto Rodrigues Salgado
Leonardo José Cordeiro Santos *Editors*

Landscapes and Landforms of Brazil

Springer

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Series Editor Preface

Landforms and landscapes vary enormously across the Earth, from high mountains to endless plains. At a smaller scale, nature often surprises us creating shapes which look improbable. Many physical landscapes are so immensely beautiful that they received the highest possible recognition—they hold the status of World Heritage properties. Apart from often being immensely scenic, landscapes tell stories that not uncommonly can be traced back in time for tens of millions of years and include unique events. In addition, many landscapes owe their appearance and harmony not solely to the natural forces. For centuries, and even millennia, they have been shaped by humans who have modified hillslopes, river courses, and coastlines, and erected structures which often blend with the natural landforms to form inseparable entities.

These landscapes are studied by geomorphology—'the science of scenery'—a part of Earth Sciences that focuses on landforms, their assemblages, surface, and subsurface processes that molded them in the past and that change them today. To show the importance of geomorphology in understanding the landscape, and to present the beauty and diversity of the geomorphological sceneries across the world, we have launched a book series *World Geomorphological Landscapes*. It aims to be a scientific library of monographs that present and explain physical landscapes, focusing on both representative and uniquely spectacular examples. Each book will contain details on geomorphology of a particular country or a geographically coherent region. This volume presents the geomorphology of Brazil, a big country with a multitude of spectacular landscapes, from the very well known—such as the steep-sided domes of Rio de Janeiro, Iguazu Falls, or majestic rivers of the Amazonian Lowland—to many hidden gems scattered across the Brazilian Shield. For such a vast and varied territory to make a selection of case studies must have been an arduous task, so inevitably they present only a small fraction of what Brazil has to offer in terms of geomorphological sceneries to enjoy. To discover and learn more, go to Brazil! This would be an unforgettable geomorphological experience.

The World Geomorphological Landscapes series is produced under the scientific patronage of the International Association of Geomorphologists (IAG)—a society that brings together geomorphologists from all over the world. The IAG was established in 1989 and is an independent scientific association affiliated with the International Geographical Union (IGU) and the International Union of Geological Sciences (IUGS). Among its main aims are to promote geomorphology and to foster dissemination of geomorphological knowledge. I believe that this lavishly illustrated series, which sticks to the scientific rigor, is the most appropriate means to fulfill these aims and to serve the geoscientific community. To this end, my great thanks go to the editors of this volume—Prof. Bianca Carvalho Vieira as the senior editor, and Profs. André Augusto Rodrigues Salgado and Leonardo José Cordeiro Santos as co-editors. They embarked on a massive and time-consuming task to select the sites to cover, to invite a large group of contributors and to guide them through the writing and reviewing

process. I am sure they see this final result as rewarding. Brazil did not have a book about its geomorphological richness in English before, now this impressive natural legacy can be enjoyed by the global geomorphological community. I also express my gratitude to all chapter authors who have shared their passion and expert knowledge with us. *Muito obrigado*!

Piotr Migoń

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Part I

Brazil: Long-term Natural Evolution of Environment

Brazil: A Land of Beautiful and Undiscovered Landscapes

1

Bianca Carvalho Vieira, André Augusto Rodrigues Salgado, and Leonardo José Cordeiro Santos

Abstract

At over 8.5 million square Km, Brazil is a country of continental dimensions. Brazil contains 27 states, including the Federal District, and is divided into five major regions: South, Southeast, Northeast, Central-West, and North. It is important to note that this country has diverse, unfamiliar landscapes. For example, the Central-West Region of Brazil was the least-known region of the world until the early 1940s and did not have towns or villages. Given the size of the Brazilian territory and the insufficiency of geomorphological and cartographic studies on an appropriate scale for analysis, as previously noted by the Brazilian Professor Aziz Ab'Saber, there are several landscapes that have never been studied and others that remain unknown to Brazilian geomorphology. For this volume, considering the aspects mentioned, specific criteria were used to choose 32 geomorphological landscapes, including the landscape's scenic beauty and the availability of results of more systematic research on its evolution, particularly its geological, climatic, and geomorphological aspects that could effectively explain its forms, processes, and dynamics.

Keywords

Continental dimensions • Several geomorphological landscapes • Undiscovery landscapes

At over 8.5 million km^2, Brazil is a country of continental dimensions. Brazil contains 27 states, including the Federal District, and is divided into five major regions: south, southeast, northeast, central-west, and north (Fig. 1.1).

The southern region, approximately 576,000 km^2, includes the states of Rio Grande do Sul, Santa Catarina, and Paraná (Fig. 1.1). This region has a subtropical climate and consists of a series of mountain ranges and plateaus primarily covered by tropical and subtropical forests (predominantly pines) and fields. The population is predominantly of European origin and mainly composed of descendants of Italian and German immigrants, among others, who immigrated in large numbers from the nineteenth to mid-twentieth century.

The southeast region (comprising the states of São Paulo, Minas Gerais, Rio de Janeiro, and Espírito Santo), approximately 924,000 km^2, is located predominantly in the humid tropical zone, and contains a series of plateaus and mountains with a portion of the most uneven relief in the Brazilian territory. The vegetation ranges from humid tropical forest to rupestrian fields on the tops of mountains, passing through areas of savanna (Cerrado) and scrublands (caatinga) in the more western and northern territories. The climate tends to be tropical, semi-humid, and even semiarid in the north. This region is the most populous and industrialized and has the largest economy in Brazil. The population derives from many backgrounds, including Portuguese immigrants, the

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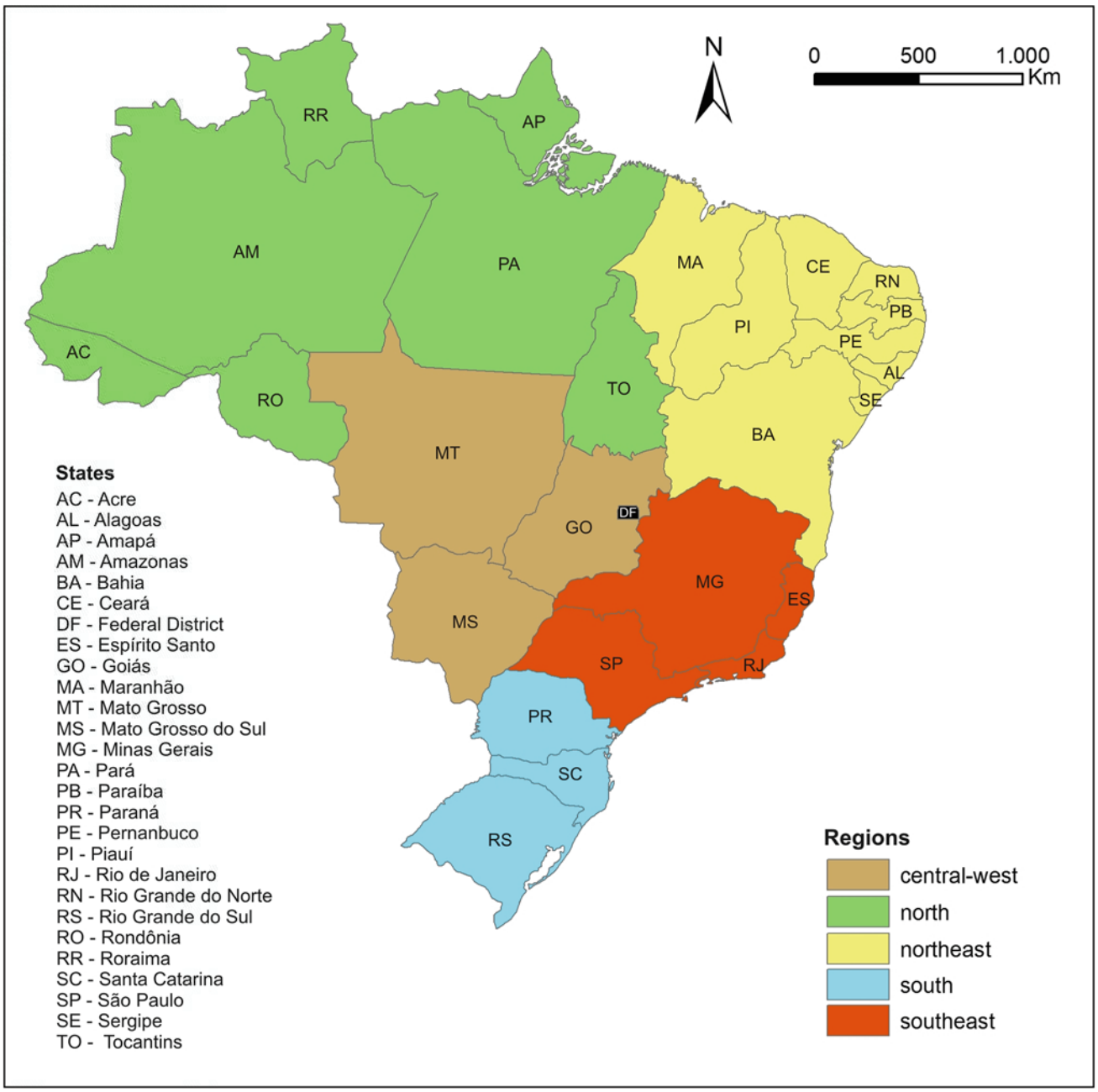

Fig. 1.1 Administrative division of Brazil. *Draw* by Breno Marent

descendants of miscegenation between the Portuguese and local Amerindians, African-descended individuals, the descendants of immigrants from other regions in Europe (mainly Italians, Germans, and Spaniards), Asian-descended individuals (particularly Japanese), and immigrants from other regions of Brazil, mainly the northeast region. The three largest cities of Brazil are located in the southeast region: São Paulo, Rio de Janeiro, and Belo Horizonte.

The northeast region, approximately 1.554 million km^2, comprises the states of Bahia, Sergipe, Alagoas, Pernambuco, Paraíba, Rio Grande do Norte, Ceará, Piauí, and Maranhão (Fig. 1.1). The coastline is typically humid tropical, whereas the inland is subjected to semiarid climatic conditions. Whereas there are many mountains and plateaus in the inland, the relief mainly consists of topographically lower plateaus and flattened or more even surfaces. On the coast and close to the northern region, the natural vegetation is marked by tropical forest. However, scrub predominates in the inner region because of the semiarid climate. Regarding its historical occupation, this region was the first to be

colonized by the Portuguese in the sixteenth century and received many slaves trafficked from Africa. Thus, this region has strong traditional and cultural aspects that are tied to ancient interactions between the Portuguese, Amerindians, and Africans.

The central-west region is the second largest in the country, approximately 1.606 million km^2, and comprises the states of Goiás, Mato Grosso, Mato Grosso do Sul , and the Federal District (Fig. 1.1). This region has a predominantly semi-humid tropical climate. The central-west relief consists mainly of plateaus, tablelands, and gently rolling or flattened plains, where savanna vegetation mainly occurs. This region has the smallest population among the five regions, mainly because of its most recent occupation, which only developed after the construction and inauguration of Brasilia—the capital of Brazil—in 1960. Currently, despite receiving immigrants from all regions of Brazil, the central-west region has been most heavily colonized by farmers from the southern region.

The northern region, approximately 4 million km^2, comprises the states of Acre, Rondônia, Roraima, Amazonas, Amapá, Pará and Tocantins (Fig. 1.1). The northern region is the Amazon region of Brazil where, although exceptions occur, it has a super-humid tropical climate and a relief composed mainly of plains and lowered plateaus covered by tropical rain forest (the Amazon rain forest). This region has a larger population than the central-west region; however, because it includes a large area of the Brazilian territory (approximately 45 %), it is the least populated (the lowest population density). Indigenous people and their descendants are common in this region.

After presenting the general characteristics of Brazil, it is important to note that this country has diverse, unfamiliar landscapes. For example, the central-west region of Brazil was the least known region of the world until the early 1940s and did not have towns or villages. The Amerindians of this region, mainly the Xavante people, were considered fearsome. Waterways, such as the Araguaia and Tocantins (both among the 50 largest in the world), did not have their sources recognized. Major mountain ranges, plateaus, and other river systems also remained completely unmapped. Much of this territory had not been flown over, and information regarding the northern region, particularly the Amazon, was also unknown. Currently, this situation has changed with the incorporation of these areas into the Brazilian nation. However, the "Geography of the Brazilian territory" has been generally explored, many places remain unknown to Brazilians themselves, particularly in the north and central-west regions.

Given the size of the Brazilian territory and the insufficiency of geomorphological and cartographic studies on an appropriate scale for analysis, as previously noted by the Brazilian Professor Aziz Ab'Saber, there are several landscapes that have never been studied and others that remain unknown to Brazilian geomorphology. The characteristics of the Brazilian territory continue to influence the current disproportion of studies regarding the extent and depth of the treatment of information.

Thus, although Brazil has many significant beautiful landscapes in the north and central-west, these regions are not extensively covered in the second part of this book because of the absence of more systematic and scientific studies that may, more broadly, be informative regarding their evolution.

For this volume, considering the aspects mentioned, specific criteria were used to choose 32 geomorphological landscapes, including the landscape's scenic beauty and the availability of results of more systematic research on its evolution, particularly its geological, climatic, and geomorphological aspects that could effectively explain its forms, processes, and dynamics. The inevitable consequence of the use of these criteria is that most Brazilian landscapes presented in this book are concentrated in the south, southeast, and northeast regions. Moreover, considering the two geotectonic mega-compartments into which the Brazilian territory can be divided, the northern and central-west regions belong to a less active compartment with a more uniform and less diversified relief. In addition to having a greater altimetry and diversity of landscapes, the other regions have an older historical occupation and the highest population densities in Brazil.

Thus, the purpose of this book is not to present the different geomorphological processes responsible for the genesis and evolution of the Brazilian relief or to address environmental problems, which are characterized in Brazilian geography and geomorphology within the general systems theory framework. For this book, we attempted to select landscapes with considerable scenic values that illustrate an important portion of the geomorphological units previously mapped by several authors, thus enabling the correlation between the genesis of these units and the climatic and morphotectonic influences in their formation and colonization processes.

Therefore, "The Landscapes and Landforms of Brazil" contains two sections that explain the broader formation of the territory and its geomorphological complexity. The first section consists of three chapters to describe its geological evolution, particularly in the context of South America (*Geological Background: a Tectonic Panorama of Brazil*), its main geomorphological aspects (*Long-Term Geomorphological Evolution of the Brazilian Territory*), and some climactic characteristics from the past and present (*Climates of Brazil: Past and Present*).

The second section features 32 landscapes (Fig. 1.2) divided by region. To better understand the distribution of these forms of relief, this book was divided into 5 "large sets of landscapes."

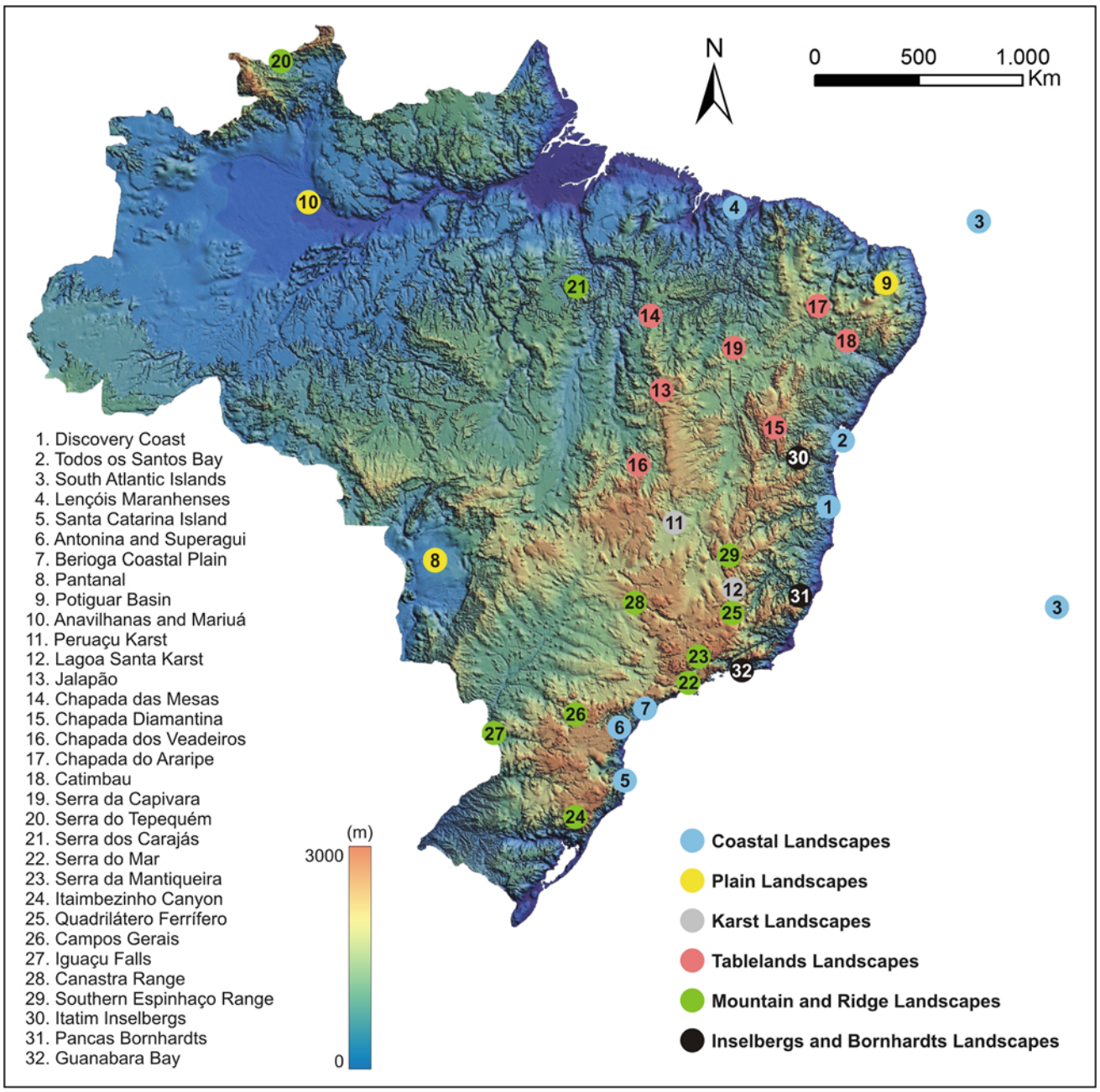

Fig. 1.2 The geomorphological landscapes presented in this book. *Draw* by Breno Marent and adapted from a DEM from JBL Françolin

The initial five chapters describe the main coastal plains and islands of Brazil that initially attracted and were described by colonists (Discovery Coast, Todos os Santos Bay, Fernando de Noronha and Trindade, Lençóis Maranhenses, Santa Catarina Island, and the Bays of Antonia and Superagui, Bertioga). The plains are then described (Pantanal, Potiguar Basin, Anavilhanas and Mariuá). The typical karst landscapes appear in the third section (Peruaçu and Lagoa Santa). The tabular forms and large plateaus are presented next and represent lush landscapes that occupy large areas throughout the Brazilian territory (Jalapão, Chapada das Mesas, Chapada Diamantina, Chapada dos Veadeiros, Araripe, Catimbau, and Serra da Capivara). The Brazilian mountains and plateaus are also discussed in this book and present a striking geomorphologic configuration from the geological structures and climatic aspects (Tepequém, Carajás, Serra do Mar, Serra da Mantiqueira, Itaimbezinho, Quadrilátero Ferrífero, Campos Gerais, Iguaçú

Falls, Canastra Range, and Serra do Espinhaço). Spectacular landscapes formed by inselbergs and bornhardts are presented at the end (Itatim, Pancas and Guanabara Bay).

Thus, although this book was never intended to present all of the Brazilian landscapes of geomorphological interest, we hope that the reader acquires a good understanding of these regions, which exemplify the diversity and beauty of the landscapes and shapes of Brazil. Furthermore, we believe that this book may contribute effectively to the research and teaching of Brazilian geomorphology. We, the editors, thank those who helped build Brazilian geomorphology because without them, it would be impossible to advance the hypotheses and theories launched at the beginning of its organization and, in some manner, formed the basis of our current geomorphological knowledge.

Geological Background: A Tectonic Panorama of Brazil

2

Fernando Flecha de Alkmim

Abstract

The landforms and landscapes discussed in this book developed in a variety of terrains, which together express the diversity of the geological background of the Brazilian territory. Located essentially in the old and relatively stable nucleus of the South American plate (known as the South American platform), Brazil comprises seven major categories of tectonic units, which are as follows: cratons, Brasiliano orogenic systems, Palaeozoic sag basins, equatorial margin basins, eastern margin basins, sub-Andean basins, and Tertiary rifts. The cratons together with the Brasiliano orogenic systems form the Precambrian basement of the continent. Exposures of these units comprise three distinct morphotectonic domains, namely the Guianas, central Brazil, and Atlantic shields. The four cratons delimited in Brazil represent stable lithospheric pieces that escaped the effects of the collisional processes responsible for the amalgamation of Gondwanaland, the large landmass from which South America and other southern continents derived. The Brasiliano orogenic systems form a network of collisional belts between the cratons, which were stitched together by the end of the Neoproterozoic Era. The Phanerozoic basins of Brazil record the long residence of South America in Gondwana and Pangaea, the breakup of the supercontinent during the Early Cretaceous, and subsequent processes. Large Palaeozoic sags cover a substantial portion of the Brazilian interior, whereas the eastern and equatorial margins host Cretaceous to Recent sedimentary successions. The tectonic units distinguished in the Brazilian territory have distinct expressions in the large-scale topographic relief. The lowlands are underlain by the cratons and covered by Palaeozoic sag basins. The highlands correspond to the Neoproterozoic orogenic systems, on which Phanerozoic structures such as arches, plateaus, and uplifts are superimposed.

Keywords

South American platform • Cratons • Brasiliano orogenic systems • Phanerozoic basins • Brazil

2.1 Introduction

From a geological Brasiliano orogenic systemsstandpoint, the geomorphological provinces focused in this book correspond to regional and local land surface expressions of rock assemblages and structures that characterize the various tectonic units exposed in the Brazilian territory. Together, these landscapes can be considered a manifestation of the Brazilian geodiversity.

Brazil is almost entirely located in the old and relatively stable nucleus of the South American plate known as the South American platform (Fig. 2.1). Defined as the portion of the continent that escaped the effects of the Andean orogenies (Almeida 1967; Almeida et al. 1981, 2000), the South American platform is underlain by Precambrian rocks and surrounded by the younger terrains of the continent,

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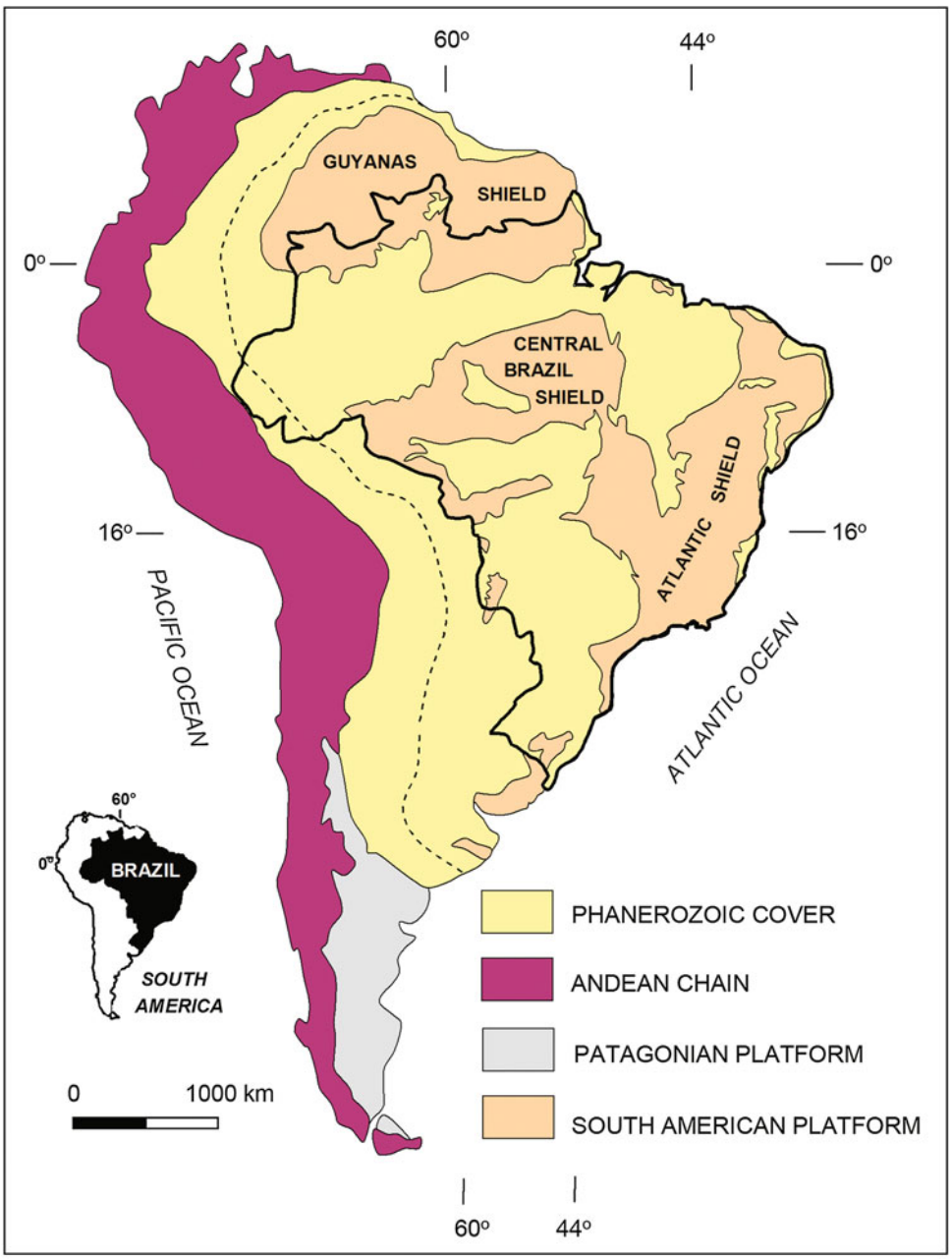

Fig. 2.1 Simplified tectonic map of South America, showing the South American platform and its shield areas (modified from Almeida et al. 1981)

represented by the Patagonian platform, the Andean chain, as well as the Pacific and Atlantic continental margin systems. Only a small portion of westernmost Brazil, the Acre basin (see next section), lies in the sub-Andean domain.

A substantial part of the South American platform is covered by Phanerozoic sedimentary successions. The areas of the platform, where the Precambrian basement is exposed, are collectively referred to as the Brazilian shield. Actually, the Brazilian shield comprises three distinct morphotectonic domains: the Guyanas, central Brazil (or Guaporé), and Atlantic shields (Fig. 2.1).

2.2 Tectonic Units of Brazil

In the Brazilian geological literature, each individual component of the South American platform and its Phanerozoic cover is traditionally portrayed as a structural province, defined as a geographically continuous domain, which differs from the adjacent terrains in terms of stratigraphy, tectonic evolution, metamorphic history, and age (Almeida et al. 1981; Bizzi et al. 2001). For simplicity, the building blocks of Brazilian geological framework are here

discriminated on the basis of their tectonic function and age. Accordingly, seven categories of tectonic units can be recognized in the Brazilian territory: (i) cratons, (ii) Brasiliano orogenic systems, (iii) Palaeozoic sag basins, (iv) equatorial margin basins and associated intracontinental rifts, (v) eastern margin basins and associated intracontinental rifts, (vi) sub-Andean basins, and (vii) Tertiary rifts (Fig. 2.2).

Cratons and Brasiliano orogenic systems, corresponding to two distinct lithospheric types, are the fundamental components of the Precambrian nucleus of South America. The Precambrian core of the continent was amalgamated as various plates converged and collided to form the large Gondwanaland by the end of the Neoproterozoic and beginning of the Palaeozoic Era (Brito Neves et al. 1999; Cordani and Sato 1999; Campos Neto 2000; Almeida et al. 2000; Alkmim et al. 2001). The cratons of the South American platform, defined as old and stable lithospheric pieces that were not affected by the Neoproterozoic collisional processes, correspond to the internal parts of the plates that converged during the assembly of West Gondwana, i.e., South America and Africa. The so-called Brasiliano/Pan-African orogenic systems, forming a network of collisional belts between the cratons, represent the margins of those plates, as well as micro-continents and magmatic arcs also involved in the amalgamation of West Gondwana (Campos Neto 2000; Almeida et al. 2000; Alkmim et al. 2001) (Fig. 2.3).

At the very end of the Palaeozoic, around 250 Ma, Gondwana joined Laurasia to form Pangaea. Pangaea remained as a supercontinent for ca. 120 Ma, until the end of the Jurassic Period, when it started to break apart, giving rise to present-day continents and oceans. The Palaeozoic, continental margin, sub-Andean, and Tertiary basins make up the Phanerozoic cover complex of the South American platform and its margins. These basins record the residence of the Precambrian nucleus of the continent in Gondwana and Pangaea, the break up history of the supercontinent, and tectonic events occurring after individualization of the South American plate. As a consequence of the dispersal of Pangaea and generation of the South Atlantic in the Lower Cretaceous, some cratons and Brasiliano/Pan-African orogenic systems split in two. Their counterparts are now exposed in the eastern Brazilian and western African shields (Porada 1989; Trompette 1994) (Fig. 2.3).

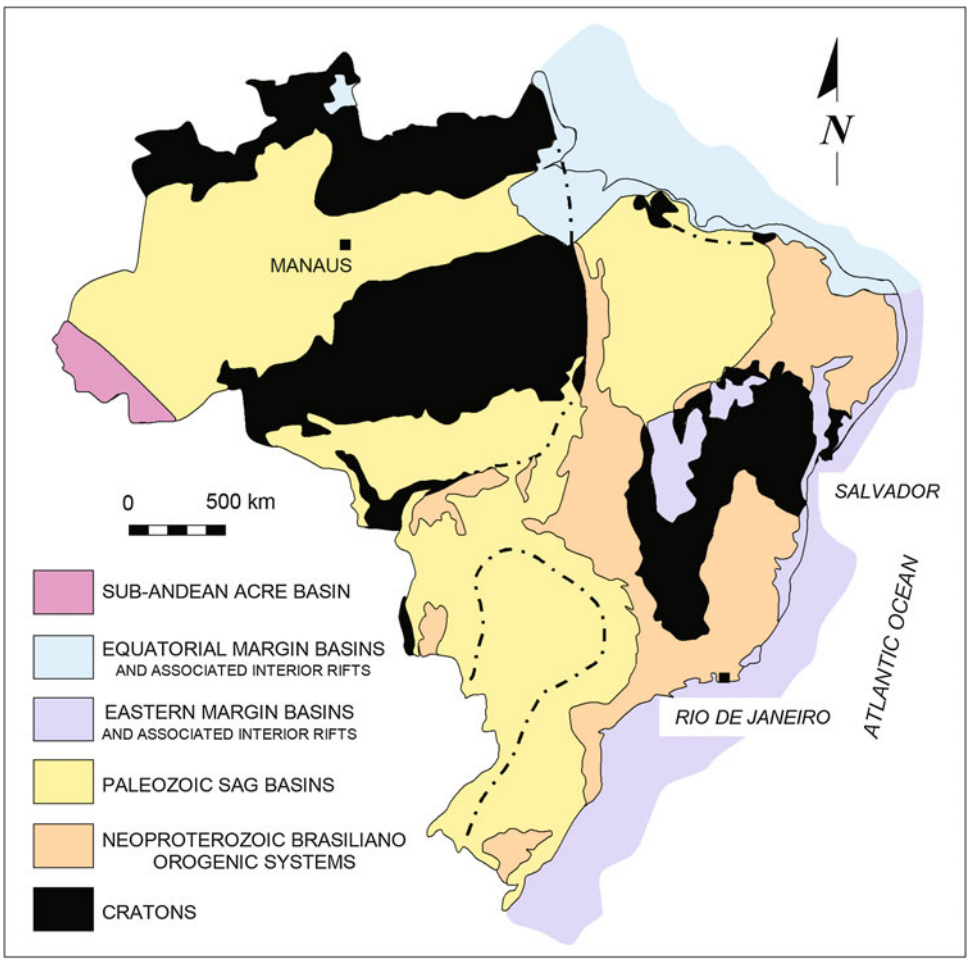

Fig. 2.2 Simplified tectonic map of Brazil, showing the distribution of the various categories of tectonic units

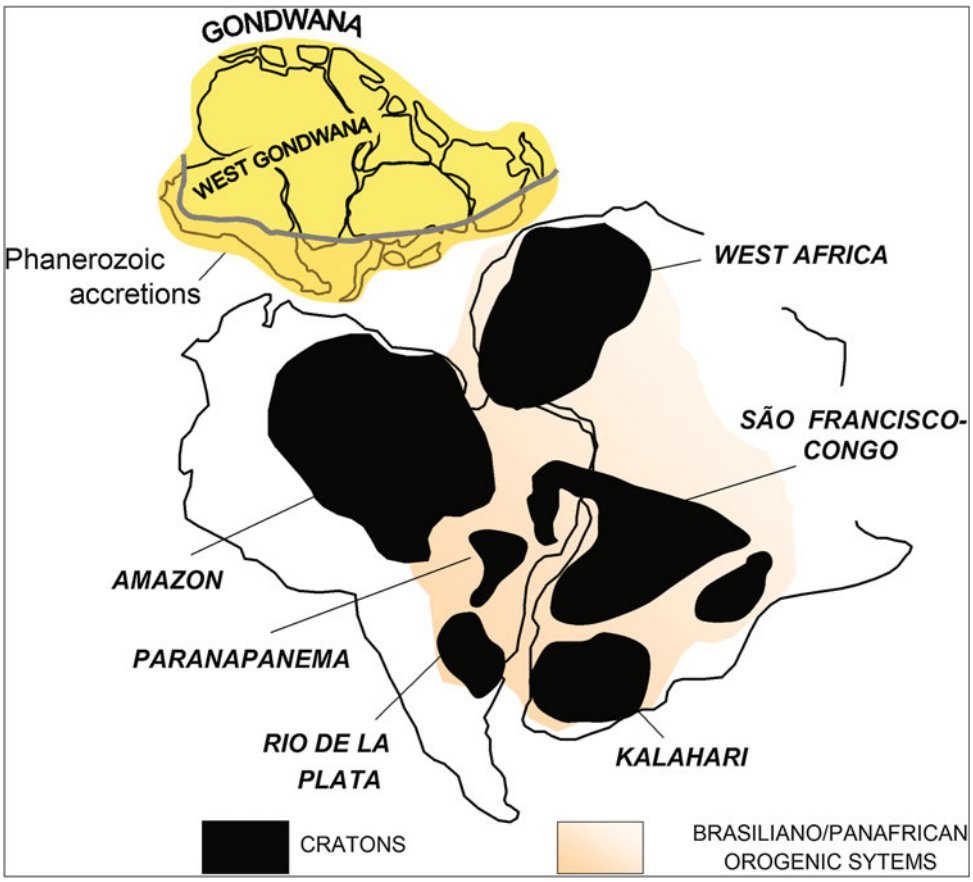

Fig. 2.3 Schematic map of West Gondwana, showing the cratons and Brasiliano/Pan-African orogenic systems (modified from Alkmim and Martins-Neto 2004)

2.2.1 Cratons

The South American platform contains four cratons (Almeida et al. 1981, 2000) (Fig. 2.4). The large Amazon[1] craton, extending far beyond the Brazilian borders, consists of an Archaean core—the so-called central Amazonian province—bounded by Palaeoproterozoic and Mesoproterozoic terranes, respectively, to the northeast and southwest (Tassinary et al. 2000; Santos et al. 2000; Santos 2003). The intracratonic Solimões and Amazon Basins cutting across the structural grain of the basement separate the Guyanas and central Brazil shield areas.

The São Francisco craton is the best exposed and one of the most intensively studied Precambrian terrains of South America. Located in eastern Brazil, it is made up of an Archaean and Palaeoproterozoic basement older than 1.8 Ga and a sedimentary cover that includes Proterozoic and Phanerozoic strata. Reconstructions of West Gondwana indicate that the São Francisco craton was connected to the Congo craton that underlies a vast segment of central West Africa (Almeida 1977; Alkmim 2004; Alkmim and Martins-Neto 2012) (Fig. 2.3).

The only exposure of the São Luis craton consists of a Palaeoproterozoic granite–greenstone terrain. Fringed to south by the Neoproterozoic Gurupi orogenic belt, the São Luis apparently represents a small fragment of the West African craton that remained in South America as the West Gondwana split apart (Trompette 1994; Brito Neves et al. 1999; Cordani et al. 1999; Campos Neto 2000; Almeida et al. 2000).

The existence of a cratonic mass beneath the large Paraná Basin in south Brazil (Fig. 2.4) has been inferred on the basis of geophysical studies. Previously portrayed as an extension of the Rio de la Plata craton partially exposed in Uruguay and northern Argentina, this piece of crust, called Paranapanema craton, is now interpreted a distinct crustal block (e.g., Almeida et al. 2000; Schobbenhaus and Brito Neves 2003).

2.2.2 Brasiliano Orogenic Systems

The Brasiliano Tocantins, Borborema, and Mantiqueira systems form a network of interfering orogens developed as the plates represented by the cratons of the platform were stitched together during the assembly of West Gondwana between 640 and 500 Ma, i.e., in the course of the Ediacaran and Cambrian periods of the Neoproterozoic and Palaeozoic eras, respectively (Brito Neves et al. 1999; Campos Neto 2000;

[1] Originally referred to as the Amazonian craton.

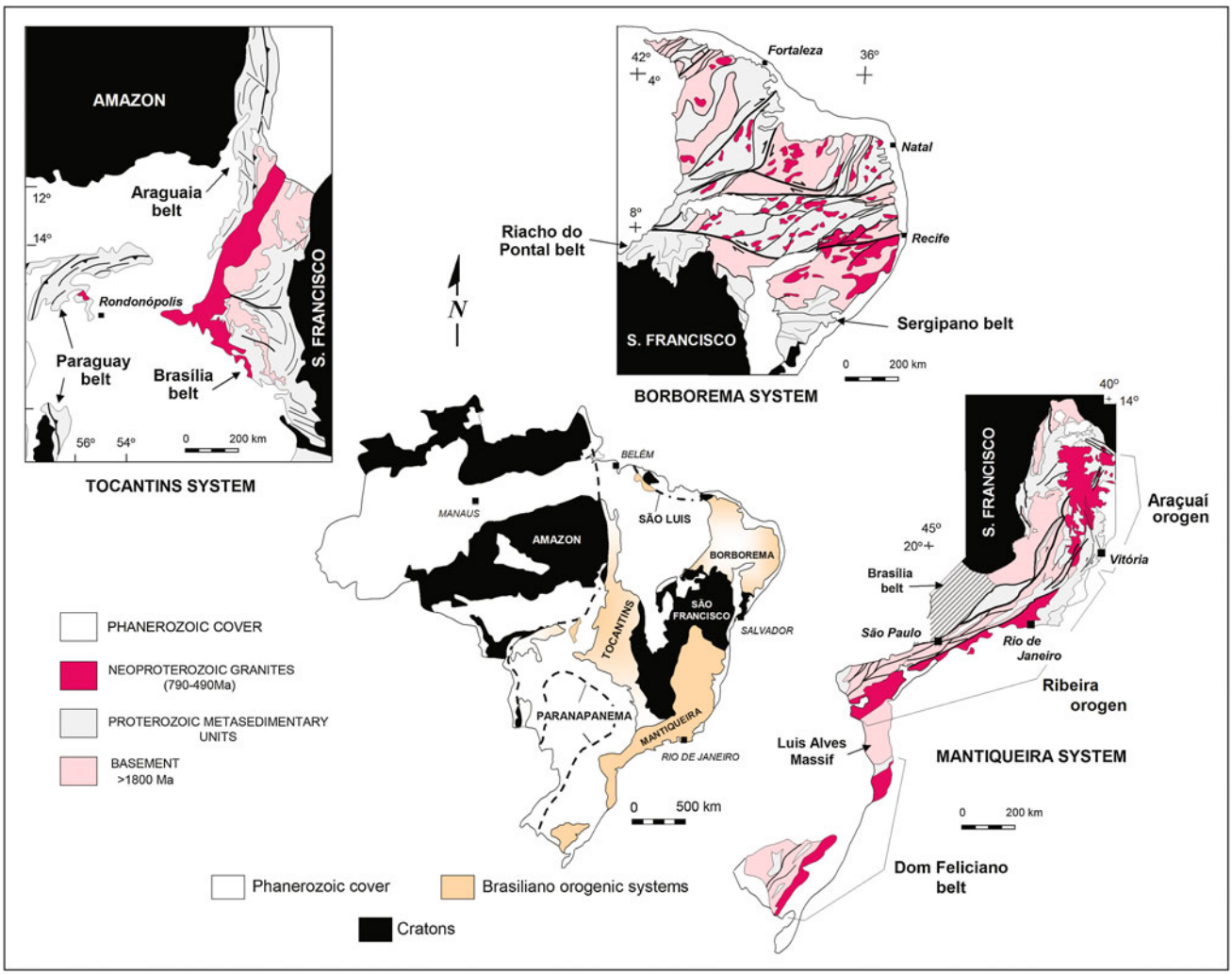

Fig. 2.4 Cratons and Brasiliano orogenic systems exposed in Brazil (detail maps based on Bizzi et al. 2001)

Almeida et al. 2000; Schobbenhaus and Brito Neves 2003) (Figs. 2.3 and 2.4). The Tocantins system in central Brazil encompasses the Araguaia and Paraguay belts developed along the margin of the Amazon craton, as well as the Brasília belt that fringes the São Francisco craton to west (Pimentel et al. 2000; Alvarenga et al. 2000; Dardenne et al. 2000) (Fig. 2.4). The diachronic collisions of the paleocontinents Paranapanema, São Francisco–Congo, and Amazonia, also involving a magmatic arc and a micro-continent (Pimentel et al. 2004; Valeriano et al. 2004), resulted in the consumption of the Goianides ocean (Brito Neves et al. 1999) and uplift of the Tocantins mountain system, The ca. 1,200-km-long and 150-km-wide Araguaia belt is made up of an Archaean and Palaeoproterozoic basement overlain by Neoproterozoic metasedimentary successions. N–S-trending faults and folds promoted tectonic transport of these units toward the Amazon craton (Alvarenga et al. 2000). Separated from the Araguaia belt by the Neoproterozoic Goiás magmatic arc and the Archaean Crixás-Goiás block, the Brasília belt corresponds to an up to 300-km-wide and 1,200-km-long orogenic zone, in which a Archaean/Palaeoproterozoic basement and Proterozoic metasedimentary successions younger than 1,800 Ma locally cut by granitic rocks are folded and thrust toward the São Francisco craton (Pimentel et al. 2004; Valeriano et al. 2004). As the youngest branch of the Tocantins system, the Paraguay belt describes a pronounced curve along the southeastern edge of the Amazon craton and involves a thick succession of Late Neoproterozoic sedimentary rocks (Alvarenga et al. 2000).

The Mantiqueira system straddles the southeastern coastal region of Brazil, forming a ca. 2,500-km long Neoproterozoic collisional domain composed of the Araçuaí orogen, the Ribeira orogen, and the Dom Feliciano belts, whose African counterparts are the West Congolian and the Kaoko belts (Fig. 2.4). Closure of the so-called Adamastor ocean that separated the paleocontinents Paranapanema and São

Francisco-Congo led to the generation of the Mantiqueira system (Brito Neves et al. 1999; Campos Neto 2000; Heilbron et al. 2004). The Araçuaí orogen corresponds to northern segment of the system. It consists of an external fold–thrust belt (also called Araçuaí belt) that curves along the eastern margin of the São Francisco craton, and an internal zone made up of high grade metamorphic and granitic rocks. In the external Araçuaí belt, the Archaean basement is covered by Proterozoic metasedimentary rocks which are intensively folded and thrust toward the São Francisco craton. The N–S-trending structures of the Araçuaí orogen bend toward NE and merge with the characteristic fabric elements of the Ribeira orogen around 21S latitude (Pedrosa-Soares and Wiedemann-Leonardos 2000; Pedrosa-Soares et al. 2001; Alkmim et al. 2006). The Ribeira orogen, partially dominated by a system of NE-trending dextral strike-slip shear zones, involves a Palaeoproterozoic basement, high grade Proterozoic metasedimentary units, the Neoproterozoic Rio Negro magmatic arc, and a considerable volume of granitic rocks (Trouw et al. 2000; Heilbron et al. 2004). The Luiz Alves gneiss massif separates the Ribeira orogen from the Dom Feliciano belt, which also consists of a Palaeoproterozoic basement, Meso- to Neoproterozoic sedimentary succession, and Neoproterozoic granitoids (Basei et al. 2000; Heilbron et al. 2004) (Fig.2.4).

Differently from all previously described Brasiliano orogenic zones, the Borborema in northeastern Brazil comprises a gigantic system of strike-slip shear zones, which apparently roots in the Tocantins system (Fig. 2.4). The fanlike array of dextral shear zones anastomoses around various basement massifs covered by Proterozoic metasedimentary units and intruded by a large volume of Neoproterozoic granites. The system also contains two fold–thrust belts, the Riacho do Pontal and Sergipano belts that bound the São Francisco craton to the north (Brito Neves et al. 2000)

2.2.3 Palaeozoic Sag Basins

Some regions of West Gondwana started to subside soon after its assembly, being converted into the initial depocenters of the large and long-lived Solimões, Amazonas, Parnaíba, Paraná, and Parecis intracontinental basins (Pedreira et al. 2003; Milani et al. 2007). The triggering mechanism of the initial subsidence of these basins between 470 and 450 Ma (Meso- to Neo-Ordovician) is still controversial, though evidence for precursor rifts has been documented in all of them (Tankard et al. 1998; Milani et al. 2007).

The Palaeozoic basins of Brazil share a series of common features. Their overall architectures are characterized by the uniform shallow dips of the infill strata toward the center and the presence of regional arches and highs. They all correspond to successor and polyhistoric depocenters, filled by major stratigraphic sequences bounded by regional unconformities of approximately the same age. Their fill units record important tectonic and climatic events affecting West Gondwana in the course of the Palaeozoic, such as major marine incursions during the Silurian, Devonian and Early Permian, the Silurian and Permo-Carboniferous glaciations (documented in the Solimões and Paraná Basins, respectively), as well as arid climatic conditions that predominated during Late Permian, Triassic, and end of the Jurassic. Besides this, the Amazonas and Paraná Basins also host thick Upper Jurassic and Eo-Cretaceous flood basalts and related intrusions, the magmatic event precursor of the West Gondwana breakup (Zalán 2004; Milani et al. 2007).

2.2.4 Equatorial, Eastern Margin, and Associated Intracontinental Rifts

The dispersal of West Gondwana in the Eo-Cretaceous, following the disaggregation of Pangaea, led to the opening of the Atlantic ocean and the generation of passive and transform margin basins along the borders of newly individualized South American and African continents.

The eastern continental margin of Brazil comprises a series of typical passive margin basins, whose development evolves from south to north with the formation of a complex system of interconnected rifts. The rift phase is recorded in these basins by a succession of Neocomian lacustrine sediments. The subsequent transitional phase is marked by the deposition of terrigenous sediments and carbonates during the Aptian, followed by the drift phase, which starts with the formation of a vast salt basin in the region that extends from the Santos to the Sergipe-Alagoas Basin and the equivalent area in the African margin (Fig. 2.5). The advanced stages of the drift phase are recorded by transgressive and regressive marine sequences of Neo-Cretaceous and Tertiary ages, respectively (Mohriak 2003; Zalán 2004; Milani et al. 2007).

The Brazilian equatorial margin evolved as a transform margin during the opening of the Atlantic. Consequently, significant differences in structural styles and nature of fill successions exist between the equatorial and eastern margin basins. Dextral strike-slip motions along E–W-trending fault zones punctuate the evolution of the equatorial margin basins from their onset in the Aptian to the full development stage in the Tertiary (Matos 2000; Mohriak 2003)

Considerable areas of the continental interior also experienced the effects of extensional tectonics that resulted in the generation of the Atlantic. Basement structures were reactivated, leading to the nucleation of intracontinental rifts such as the Tacutu, the Recôncavo-Jatobá-Tucano, and Potiguar onshore basins (Fig. 2.5).