# Geomorphological Units of Brazil: A Review in the Context of Brazilian Spatial Planning

**Jurandyr Luciano Sanches Ross, Marciel Lohmann, and Camila Cunico**

**Abstract** This paper aimed to elaborate a new division of Geomorphological Units of Brazil based on the division of Relief Units of IBGE (Mapa das Unidades de Relevo do Brasil. Brazilian Institute of Geography and Statistics, Rio de Janeiro, 1993) and on the Geomorphological Map of Brazil of Ross (Ecogeografia do Brasil: subsídios para planejamento ambiental. São Paulo, Oficina de Textos, 2006). The derived product at the scale of 1:5,000,000 was used in the research "Brazilian Territorial Planning: Natural Potentialities and Social Vulnerabilities, to characterize the physical-natural environment of Brazil, to identify the Natural Environmental Units, and finally, to integrate the analyzed variables in land units for the territorial planning of the mentioned geographic clipping. The technical procedures involved the georeferencing and digitalization of the Geomorphological Map of Ross (Ecogeografia do Brasil: subsídios para planejamento ambiental. São Paulo, Oficina de Textos, 2006) since it was in analogical format. The relief unit map of IBGE (Mapa das Unidades de Relevo do Brasil. Brazilian Institute of Geography and Statistics, Rio de Janeiro, 1993) was obtained from the official website of the institution, already in format compatible with Geographic Information System environment. In possession of the bases in digital format, a rereading of the maps was elaborated, resulting in a new proposal of geomorphological units for Brazil. The results provided the identification of a greater number of Geomorphological Units, especially those associated with sedimentary basins and orogenic belts.

J. L. S. Ross (✉)
University of São Paulo—FFLCH, São Paulo, Brazil
e-mail: juraross@usp.br

M. Lohmann
Department of Geosciences, Londrina State University, Londrina, Brazil
e-mail: marciel@uel.br

C. Cunico
Department of Geosciences, Federal University of Paraíba, João Pessoa, Brazil

© The Author(s), under exclusive license to Springer Nature Switzerland AG 2022

G. Barbosa dos Santos et al. (eds.), *Geomorphology of Brazil: Complexity, Interscale and Landscape*, Springer Proceedings in Earth and Environmental Sciences,
https://doi.org/10.1007/978-3-031-05178-4_2

# 1 Introduction

The Brazilian relief results from morphogenetic processes related to the Meso Cenozoic epigenesis resulting from the drift of continents and from the Tertiary and Quaternary denudational processes, acting over ancient structures represented by cratons, ancient orogenetic belts, and Phanerozoic sedimentary basins. The altimetric variations result from the combination of Meso Cenozoic tectonics promoting unequal uplift of pre-existing macrostructures and denudational downdrafts with also unequal speeds, produced by climatic variations (dry and humid climate) in the Tertiary and Quaternary.

For the application of the Brazilian relief map in land use planning, it was necessary to integrate two distinct cartographic products, i.e., the IBGE map, published in 1993, and the Ross map, from 2006, which presented different levels of detail: the first more detailed and the second more generic, producing a map of intermediate resolution. Thus, the objective of this work was to generate the division of the geomorphological units of Brazil in order to meet the Brazilian Territorial Planning research prepared at the scale of 1:5,000,000.

The mentioned research was structured from the perspective of ensuring environmental quality, sustainable development, and improvement of living conditions of the Brazilian population, having Brazil as the adopted geographic cutout. Based on the premise that the territorial planning needs to be grounded on the foundations of sustainable development, it is essential to consider in its implementation the environmental and ecological, social, and economic approaches.

Many possibilities arise in parallel to the initiative of territorial planning, such as: integrated socio-environmental diagnosis, involving society-nature relations, the implementation of integrated public policies guided by the principles of environmental conservation and social and economic development and the possibility of identifying the potentials, vulnerabilities, and fragilities of the territory. Given these perspectives, the understanding of geomorphology, as well as its characterization through relief units, becomes a basic principle.

The new division of the geomorphological units of Brazil was necessary for the physical-natural characterization of the territory, from the perspective of an integrated socio-environmental diagnosis; for the identification of the Natural Environmental Units, which consider the geology, geomorphology, pedology, as well as information on the climate and natural vegetation cover; and finally, for the identification of the Land Units for the territorial planning of the mentioned geographic clipping.

# 2 Study Area

The major relief compartments found in Brazil and South America are associated with macrostructures, such as cratons or platforms, ancient and recent orogenic belts, large paleo-mesozoic and cenozoic sedimentary basins.

The oldest terrains are the cratons dating from the middle to lower Precambrian, with ages of hundreds of millions of years. They are composed of a diversity of lithologies and structures, among which dominate the very old metamorphic rocks of the Middle to Lower Precambrian (Archeozoic) and the old intrusive rocks of the Middle to Upper Precambrian (Proterozoic) overlain by sedimentary rocks dated to the Upper Precambrian (Proterozoic), which residually cover more restricted areas of the cratons or platforms. To represent these ancient terrains, the Amazon, São Francisco, and Uruguaio-sul-rio-grandense cratons or platforms are cited as examples.

It corresponds to the extensive strips of folded structures located in the Brazilian territory, the so-called orogenetic belts. Such structures are also very old and were generated during the Precambrian Superior (Proterozoic). They are characterized for portraying bands of suture between cratons, founding in South America, the lands of the Precambrian. Recognized examples of these fold belts in Brazil are the Atlantic, Tocantins, and Paraguayan belts.

The large Paleo-Mesozoic sedimentary basins correspond to the third type of macrostructures, which confer the Oriental Amazon, the Parnaíba-SanFranciscana, the Paraná, and the Parecis basins. These large basins were formed in lower altimetric conditions and underwent tectonic processes of syneclizes and amphiclizes, mainly from the Jura-Cretaceous. The sedimentary strata formed by marine, continental, glacial and desert deposits constitute the great South American basins. It is relevant to note that at the end of the Mesozoic (Cretaceous) there was an interruption of extensive sedimentation in these basins.

The Andes mountain range and the cenozoic sedimentary basins formed simultaneously. Tectonic processes have reactivated ancient faults and promoted the formation of escarpments with epeirogenic uplifts and archegations in the central and eastern parts of the continent. In parallel, an intensification of erosional upheaval took place, which was decisive for the lowering of the plateaus and mountain ranges in the central and eastern parts of the continent. The Cretaceous is a very important temporal divisor to unravel the enigmas of the morphogenesis of the relief of Brazil and South America in general, as emphasized by Ross (2016).

## 3 Materials and Methods

The methodological support of the relief map presented here follows the theoretical assumptions defined by the orientation of the Russian geomorphologist I. P. Guerassimov along the 1960s and Mescerjakov (1968), which were the basis for the taxonomic proposal of Ross (1992) concerning the geomorphological cartography. In this context, Ross (1992) presented a taxonomic sequence to be applied in geomorphological mappings in Brazil in six taxa.

The first and second taxons correspond to the structural and sculptural macro-influences in the genesis of the Brazilian relief, following what was established by the Russian authors, that is, the morphostructures and the morphoscultures.

The third taxon corresponds to the smaller units, contained in the morphostructures and morphoscultures, but being determined by more recent sculptural processes, being defined by the relief dissection modulations, also more recently called topographic rugosity.

The fourth taxon represents individual forms such as hills, hills, river plains, sea plains, escarpments, structural terraces, erosional terraces, and others.

The fifth taxon is represented by the slope typologies, such as concave, convex, rectilinear slopes, convex tops, flat tops, sharp tops, and the sixth taxon is represented by the forms generated through current processes, such as furrows, ravines, gullies, embankments, slope cuts, opening of channels produced by anthropogenic processes. In this work, due to the scale, the first two taxa of Ross (1992) were used, i.e., the Morphostructural Units, and, in the context of each of these, the Morphocultural Units, in which the differentiation in the topographic rugosity can be identified, conditioning the territorial planning and signaling for the investigation of the potential and natural environmental fragilities in the face of human interventions.

The technical procedures involved, at first, the georeferencing and digitization of the Geomorphological Map of Ross (2006), because it was in analog format. To do so, it was used a geoprocessing *software* in which one can make the screen scanning of each polygon that represented a geomorphological unit. After this procedure, a file was obtained in. SHP (*shapefile*) *format was obtained* with all the geomorphological units.

The relief unit map of IBGE (1993) was obtained from the official website of the institution, already in a format compatible with the Geographic Information System (GIS) environment.

In possession of the two databases, the vectors were architected in a GIS environment with the final purpose of elaborating a rereading of the maps, resulting in a new division of geomorphological units for Brazil. Each of the defined units was characterized and integrated into the final map containing 34 geomorphological units.

## 4 Brazilian Geomorphological Units: General Characterization Applied to Land Use Planning

The results resulted in the identification of a greater number of relief units, especially those associated with sedimentary basins and orogenic belts, becoming more compatible with the interests and needs of the Brazilian Territorial Planning research at the 1:5,000,000 scale. To illustrate the geomorphological units, Figs. 1 and 2 follow, with the divisions of the first and second taxa. In the first taxon are found the morphostructures of the Amazon Craton, the Ancient Orogenic Belt, the Paleo-Mesozoic Sedimentary Basins, and the Cenozoic Sedimentary Basins. In the second taxon, the morphosculptural divisions are recognized, i.e., plateaus, depressions, mountains,

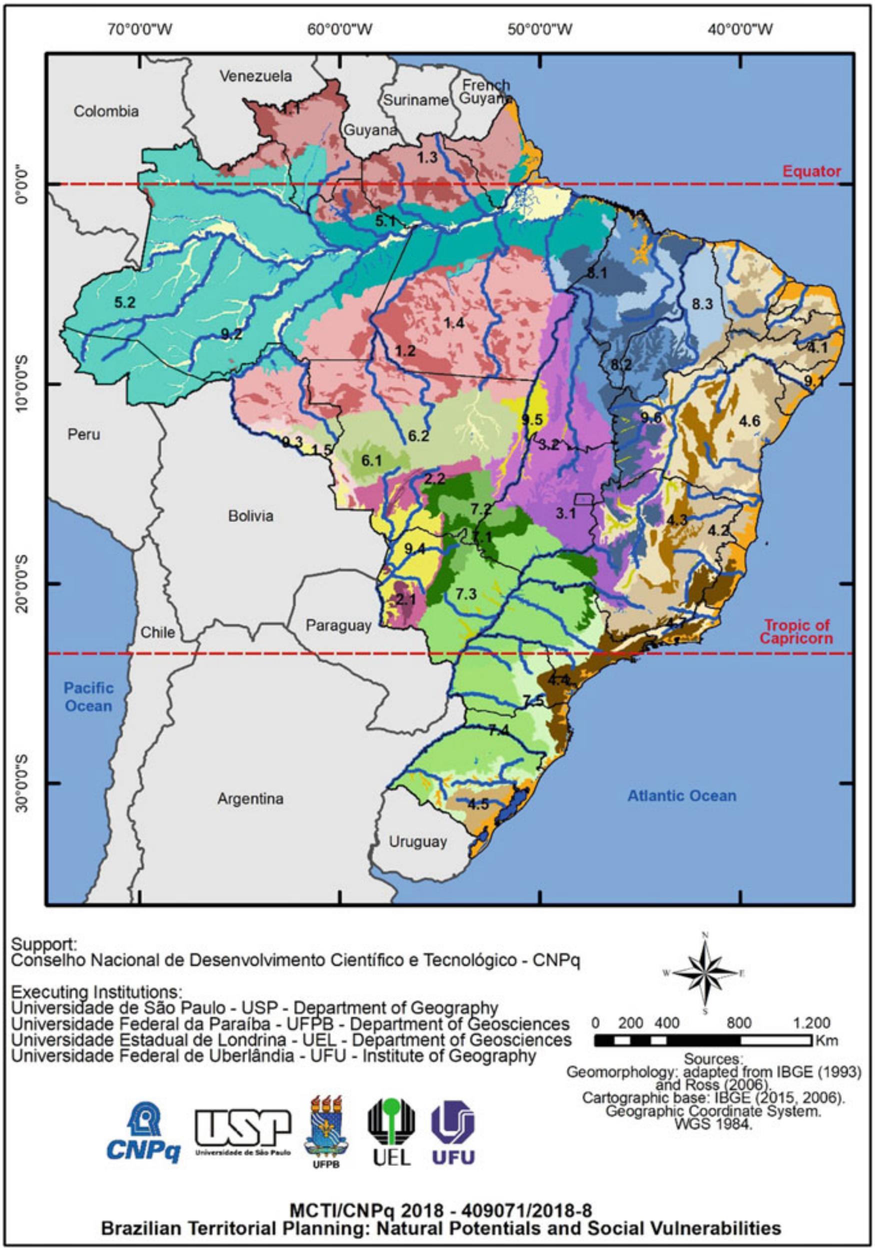


**Fig. 1** Map of the division of geomorphological units of Brazil. *Source* of data: adapted from IBGE (1993); and Ross (2006). Elaboration: The authors

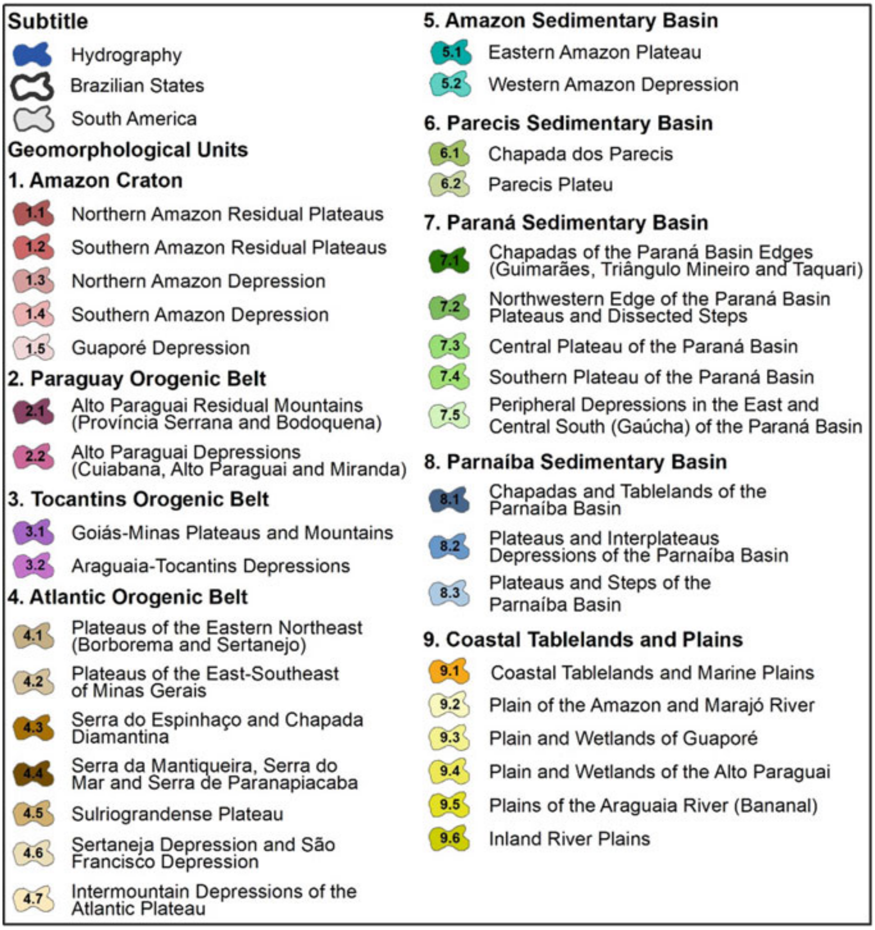


**Fig. 2** Legend of the geomorphological units division map of Brazil. *Source* of data: adapted from IBGE (1993); and Ross (2006). Elaboration: The authors

and plains. The morphosculptures are associated with each of the mega-structures presented in the first taxon.

The Brazilian landforms predate the present configuration of the South American continent. The effects of the Andean orogeny and the opening of the Atlantic Ocean since the Jurassic (130 Ma) are responsible for the current shape.

The global geotectonic processes that are reflected in the conformation of the South American continent undergo a significant change in behavior from the Jurassic, extending through the Cenozoic. Consequently, this change is also reflected in the geological structure and in the genesis of the relief of what would become, in the Tertiary and Quaternary, the South American continent. The continuous weathering progressively sculpts the plateaus, mountain ranges, mountains as well as the relative depressions that surround the Brazilian sedimentary basins.

In the South American Central Depression and the basins of the Western Amazon (Solimões), Orinoco, Paraguay-Paraná (Pantanal of Matogrosso and Guaporé, as shown in Fig. 3), Araguaia, and Atlantic rift, Cenozoic deposits compose sedimentary basins in *rift valleys* and platform coverings.

In Brazil and Venezuela, the oldest terrains are related to the Amazon Craton, identified on the map as the Amazon Craton Morphostructure (Fig. 4). The largest

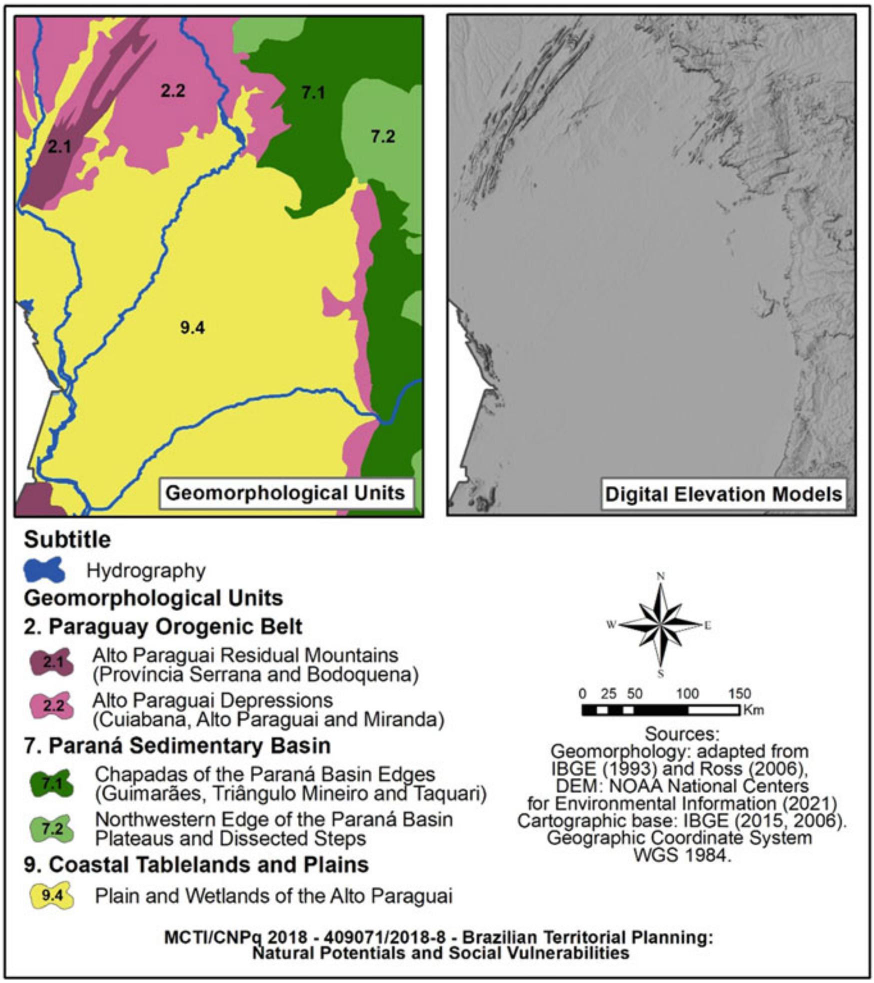


**Fig. 3** Detailing of the geomorphological unit plain and wetlands of the Alto Paraguay and its surroundings. *Sources* adapted from IBGE (1993); Ross (2006). Elaboration: The authors

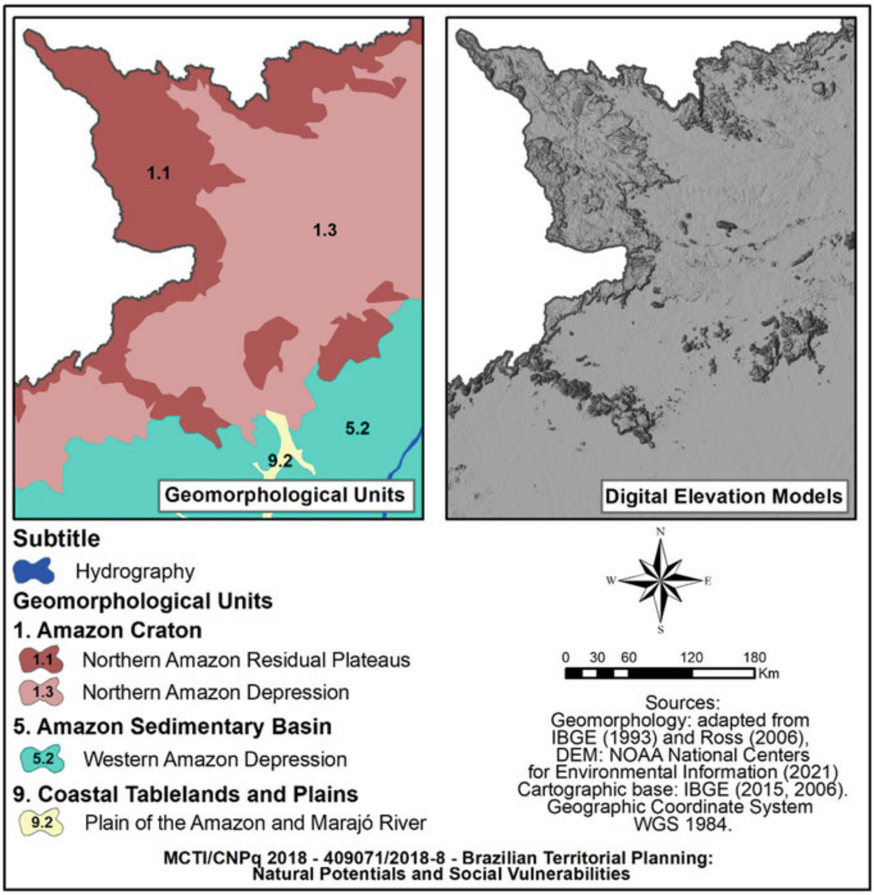


**Fig. 4** Detailing of the geomorphological unit Northern Amazon Residual Plateaus and its surroundings. *Sources* adapted from IBGE (1993); Ross (2006). Elaboration: The authors

territorial extension in this morphostructure, according to Ross (1990), is represented by the flattened and lowered surface with altitudes that range between 100 and 300 m. The metamorphic rocks of the Middle Precambrian (1.8 to 2.5 billion years) give support to this surface, denominated by Ab'Saber (1972) as North and South Amazonian Marginal Depression in relation to the presence of the Eastern Amazon Sedimentary Basin. The northern and southern edges of this basin reveal cuestiform reliefs, containing higher parts between 350 and 400 m. Between the tops of the Cuesta reverses and their base, there are 200 to 300 m of unevenness which Ab'Saber (1972) interpreted as an "eversion surface", due to the erosive processes that would have occurred during the Tertiary-Quaternary period. This surface to the north of the Sedimentary Basin of the Oriental Amazon receives the name Depression or North Amazonian Surface and its correspondent to the south, Depression or South Amazonian Surface.

Throughout this low and dissected surface in hills and low hills, with accentuated topographic rugosity, higher reliefs, with altitudes above 600, reaching in restricted areas, more than 1000 m. The igneous rocks of the granite family, the presence of acid volcanic rocks such as rhyolites, and the residual platform coverings composed of silicified sandstones, support these higher reliefs and are examples of the great lithological diversity present.

There is also the presence of high reliefs, where the tops are preserved by iron and manganese formations, products of supergene deposits from the Precambrian, very resistant to erosive processes. Examples are the Carajás mountain range complex, located in the state of Pará, and Urucum, located in the state of Mato Grosso do Sul. It is pertinent to note that these higher elevations are represented in the geomorphological units by the North and South Amazonian Residual Plateaus.

The fold belts of the Brazilian cycle are represented by the Paraguay (Fig. 5), Tocantins, and Atlantic Orogenetic Belts. From a morphogenetic perspective, they correspond to residual reliefs resulting from erosive processes that developed during the Phanerozoic, lowering the ancient mountain chains to current topographic levels.

In general, these macrostructures support reliefs marked by excavated anticlines, raised synclinals, fault scarps, and tectonic pits that define complex mountain systems composed of aligned mountains roughly parallel to each other. They are present in these orogenetic belts underlying intrusive masses, represented by igneous with prominence for the granites, that are exposed on surface as a result of the erosive lowering that eroded the highest parts of these old mountain chains. Examples are the Caparaó, Cantareira, São Francisco, Itaqui and countless others in the Atlantic Belt, or still the Dourada and Mesa Mountains, in the Tocantins-Brasilia Belt, and Serra de São Vicente, in the Paraguay Belt.

However, what most highlights these mountainous reliefs of Brazil are the mountain ranges held by metamorphic rocks, such as quartzite or sedimentary, and by ancient rocks, such as silicified sandstones that support the edges of excavated anticlines and uplifted synclinals. These aligned mountain ranges are observed mainly in the Tocantins Orogenetic Belt, such as the Serra da Canastra; in the Paraguayan Belt, especially the Serra do Espinhaço; and in the Atlantic Orogenic Belt, such as the Chapada Diamantina. Among the mountains that configure the relief of these morphostructures, there are surfaces lowered by erosion, which interpenetrate forming the Intermontane Depressions or those that accompany parallel mountain ranges (Ross 2016).

The sedimentary basins of the Oriental Amazon and Parecis partially cover the Amazon Craton. The Parecis basin, located in the watershed of the rivers that flow into the Amazon River, to the north, and the Paraguay/Paraná River, to the south, is composed of Cretaceous sandstones. These geological formations correspond to the superior extracts of these basins, being that the highest parts in the Amazon Basin, are between 350 and 400 m, while the Parecis Plateau, oscillate between 400 and

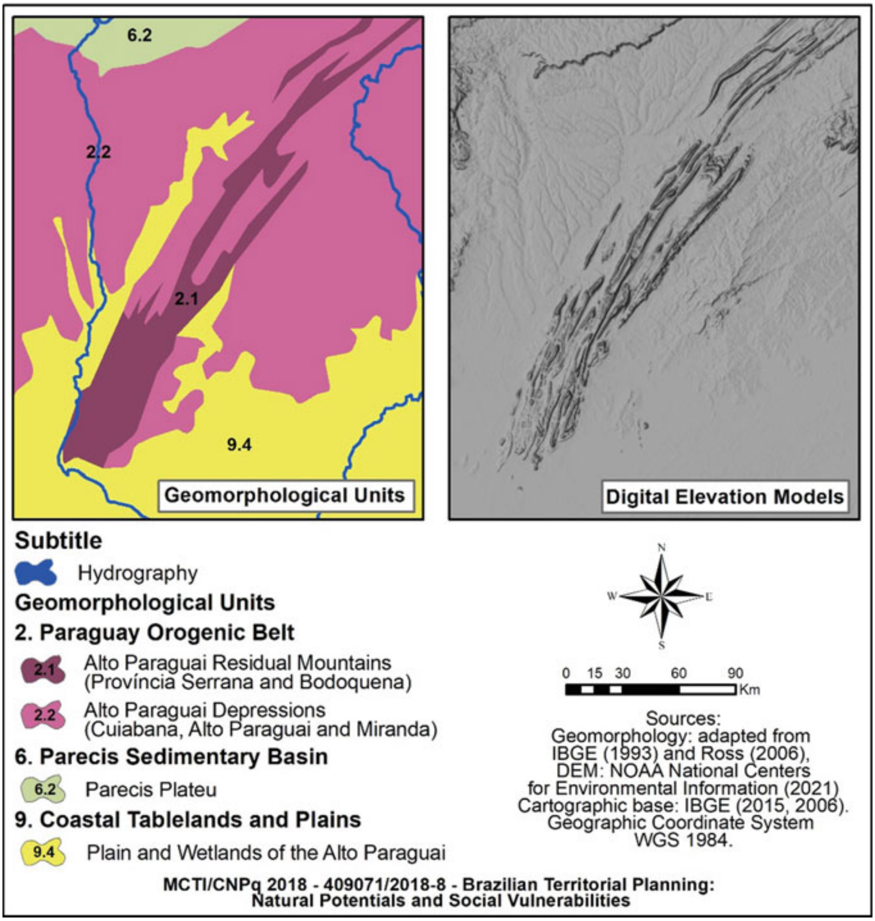


**Fig. 5** Detailing of the geomorphological unit Alto Paraguay Residual Mountains (Serrana and Bodoquena Province) and its surroundings. *Sources* adapted from IBGE (1993); Ross (2006). Elaboration: The authors

800 m. These altimetric levels indicate that the Amazon Craton was also affected by the Cenozoic epigenetic processes in an uneven manner.

The sedimentary basins of Paraná and Parnaíba-Sanfranciscana are configured in Plateaus and Chapadas and have their edges uplifted by the effects of the Meso Cenozoic tectonics with the highest altitudes oscillating between 800 and 1200 m. However, they reach 1500 m in the Planalto de Vacaria, in the region known as Aparados da Serra, in the northeast of the State of Rio Grande do Sul and southeast of Santa Catarina (Fig. 6).

The craggy edges of these large sedimentary basins of Paraná and Parnaíba-Sanfranciscana present, in general, cuestiform reliefs that are accompanied by Peripheral and Marginal Depressions, with regional differentiation among them. The

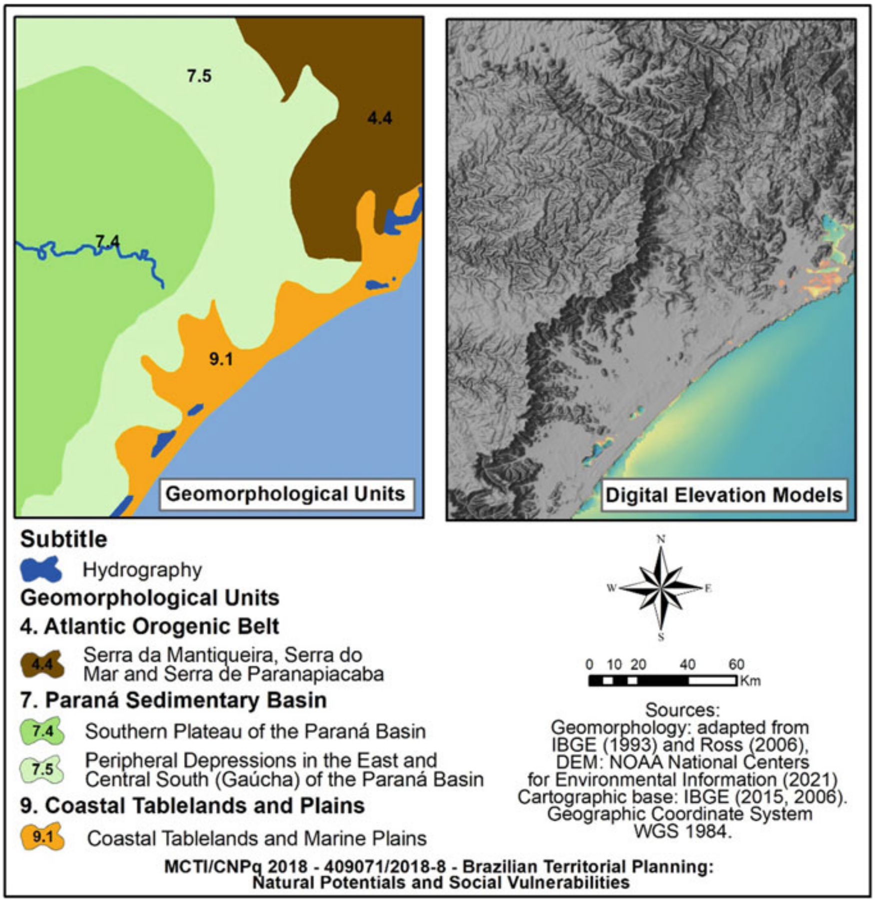


**Fig. 6** Detailing of the geomorphological unit Southern Plateau of the Paraná Basin and its surroundings. *Sources* adapted from IBGE (1993); Ross (2006). Elaboration: The authors

altitudes of these depressions, which are characterized by surfaces eroded during the Cenozoic, are very varied and depend on the greater or lesser effects of the post-Cretaceous epeirogeny (Fig. 7).

The Sertaneja and São Francisco Depressions are between a few tens of meters as in the State of Ceará and reach around 400 m in the São Francisco basin in the State of Minas Gerais. The Peripheral Depression of the eastern edge of the Paraná Basin, in the state of São Paulo known as Peripheral Depression Paulista, has altitudes between 550 and 700 m, but changes its morphological aspect in the east of the states of Paraná and Santa Catarina, when it is called Second Plateau because it defines a physiognomy of a wide and well-marked structural plateau supported by Devonian

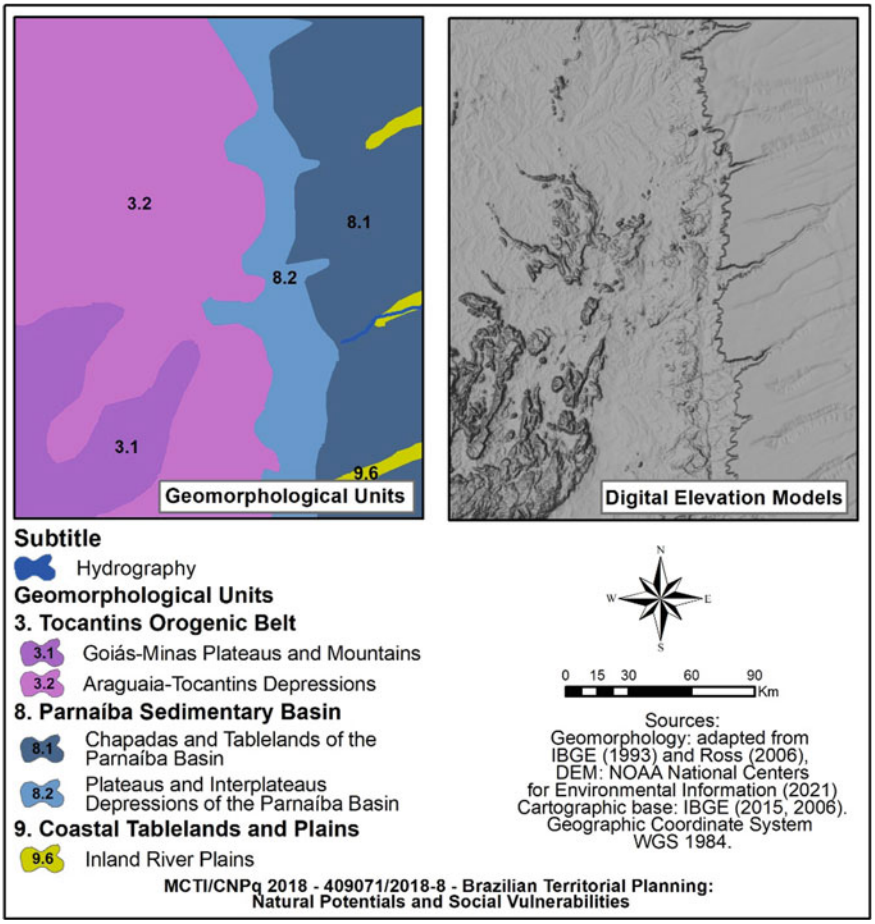


**Fig. 7** Detailing of the geomorphological unit Chapadas and Tablelands of the Paraníba Basin and its surroundings. *Sources* adapted from IBGE (1993); Ross (2006). Elaboration: The authors

rocks. In the state of Rio Grande do Sul, the Central Depression has altitudes not much higher than 200 m in the highest parts.

A similar fact also occurs with the Upper Paraguay River Depressions in the states of Mato Grosso and Mato Grosso do Sul, whose altimetric values are around 100 to 300 m.

Ross (2014) considers that Chapada dos Guimarães, to the northwest of the Paraná sedimentary basin, as well as Chapada dos Parecis, further to the northwest, have their genesis associated with the combination of geotectonic processes such as crustal movement, resulting from the opening of the Atlantic, the Andean orogeny and the generalized uplift of the South American platform from the Jura-Cretaceous to the Cenozoic. These movements promoted dome arcing along major structural alignments, such as the one that occurs along the fold belts of the Paraguay Orogenetic Belt, positioned between the above-mentioned plateaus and known in the geological literature as the São Vicente Arch (Ross 2014), has genetic relationships with these movements.

On the flat tops of these chapadas, which are composed of rocks of the Cretaceous (Bauru and Parecis Groups), there is a thick clay and ferruginous pedological cover constituting deep soils. Surrounding these are escarpments articulated to the depressions of the upper Paraguay.

These facts aligned to interpret the morphogenesis of Chapada dos Guimarães also apply to Chapada dos Parecis and the other plateaus that are located on the edges of the sedimentary basins of Paraná and Parnaíba-Sanfranciscana, considering, obviously, the specificities of each one of them (Fig. 8). The mentioned plateaus and

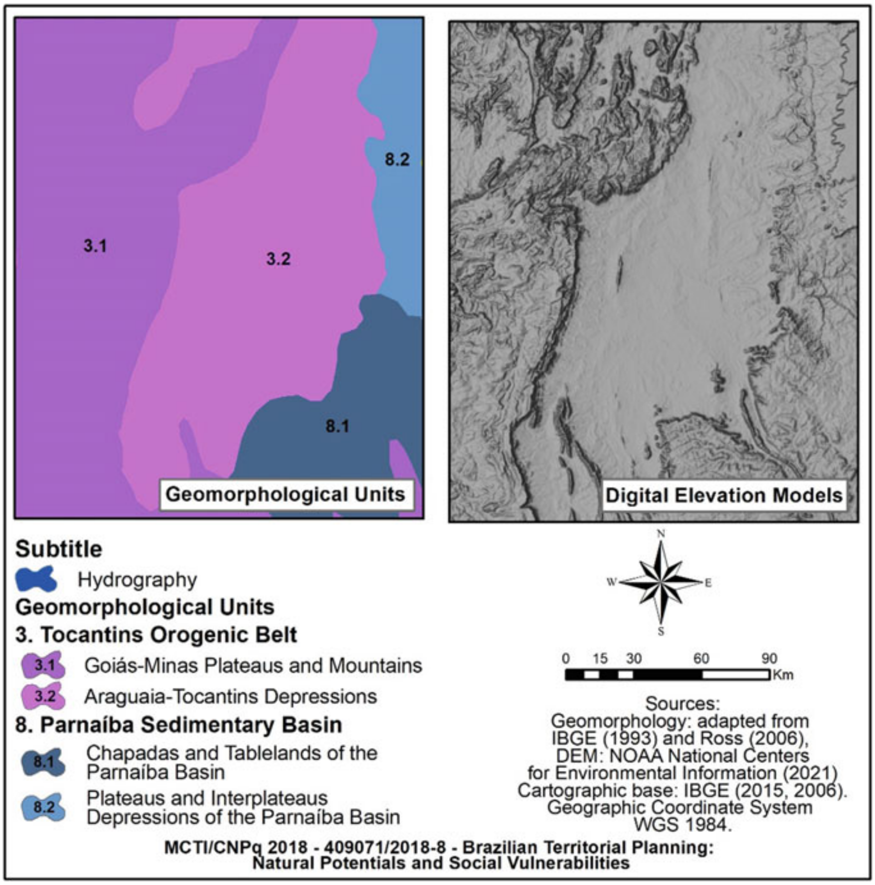


**Fig. 8** Detailing of the geomorphological unit Araguaia-Tocantins Depressions and its surroundings. *Sources* adapted from IBGE (1993); Ross (2006). Elaboration: The authors

the depressions that surround them, to the south as well as to the north and west, were generated by simultaneous processes of tectonics and erosional lowering for more than 60 Ma, according to Ross (2014). This interpretation is in contrast to that of Ab'Saber (1972), who considered them to have resulted from denudational processes from the Plio-Pleistocene onwards.

The surfaces lowered by erosion gave rise to the Peripheral and Marginal Depressions, according to Ab'Saber (1949, 1972). According to the interpretation, these were sculpted by more or less intense phases, combined with the intermittent impulses of tectonic activities (neotectonics) and greater or lesser erosive vigor, depending on whether the climate conditions were drier or more humid and hot.

The *rift valleys* marked by transcurrent faults, scarps, generation of grabens/horsts, and formation in these tectonic depressions of syntectonic sedimentary basins (Fig. 9) both continental and marine are also associated with the tectonics from the Jurassic extending to the Cenozoic. These traphogenetic sedimentary basins in emersed lands correspond to the Cenozoic basins of São Paulo, Taubaté, Rezende, Curitiba, Pariquera-Açu, Volta Redonda, Guanabara, Itaboraí, generated, according to Riccomini (1989), from the Oligocene–Miocene.

The submerged basins composed of marine and continental sediments are part of this *rift* system. Among them are the Pelotas, Santos, Campos Espírito Santo, Bahia-Sul and Sergipe-Alagoas basins, as recorded by Chang et al. (1992). The materials that compose the sedimentary packages are from different phases of marine sedimentation in shallow or deeper sea conditions. These variations are a function of the movement processes of the structural blocks throughout the Cretaceous and especially in the Tertiary.

In the *rift* concentration areas according to Riccomini (1989) and reaffirmed by Gontijo (1999), the tectogenetic activities are still active, revealed by the testimonies observed in the Rezende, Taubaté, and São Paulo basin deposits.

The application of dating techniques using fission trace analysis (TFA) on apatites and U-Th/He ages in vertical profiles in the central-southern portion of Serra do Mar, as reported by Ribeiro et al. (2011), indicates that there was, in the Upper Cretaceous to Paleocene, a strong tectonic uplift, from which erosional cycles were installed, and that this probably repeated itself in the Eocene–Oligocene.

The results revealed by the data of 2013 and 2014 of the Brazilian Seismographic Network and revealed by Assumpção et al. (2015), strengthen the interpretation of the active tectonics in current times. The publication shows us, through a summary map, that in some axes or areas the frequency of seismic tremors is more frequent in the Brazilian territory. This is very evident in the Atlantic strip, in the southeast region, and for the strip that enters the center north of the country following the Orogenetic Belts of the Atlantic, Tocantins, and Paraguay.

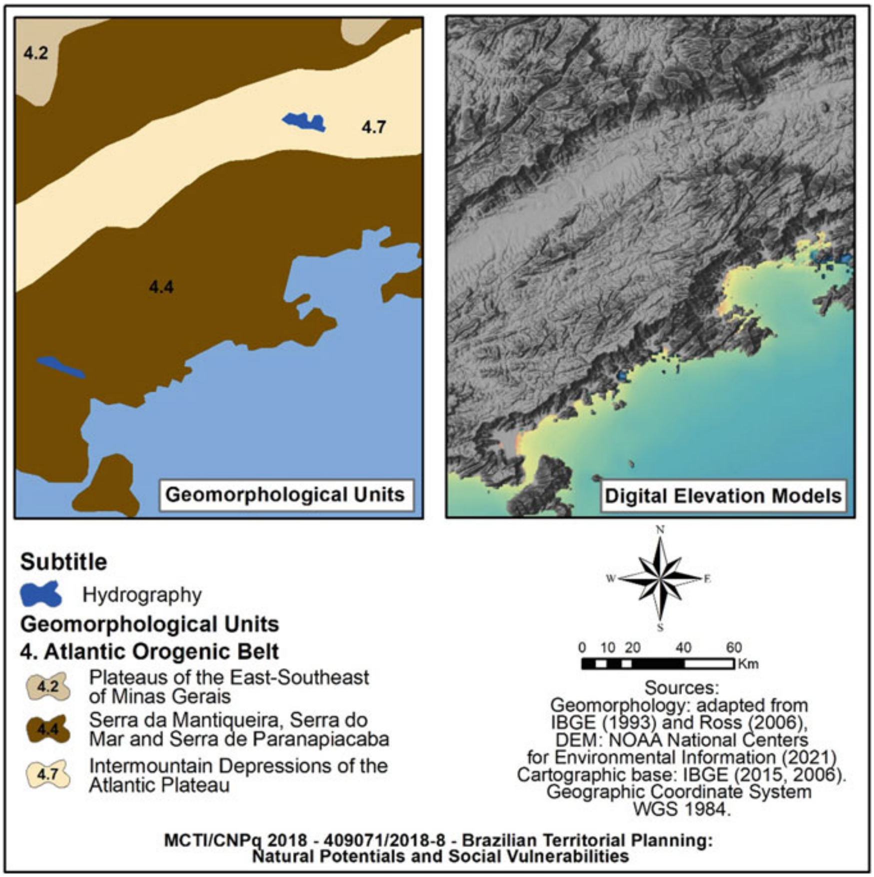


**Fig. 9** Detailing of the geomorphological unit intermountain depressions of the Atlantic Plateau. *Sources* adapted from IBGE (1993); Ross (2006). Elaboration: The authors

## 5 Final Considerations

Some regional generalizations made here allow us to highlight two conclusions: the first is that flattened, or at least rectilinear, levels of the tops of fold belts (belts) bear witness to Cretaceous or earlier erosional phases. They are manifestations observed in the extensive leveled and low surfaces that are carved on the Amazon and São Francisco Cratons. Another fact considered scientifically accepted is that the inter-planaltic depressions and surfaces embedded in the edges of large sedimentary basins are of more recent age (Tertiary and Quaternary).

It is possible to affirm that the local and regional morphological or topographic levels are associated with diverse origins and genesis, contemplating the combined relationship of the Meso Cenozoic tectonics, which promoted uplift/arcs/basculations, and the erosive processes that acted and continue to act in the lowering and deposition, whether by processes triggered by drier climatic conditions or in hot and humid conditions, where mechanical and geochemical lowering are determinant to differentiate the speed of weathering due to differences in mineralogical resistance of the rocks.

From this morphogenetic analysis, presented in more detail by Ross (2016), followed by the technical work to merge the two geomorphological cartographic products, a new division of the geomorphological units of the relief is presented, considering the general context of South America. The relief division was thought from the geological macrostructures that define the mega-units of relief and geodiversity of Brazil.

The rereading of the geomorphological units applied to territorial planning has enabled more emphatic integrated studies of the national territory, considering the understanding of the dynamics of the functioning of the physical-natural environment with the intervention of human actions. Land use planning, based on technical-scientific principles, optimizes and orders the use of Brazilian geographic space through rational occupation and sustainable use of natural resources. Thus, it is possible to increase the effectiveness of political decisions, public intervention in the management of the territory, as well as an effective organization of information needed to plan and reorder the territory of the country.

**Acknowledgements** We thank CNPq for the partial funding of the research through the project registered under No. 409071/2018-8 and entitled "Brazilian Territorial Planning: Natural Potentialities and Social Vulnerabilities".

## References

Ab'Saber AN (1949) Regions of Post-Cretaceous Circundesnudation in the Brazilian Plateau. Boletim Paulista de Geografia 1:1–21

Ab'Sáber AN (1972) Participation of peripheral depressions and flattened surfaces in the compartmentalization of the Brazilian Plateau. Geomorphology 28:1–38

Assumpção M, Barbosa JR, Bianchi M, Rouet S, Rocha MP, Ferreira JM (2015) Regional Earthquakes Detected by the Brazilian Seismographic Network-RSBR in 2013–2014. In: XV National Symposium of Tectonic Studies

Chang HK, Kowsmann RO, Figueiredo AMF, Bender AA (1992) Tectonics and stratigraphy of the east Brazil Rift system: an overview. Tectonophyscs 213:97–138

Gontijo AHF (1999) Morphotectonics of the Middle Paraíba do Sul River Valley: Serra da Bocaina Region, SP-RJ States. PhD Thesis: Institute of Geosciences and Exact Sciences, UNESP Rio Claro

IBGE (1993) Mapa das Unidades de Relevo do Brasil. Rio de Janeiro. Brazilian Institute of Geography and Statistics

Mescerjakov JP (1968) Les concepts de morphostructure et de morphosculpture: un nouvel instrument de l'analyse géomorphologique. Annales de Geographie, 423:539–552

Ribeiro MCS, Hackspacher PC, Ribeiro LFB, Neto JCH (2011) Tectonic and Denudational Evolution of the Serra do Mar-Southeastern Brazil at the Boundary between the Upper Cretaceous and Paleocene Using Fission Trace Analysis and U-TH/HE in Apatites. Brazilian Journal of Geomorphology. 12(3):03–14. https://doi.org/10.20502/rbg.v12i0.254

Riccomini C (1989) The Continental *Rift of* Southeastern Brazil. PhD Thesis: Institute of Geosciences, USP

Ross JLS (1990) Relevo Brasileiro: Uma nova proposta de classificação. Journal of the Department of Geography, 4:25–39. https://doi.org/10.7154/RDG.1985.0004.0004

Ross JLS (1992) The cartographic record of geomorphic facts and the question of relief taxonomy. Journal of the Department of Geography, 6:17–30. https://doi.org/10.7154/RDG.1992.0006.0002

Ross JLS (2006) Ecogeografia do Brasil: subsídios para planejamento ambiental. São Paulo, Oficina de Textos

Ross JLS (2014) Chapada dos Guimaraes: Edge of the Paraná Basin. Journal of the Department of Geography, 28:180–197. https://doi.org/10.11606/rdg.v28i0.525

Ross JLS (2016) The Brazilian Relief in the Context of South America. Revista Brasileira de Geografia, IBGE 61(1): 21–58. https://doi.org/10.21579/issn.2526-0375_2016_n1_art_2