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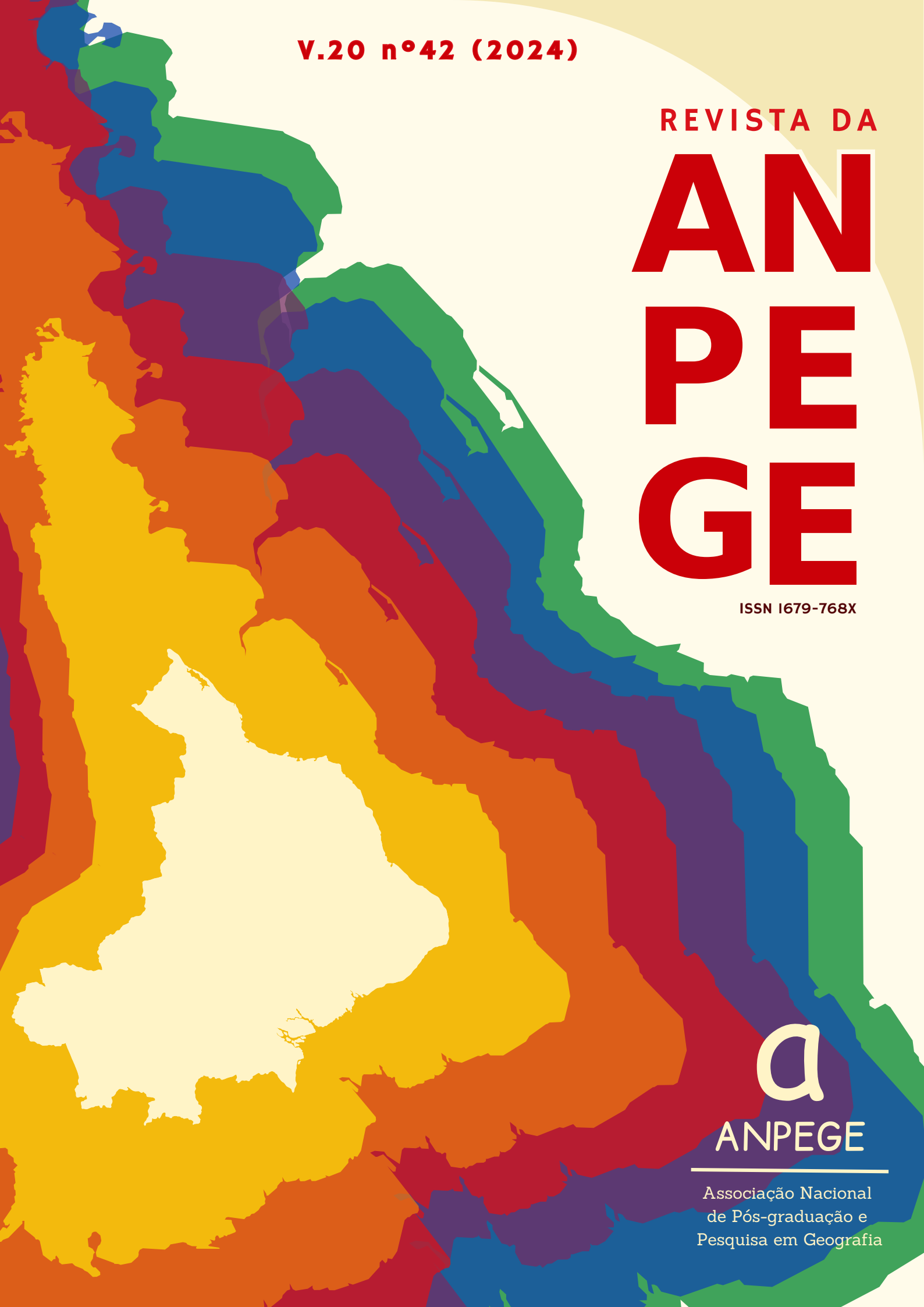

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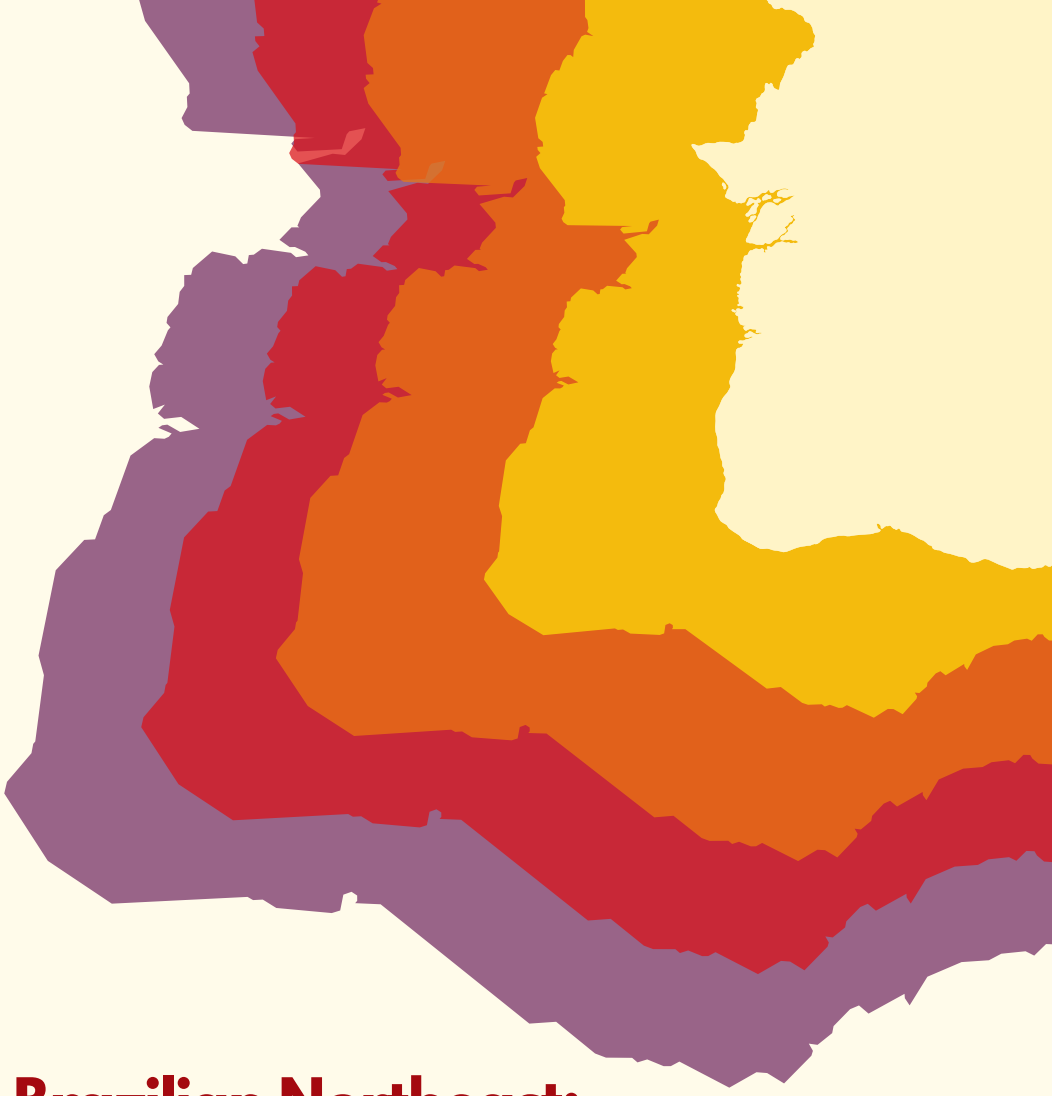

Geopolitics in the Brazilian Northeast: the western foothills of Serra da Ibiapaba and the Ceará-Piauí territorial dispute

Geopolítica no Nordeste Brasileiro: o sopé ocidental da Serra da Ibiapaba e a disputa territorial Ceará-Piauí

Géopolitique dans le nord-est brésilien : les contreforts occidentaux de la Serra da Ibiapaba et le conflit territorial Ceará-Piauí

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ABSTRACT: Territorial disputes between states, exemplified by the controversy between Ceará and Piauí, represent complex challenges rooted in social, cultural, economic, historical and geographic aspects. This study, centered on Serra da Ibiapaba, covers historical and geological-geomorphological mapping, anchored in historical sources and documents. When reconstructing the narrative from the colonial period, the western foothills of the Serra da Ibiapaba are based as a natural border. In the geological context, the coincidence between the limits of the Ibiapaba Plateau and the "Serra Grande" stratigraphic group, deposited 420 million years ago, stands out. The mapping reveals the extent of the Serra Grande Group in Ceará and Piauí, contesting the current delimitation by IBGE. The results highlight the need to review the border, sustained by a distance of more than 40 km in some places and the historic territorial advance of Piauí over Ceará lands. It is therefore argued that the disputed area belongs to the administrative jurisdiction of Ceará, given that this State has had possession of it for centuries.
Keywords: Ceará-Piauí litigation; glint from ibiapaba; geohistory.

RESUMO: As disputas territoriais entre estados, exemplificadas pela controvérsia entre Ceará e Piauí, representam desafios complexos enraizados em aspectos sociais, culturais, econômicos, históricos e geográficos. Este estudo, centrado na Serra da Ibiapaba, abrange mapeamento histórico e geológico-geomorfológico, ancorando-se em fontes e documentos históricos. Ao reconstruir a narrativa desde o período colonial, fundamenta-se o sopé ocidental da Serra da Ibiapaba como divisa natural. No contexto geológico, destaca-se a coincidência entre os limites do Planalto da Ibiapaba e o grupo estratigráfico "Serra Grande", depositado há 420 milhões de anos. O mapeamento revela a extensão do Grupo Serra Grande no Ceará e Piauí, contestando a atual delimitação pelo IBGE. Os resultados evidenciam a necessidade de revisão da divisa, sustentada por uma distância de mais de 40 km em alguns locais e o histórico avanço territorial do Piauí sobre terras cearenses. Argumenta-se, desse modo, que a área litigiosa pertence à

jurisdição administrativa do Ceará, dado esse Estado ter posse sobre ela há séculos.
Palavras-chave: litígio Ceará-Piauí; glint da ibiapaba; geohistória.

RÉSUMÉ: Les conflits territoriaux entre États, illustrés par la controverse entre le Ceará et le Piauí, représentent des défis complexes enracinés dans des aspects sociaux, culturels, économiques, historiques et géographiques. Cette étude, centrée sur la Serra da Ibiapaba, couvre une cartographie historique et géologique-géomorphologique, ancrée dans des sources et des documents historiques. Lors de la reconstruction du récit de la période coloniale, les contreforts occidentaux de la Serra da Ibiapaba constituent une frontière naturelle. Dans le contexte géologique, la coïncidence entre les limites du plateau d'Ibiapaba et le groupe stratigraphique « Serra Grande », déposé il y a 420 millions d'années, est remarquable. La cartographie révèle l'étendue du groupe Serra Grande dans le Ceará et le Piauí, contestant la délimitation actuelle de l'IBGE. Les résultats mettent en évidence la nécessité de revoir la frontière, soutenue par une distance de plus de 40 km dans certains endroits et l'avancée territoriale historique du Piauí sur les terres du Ceará. Il est donc avancé que la zone litigieuse appartient à la juridiction administrative du Ceará, étant donné que cet État en est propriétaire depuis des siècles.
Mots-clés: litige Ceará-Piauí; reflet d'ibiapaba; géohistoire.

Introduction

Territorial disputes between states represent complex challenges, often rooted in the specific social, cultural, economic and geographical characteristics of the regions involved. In the Brazilian context, the current dispute between Ceará and Piauí over the delimitation of their borders, which has been pending before the Federal Supreme Court (STF) through Original Civil Action (ACO) 1.831 since 2011, stands out as an example of this scenario.

The epicenter of this dispute is concentrated in the Serra da Ibiapaba, not only a region of economic and geographical importance for Ceará, but above all a place imbued with historical significance and a deep sense of belonging by the population to this state (Souza, 2020). The roots of this connection go back to colonial times and are fundamental to understanding the clash in question.

By reconstructing historical facts from the colonial period to the Brazilian Empire, we seek to elucidate the roots (foothills) of the Serra da Ibiapaba as the border between the states, anchored in sources such as Gaspar (2023), Medeiros e Lima (2023), as well as the works "Annaes Historicos do Estado do Maranhão" by Bernardo Pereira de Berredo (1849), "Algumas Notas Genealógicas" by João Mendes de Almeida (1886) and "A Barra da Tutoya" by Justo Jansen Ferreira (1908) , accompanied by historical maps that corroborate this delimitation.

In this context, this technical note aims to map the western foothills of the Serra da Ibiapaba, which is essential for delimiting the border between Ceará and Piauí. This multidisciplinary approach seeks to make a significant contribution to understanding the history and geographical configuration of the region, providing robust subsidies for resolving this territorial dispute, with fundamental considerations in historical, geomorphological, geological and geographical aspects.

In this context, the importance of geological-geomorphological mapping to identify the border in dispute in ACO 1.831 is highlighted. By concentrating efforts on understanding the physical aspects of the border, especially the precise mapping of the western foothills (roots) of the Serra da Ibiapaba, i it is aimed to extract valuable information that goes beyond the demarcation lines on historical maps, comparing the historical portrait of the border with the current configuration adopted by the Brazilian Institute of Geography and Statistics (IBGE) in its Demographic Censuses.

Thus, this paper proposes to explore the relevance of geomorphological mapping as another useful tool for resolving this controversy, offering a technical approach to understanding the physical characteristics of the region and thus contributing to scientifically-based decisions.

Methodology

This work was developed using qualitative methodologies, through documentary, cartographic and bibliographic research, in order to obtain published theoretical contributions on the history of the territorial dispute between the states of Ceará and Piauí. Thus, for the systematic review of the literature, specific internet pages were used as search tools, such as the CAPES Periodical Portal, SciELO and Google Scholar.

Relief mapping and production of maps of the border limits established by the various agencies that deal with the subject were also carried out. The mapping was done in a GIS environment, using the QGIS software. The supporting maps were geological and geographic maps from the Brazilian Geological Survey (CPRM) and the Brazilian Institute of Geography and Statistics (IBGE). The GIS environment also served as a basis to produce block diagrams.

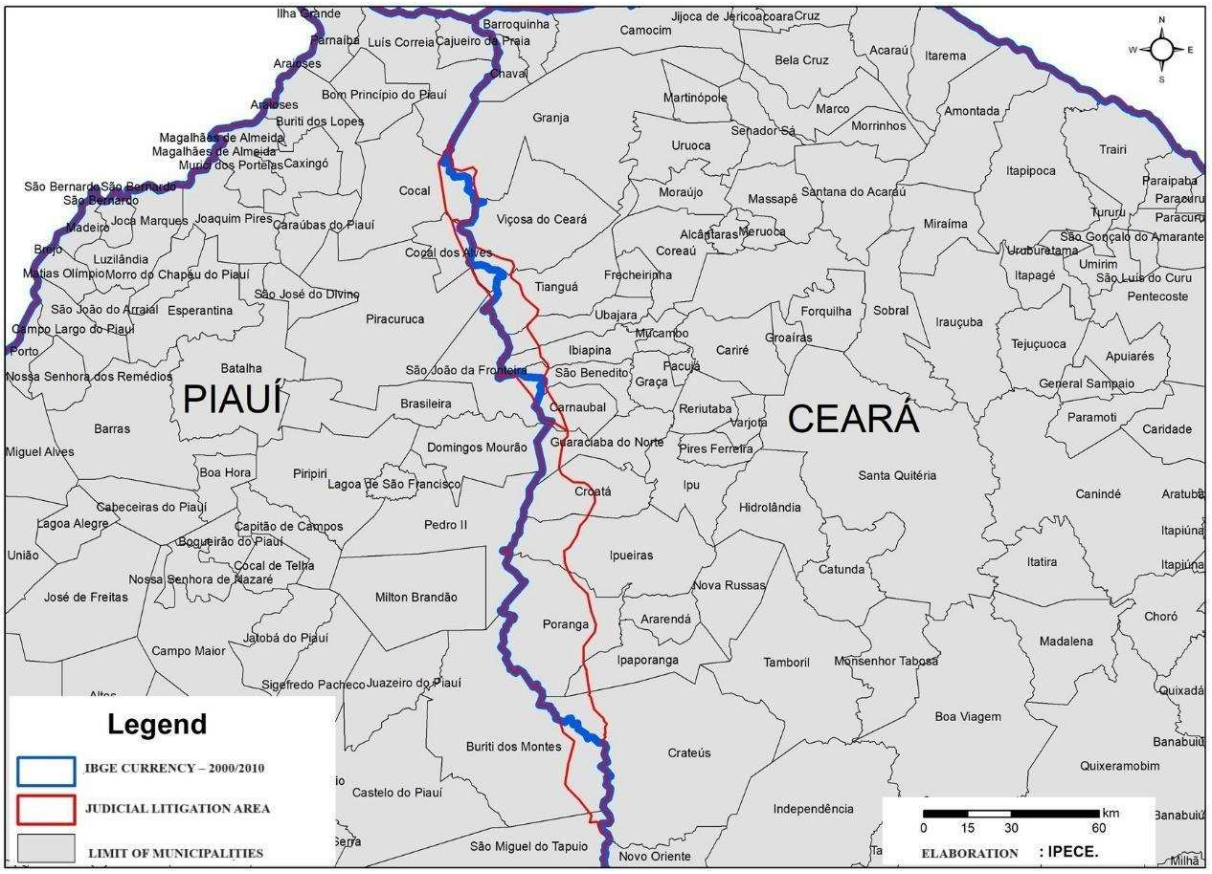
The work was also developed through field research, which sought to identify the geological and geomorphological aspects of the analysis area, seeking to define the western limits of the Serra da Ibiapaba on the ground.

Results and Discussion

The area of dispute

In 2011, the state of Piauí filed an Original Civil Action (ACO) with the Federal Supreme Court (STF), contesting territorial delimitations with Ceará. Within the scope of this lawsuit, the plaintiff state is seeking a review of three disputed areas (Figure 1). These disputed areas total approximately 3,000 km² involving parts of 13 municipalities in Ceará and 9 in Piauí.

Figure 1 - Municipalities directly involved in the dispute area



Source: IPECE.

The area in question covers several municipalities in both states. On the Ceará side, Granja, Viçosa do Ceará, Tianguá, Ubajara, Ibiapina, São Benedito, Carnaubal, Guaraciaba do Norte, Croatá, Ipueiras, Poranga, Ipaporanga and Crateús stand out. On the Piauí side, Cocal, Cocal dos Alves, Luís

Correia, Piracuruca, São João da Fronteira, Pedro II, Buriti dos Montes, Domingos Mourão and São Miguel do Tapuio are included.

Figure 1 provides a clear view of the territorial context, highlighting the municipalities of Ceará in the Serra da Ibiapaba and Sertão dos Crateús regions. This area of litigation is not only a political and legal challenge, but also carries with it a wealth of geography, culture and history that demands a systemic and holistic analysis. Through geological-geomorphological mapping of the western foothills of the Serra da Ibiapaba, this study seeks to shed light on one of the important aspects to be considered in this analysis, contributing to a deeper and more comprehensive understanding of the complexity involved in the territorial dispute between Ceará and Piauí in the context of ACO 1.831.

The historical border between Ceará and Piauí

According to Medeiros and Lima (2023), the land disputes between Ceará and Piauí date back to the colonial period, more than 300 years ago. In this context, Piauí, then linked to the state of Maranhão, began to requisition the lands of the Ibiapaba Mission. These lands were inhabited by the Tabajara Indians, who belonged to Ceará, which at the time was linked to the state of Brazil.

In 1721, a royal charter issued by the King of Portugal, João V, established that the entire Serra da Ibiapaba would be destined for the Tabajara nation, located in the captaincy of Ceará, in response to the indigenous people's deep sense of belonging.

It is worth noting that this document refers to the historical jurisdiction of the disputed area discussed in ACO 1.831 for the state of Ceará. In addition, the royal charter not only delineated Ceará's ownership of the entire Ibiapaba mountain range, but also attested to the inhabitants' territorial and cultural identity with the territory, rooted in centuries of history and tradition.

After a period of years, the then Province of Piauí claimed the administration of the Parish of Amarração, which was under the jurisdiction of Ceará. The justification for this claim was the construction of a port that would boost the development of the province. This claim was put into effect by Imperial Decree no. 3.012, dated 1880, which resulted in the exchange of two territories. In this way, the parish of Amarração, comprising the current municipalities of Luís Correia and Cajueiro da Praia, passed to the domain of Piauí, while the Comarca de Príncipe Imperial, encompassing the current municipalities of Crateús and Independência, became part of the territory of Ceará (Gaspar, 2023).

According to Gaspar (2023) and Medeiros (2022), this decree exclusively delimited the area of the two exchanged territories and did not establish, as the state of Piauí claims, the full border between Ceará and Piauí through the watershed of the Ibiapaba mountain range. Thus, the Ibiapaba mountain

range remained entirely under the domain of Ceará, since the historical boundary between these then provinces corresponded to the western foot of this mountain since the time of the States of Brazil and Maranhão.

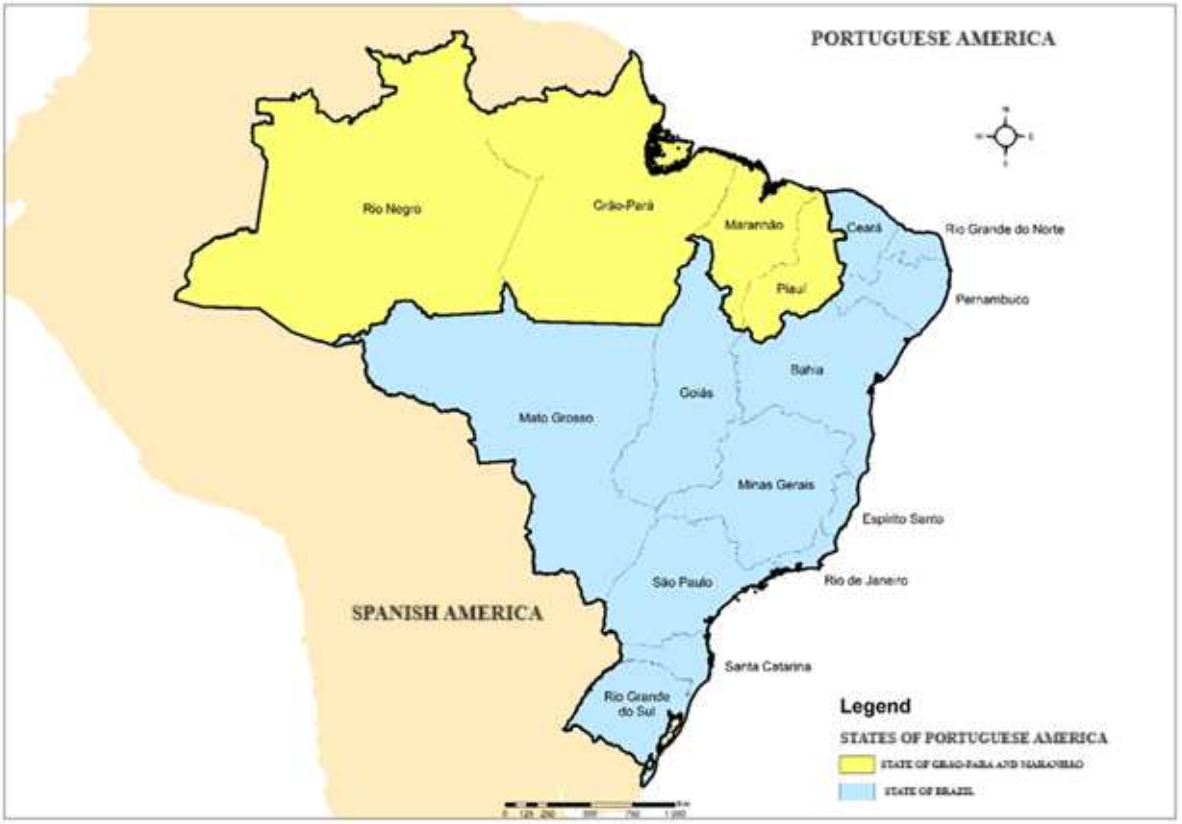
It is mentioned that the Empire of Brazil was made up of two vast regions, representing former colonies of the Portuguese Monarchy. The Northern region, known as the State of Maranhão[1], and the Southern region, called the State of Brazil, were distinct areas, both under the authority of the Portuguese crown, but administered separately.

This geographical division, shown on maps from the time, reflects the organizational structure during Portuguese rule (Figure 2). This historical context is crucial for understanding the current territorial dispute between Ceará and Piauí, which is intrinsically related to the delimitations established in the Brazilian Empire.

According to Gaspar (2023), from the time when the Brazilian Empire was made up of the states of Brazil and Maranhão, the roots (western side) of Ibiapaba mountain range already served as the boundary between Ceará and Piauí, with this mountain being located in Ceará territory.

[1] Created as the State of Maranhão in 1621 by Philip II of Portugal, it was renamed the State of Maranhão and Grão-Pará in 1654. Later, in 1751, it was again renamed the State of Grão-Pará and Maranhão, which was divided in 1772.

Figure 2 - States of Maranhão and Brazil

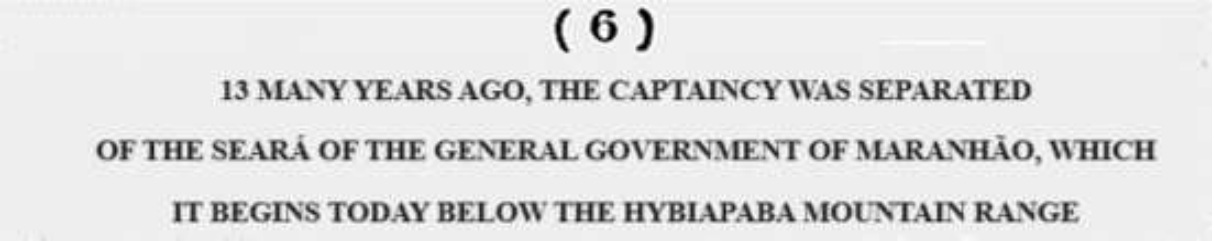


Source: Instituto do Ceará. Organized by the authors.

The author mentions that Bernardo Pereira de Berredo[2], who was governor-general of Maranhão from 1718 to 1722 (the captaincy of Piauí was linked to Maranhão), gave a precise description of the border between the states of Maranhão and Brazil. In his work "Annaes Historicos do Estado do Maranhão" (Figure 3), completed in 1718, he states that the state of Maranhão "has its beginning today below the Hypiapaba mountain range", clearly establishing the location of the demarcation.

[2] Book "Annaes Historicos do Estado do Maranhão - do seu descobrimento até o ano de 1718" by Bernardo Pereira de Berredo, 1849, 2nd edition, Typographia Maranhense, São Luís (MA).

Figure 3 - Part of the publication Annaes Historicos do Estado do Maranhão[3]


(6)

13 MANY YEARS AGO, THE CAPTAINCY WAS SEPARATED
OF THE SEARÁ OF THE GENERAL GOVERNMENT OF MARANHÃO, WHICH
IT BEGINS TODAY BELOW THE HYBIAPABA MOUNTAIN RANGE

Source: Gaspar, 2023.

When analyzing the quote from the Governor of the State of Maranhão, Bernardo Pereira de Berredo, it is essential to put the geographical scenario of the time into context. When the author mentions that the State of Maranhão begins below Ibiapaba mountain range, this reference applies to the territory located to the west of the aforementioned mountain range, given that the State of Maranhão was located to the west of the province of Ceará.

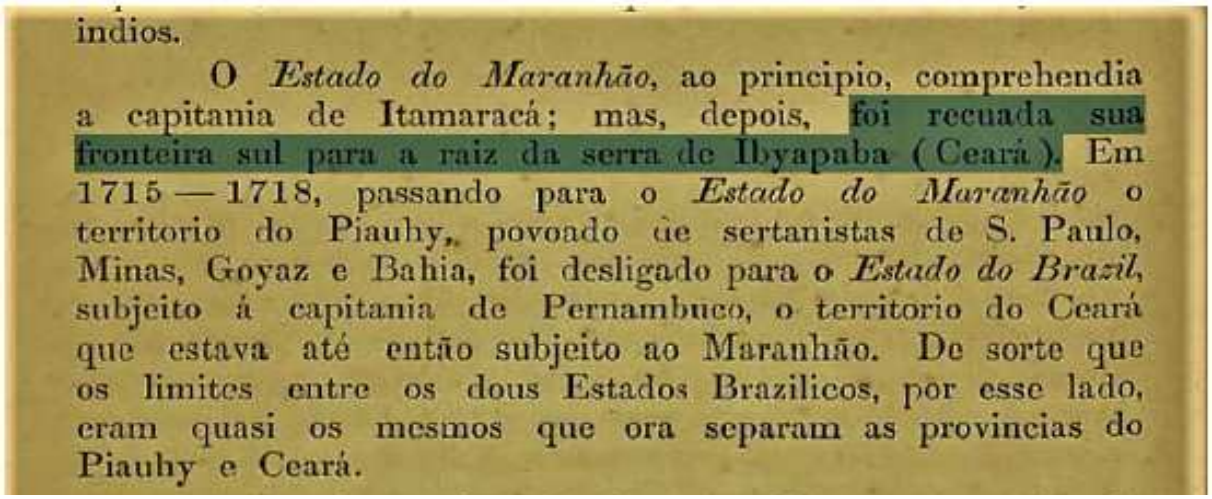
Therefore, the western foothills of Ibiapaba mountain range are found closer to the state of Maranhão, followed by the reverse side of the Cuestiform Plateau of Ibiapaba, which is inclined towards the front; in other words, it increases its altitude from the state of Maranhão towards the province of Ceará, corresponding to the behavior of the summit of the cuesta (highest parts of the mountain), before reaching the escarpment of Ibiapaba mountain range.

This geographical sequence clearly indicates that the historical demarcation of the border was established in the western foothills of Ibiapaba mountain range, in line with the royal charter of 1721 in which the King of Portugal determined that the entire Ibiapaba mountain range would belong to the captaincy of Ceará. Thus, the geographical direction and natural conditions justify the demarcation in the western foothills, in view of the west/east direction from the State of Maranhão to the Province of Ceará.

Over time, various historical sources have corroborated the words of the then governor-general of Maranhão, Bernardo Pereira de Berredo: “Maranhão begins below Ibiapaba mountain range”. As an illustration, Figure 4 shows the transcription of the delimitation between Ceará and Piauí by the historian João Mendes de Almeida, in his work “Some Genealogical Notes”[4], published in 1886.

[3] Available on the internet: https://bdlb.bn.gov.br/acervo/handle/20.500.12156.3/440067.
[4] Available on the internet: https://www2.senado.leg.br/bdsf/handle/id/518647.

Figure 4 - Part of the publication Some Genealogical Notes



indios.

O *Estado do Maranhão*, ao principio, comprehendia a capitania de Itamaracá; mas, depois, foi recuada sua fronteira sul para a raiz da serra de Ibyapaba (Ceará). Em 1715 — 1718, passando para o *Estado do Maranhão* o territorio do Piauhy, povoado de sertanistas de S. Paulo, Minas, Goyaz e Bahia, foi desligado para o *Estado do Brazil*, subjeito á capitania de Pernambuco, o territorio do Ceará que estava até então subjeito ao Maranhão. De sorte que os limites entre os dous Estados Brazilicos, por esse lado, eram quasi os mesmos que ora separam as provincias do Piauhy e Ceará.

Source: Almeida, 1886. Free translation by the authors: the state of Maranhao comprised the captaincy of Itamaraca; but later, its southern border was pushed back to the base of the Serra da Ibyapaba (Ceara). In 1715-1718, the territory of Piauhy, populated by backwoodsmen from São Paulo, Minas, Goyaz and Bahia, passed to the state of Maranhao, and the territory of Ceara, which had until then been subject to Maranhao, was separated from the state of Brazil, subject to the captaincy of Pernambuco. So the boundaries between the two Brazilian states, on this side, were almost the same as those that now separate the provinces of Piauhy and Ceara.

It is noteworthy that Ferreira (1908) records that the border between the state of Maranhão and the captaincy of Ceará corresponded to the fringes of the Grande Mountain range, as Ibiapaba mountain range is also known, being in Ceará territory.

It is worth mentioning that according to Soares (1988), cited in Lima and Lima (2020), when a boundary is established by natural delimitation where the landform is a mountain, the boundary can pass through the ridge line, the foothills, or the water line.

Gaspar (2023) explains that the term “fralda” is defined by any Portuguese dictionary as “the lower part, the flaps, or the foot (of a mountain, hill, etc.)”. This implies that the captaincy of Piauí, at the time linked to the state of Maranhão, began at the foot of Ibiapaba mountain range, i.e. the western roots of this mountain range.

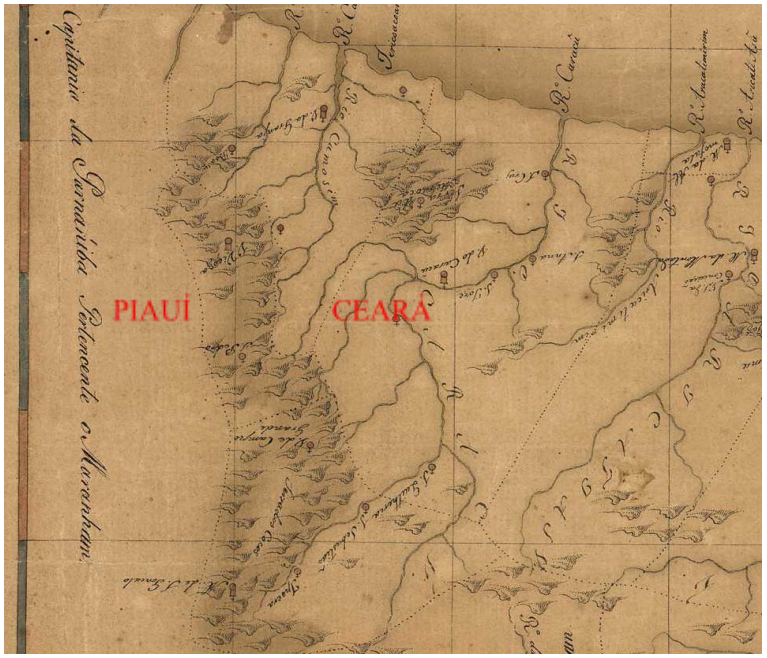
It should also be noted that several historical maps show the border between the states of Ceará and Piauí as being the western foothills of Ibiapaba mountain range (Medeiros and Lima, 2023)[5]. Examples include the map of the Captaincy of Ceará from 1800 (Figures 5 and 6), the map of the Captaincy of Piauí from 1809 (Figures 7 and 8) and the map of Ibiapaba mountain range from 1922 (Figure 9).

[5] Available at: https://www.pge.ce.gov.br/wp-content/uploads/sites/47/2023/12/Nota_Tecnica_Documentos_Historicos_Litigio_Ceara_Piaui.pdf.

Figure 5 - Geographical map of the Captaincy of Ceará - 1800

Source: Digital Library of the National Library Foundation.[6]

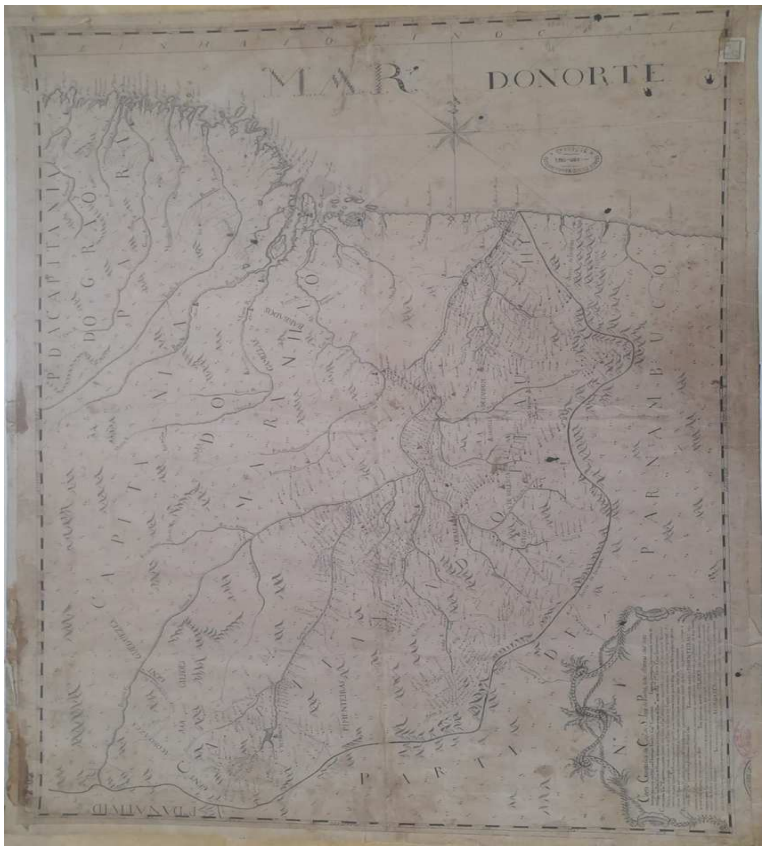
Figure 6 - Detail of the Geographical map of the Captaincy of Ceará - 1800, showing the entire Ibiapaba mountain range in Ceará territory. The border between the provinces of Ceará and Piauí corresponded to the western roots of this mountain range



Source: Digital Library of the National Library Foundation [9].

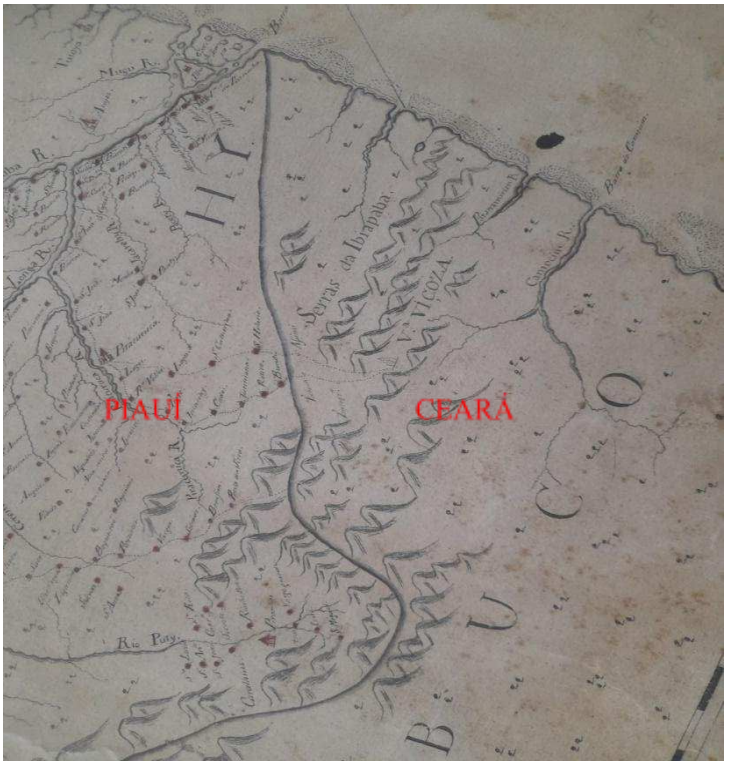
[6] Available at: http://objdigital.bn.br/objdigital2/acervo_digital/div_cartografia/cart511693/cart511693.jpg.

Figure 7 - Geographical map of the Captaincy of Piauí, drawn up by Joze Pedro Cezar de Menezes, 1809



Source: Medeiros e Lima (2023).

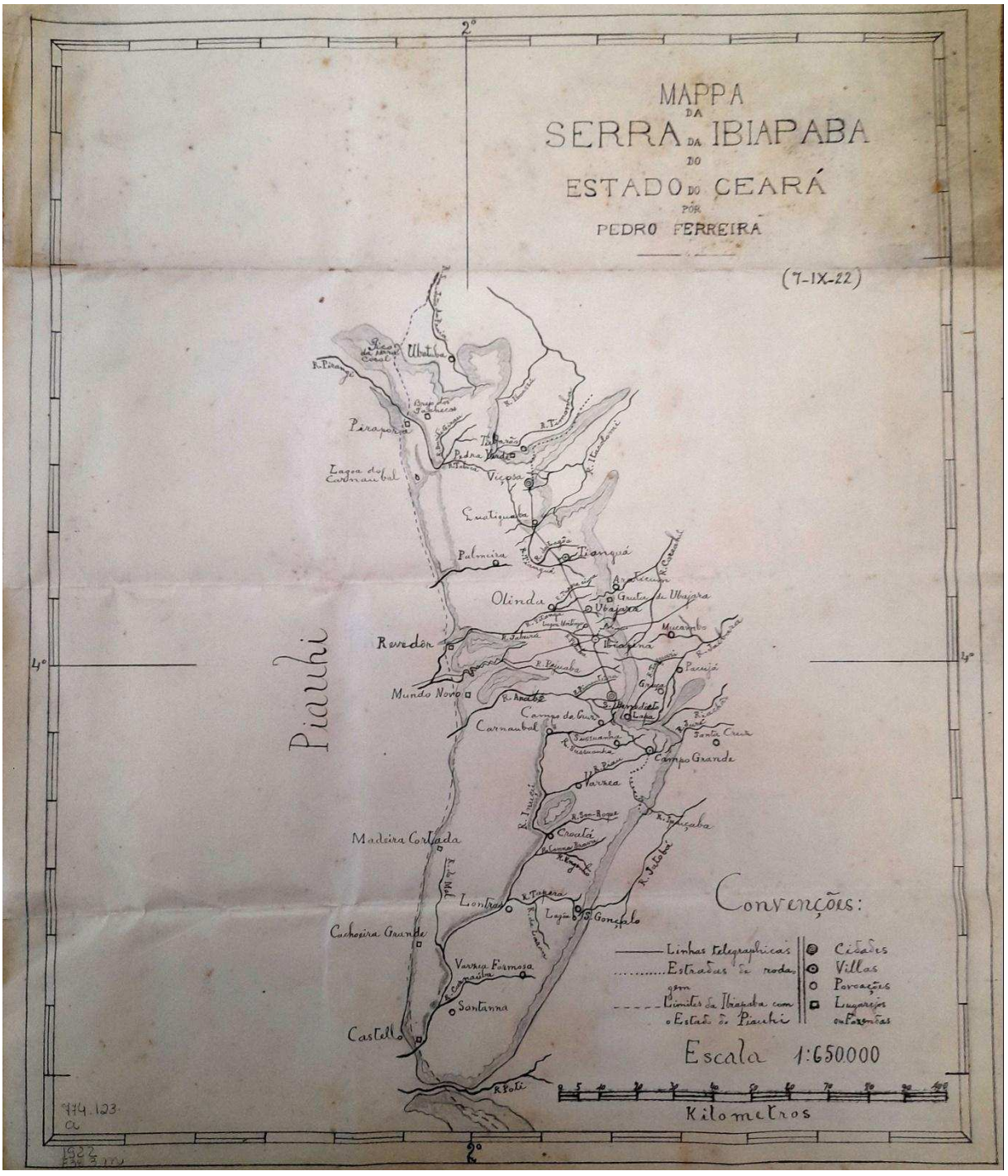
Figure 8 - Detail of the Geographical map of the Captaincy of Piauí - 1809, showing the entire Ibiapaba mountain range in Ceará territory.



Source: Digital Library of the National Library Foundation[9].

Figure 9 shows a map of the Ibiapaba mountain range on a scale of 1:650,000, providing a detailed view of the region. The demarcation of the border between Ceará and Piauí is clearly delineated as being at the western roots of the Ibiapaba, providing a clear visual representation of the border between the two states.

Figure 9 - Map of the Serra da Ibiapaba, drawn up by Pedro Ferreira, on a scale of 1:650,000



Source: Brazilian Historical and Geographical Institute (IHGB).

In addition, the map highlights infrastructure and communication features, such as telegraph lines and highways, which often reflect the development and administration of the territory. These elements indicate the region's historical and geographical connection with Ceará, consolidating the historical and legal basis for the state's jurisdiction over the Ibiapaba mountain range.

Another significant aspect is the precise identification of the location of towns, villages and hamlets on the map. For example, the towns of Cachoeira Grande and Pirapora are clearly located in Ceará territory, confirming the presence of the state of Ceará in the region.

It can therefore be concluded that the border between the states of Ceará and Piauí corresponds to the roots of Ibiapaba mountain range on its western side, keeping this mountain entirely in Ceará territory since 1718, when the captaincy of Piauí was annexed to the state of Maranhão, and the captaincy of Ceará was reincorporated into the state of Brazil.

In the meantime, it is important to point out that historical maps, especially those drawn up in the 18th and 19th centuries, represent valuable sources of information about the perception and representation of the world by the people of the time. However, it is crucial to bear in mind that the accuracy and cartographic methods used in those eras can vary considerably compared to modern cartographic standards.

Such maps should not be used categorically or in isolation to claim territorial ownership today. For contemporary legal issues and territorial disputes, it is imperative to resort to more recent data sources and more accurate mapping techniques, as well as listening to the population living in the region.

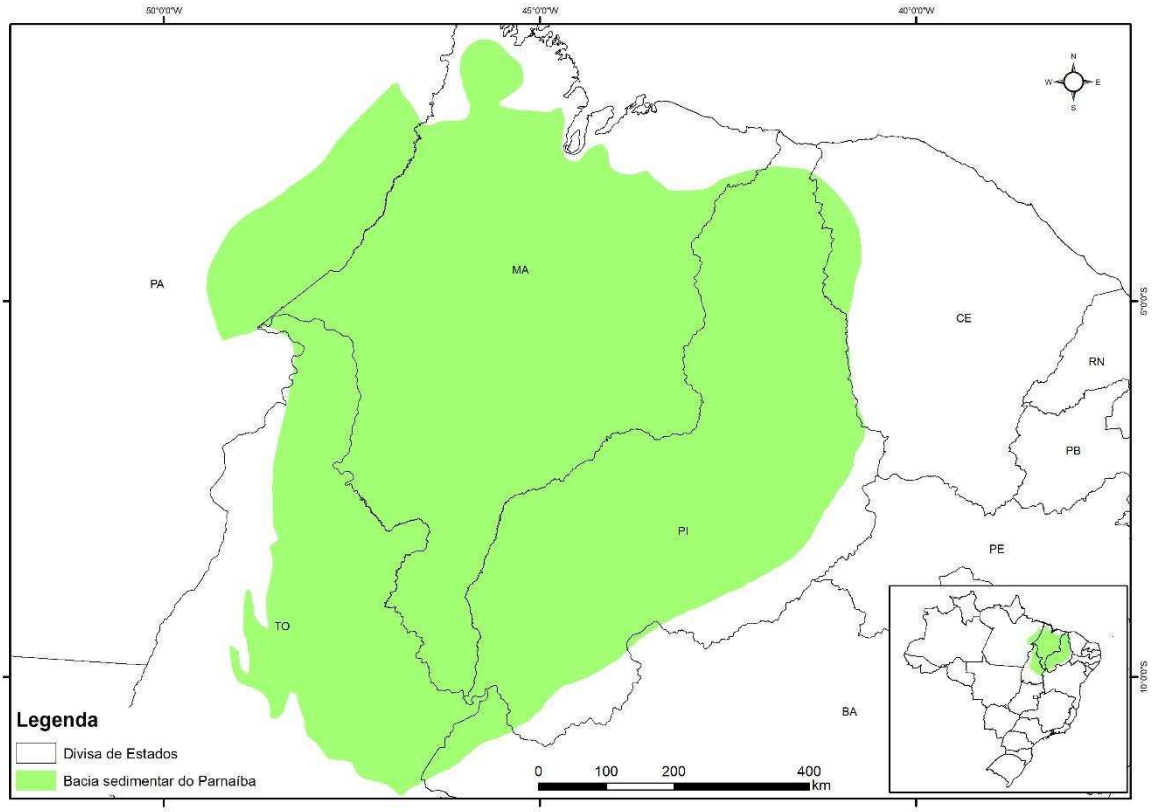
The geological-geomorphological analysis and mapping of the western foothills of Ibiapaba mountain range was carried out in order to delimit the historical boundary between the states of Ceará and Piauí. To this end, modern cartographic techniques and remote sensing products were used, and the cartographic data was analyzed using an integrated Geographic Information System (GIS).

The western foothills of the Ibiapaba mountain range

The Parnaíba basin, where Ibiapaba mountain range is located, is first put into context. This basin corresponds to a Brazilian intracratonic sedimentary basin, located in the western Northeast region. Occupying an area of 665,888 km², it is spread over the states of Piauí, Maranhão, Pará, Tocantins, Bahia and Ceará (Almeida; Brito Neves; Carneiro, 2000).

The Parnaíba basin (Figure 10) is elliptical in shape, with the major axis-oriented NE-SO and a length of approximately 1,000 km; in the depocenter, the thickness of the sedimentary column reaches around 3,500 meters (Castro et al., 2013).

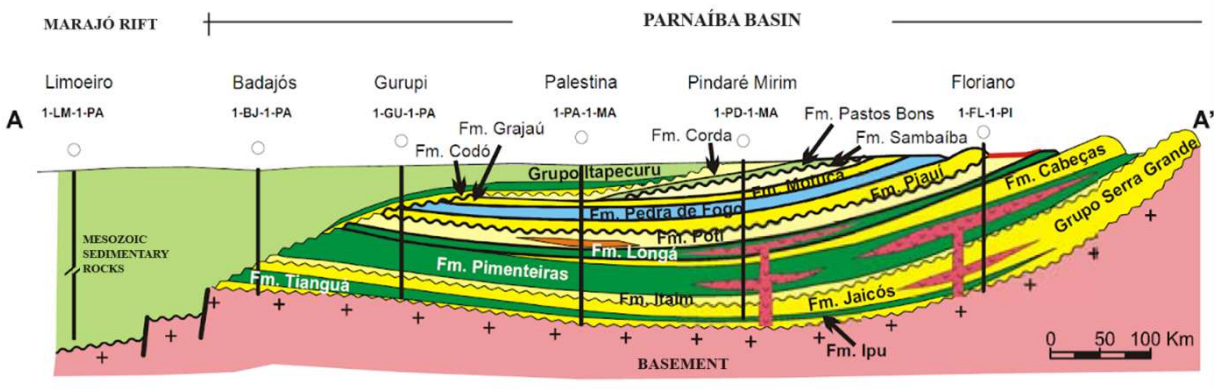
Figure 10 - Location of the Parnaíba sedimentary basin in the context of Brazil



Source: The authors.

The sedimentary column of the Parnaíba Basin is made up of three geological groups: the Mountain Range Grande Group, of Silurian age (443 - 419 million years ago), the Canindé Group, of Devonian-Carboniferous age (419 - 298 million years ago), and the Balsas Group, of Carboniferous-Triassic age (298 - 200 million years ago) (ANP, 2015). These groups are subdivided into various geological formations. Figure 11 illustrates the distribution of these geological elements.

Figure 11 - Stratigraphy of the Parnaíba Basin



Source: Caputo; Iannuzzi; Fonseca, 2005.

The oldest sequence in the Parnaíba sedimentary basin thus corresponds to the "Serra Grande Group" stratigraphic unit, characterized by the presence of clastic rocks. It is made up of the Ipu (base), Jaicós and Tianguá (top) formations (CPRM, 2020). The maximum subsurface thicknesses are: 200 meters in the Tianguá Formation, 350 meters in the Ipu Formation, and 360 meters in the Jaicós Formation (Góes; Feijó, 1994).

Although the Grande Mountain range Group is the oldest and corresponds to the base of the basin, it outcrops on the eastern, southeastern and northeastern edges and flanks. In these segments, the Grande Group Mountain range has large exposures, and very well demarcates the current boundaries of the basin, maintained by sandstones that form plateaus and features with abrupt terminations, of the cuestiform type (Santos; Carvalho, 2004).

There are two reasons why the Grande Group Mountain range emerges on the surface, forming important reliefs on the edges of the basin, and both are tectonic in nature. The first situation is associated with the process of genesis of the sedimentary basin itself, in the Paleozoic/Mesozoic, and the second with the subsequent evolutionary process, in the Mesozoic/Cenozoic.

In the first case, it is necessary to understand the multifaceted process of formation of post-orogenic sedimentary basins. As stated by Penteado (1978), sedimentary basins with a calm structure are those which, after their formation, were not disturbed by orogenesis, with folds, faults or fractures, to the point of modifying the original structure. The Parnaíba sedimentary basin would fit into this type of structure, since it was formed in the context of the post-orogenic Neoproterozoic Brazil (Brito Neves; Fuck, 2013).

In this case, the layers are arranged on top of each other, either concordantly or discordantly. The result is the formation of a package of sediments in stacked layers. According to Penteado (1978), this structure can include reliefs such as structural plains, cuestas, peripheral depressions and tabular plateaus.

Each of these types of relief depends on the arrangement of the layers. In practice, this reality is witnessed by the morphology of the eastern, northeastern and southeastern edges of the basin, with their typical reliefs of sedimentary structures (Santos; Carvalho, 2004).

According to Penteado (1978), the sedimentation cycle begins in a continental area which, after being devastated, is subjected to a marine transgression, resulting in sedimentation. A regression of the sea or an uplift of the coast causes these sediments to emerge, forming the basin. More detailed research indicates that the sedimentary cycles in this basin are characterized by the occurrence of a

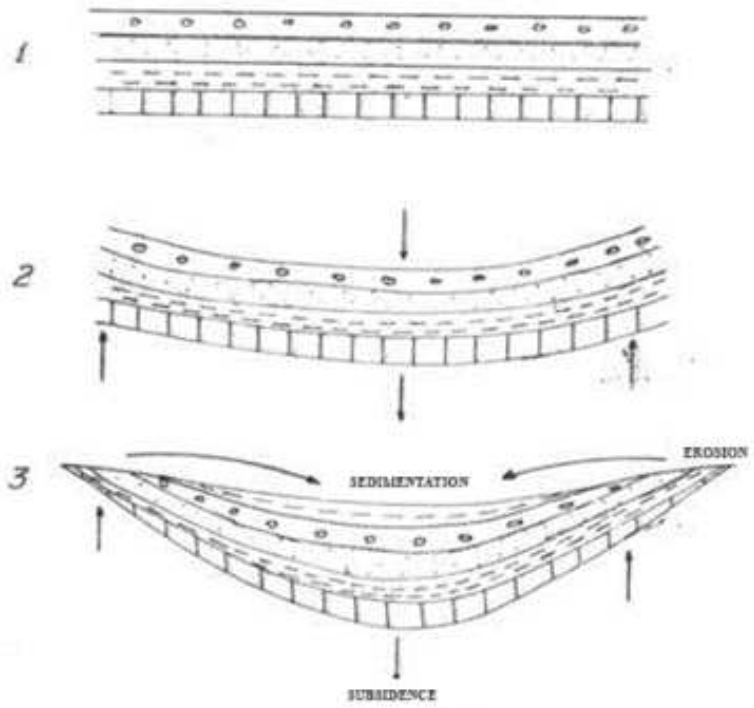
continental fluvial cycle at the beginning, overlapped by a marine cycle and ended by another continental fluvial cycle (Caputo; Lima, 1984; Santos; Carvalho, 2004).

In addition, it should be noted that the formation of the sedimentary basin also involved isostatic compensation phenomena, due to the overloading of the sediments. According to Penteado (1978), the evolution of a basin is as follows:

1. rhythmic sedimentation on the endocontinental sea floor, in a horizontal arrangement;
2. central subsidence due to sediment overload and uplift of the edges;
3. marginal uplift activates erosion which contributes to sedimentation in the center of the basin;
4. an erosion surface forms on the edges of the basin as a result of a central base level;
5. the continuity of the process tends to increasingly limit the central area of sedimentation and the deposits towards the center are increasingly recent;
6. at the end of the phase, the center of the basin becomes a lake and marine sedimentation is replaced by lacustrine and finally continental sedimentation.

This scheme, illustrated in Figure 12, is simplified. In reality, the phenomena are more complex. Both the subsidence and uplift of the edges do not occur regularly, either in time or space. However, these processes explain how the Grande Mountain range Group, which is the oldest and most basal (the first to be deposited), emerges at the edges of the basin.

Figure 12 - Schematic of the formation of a sedimentary basin



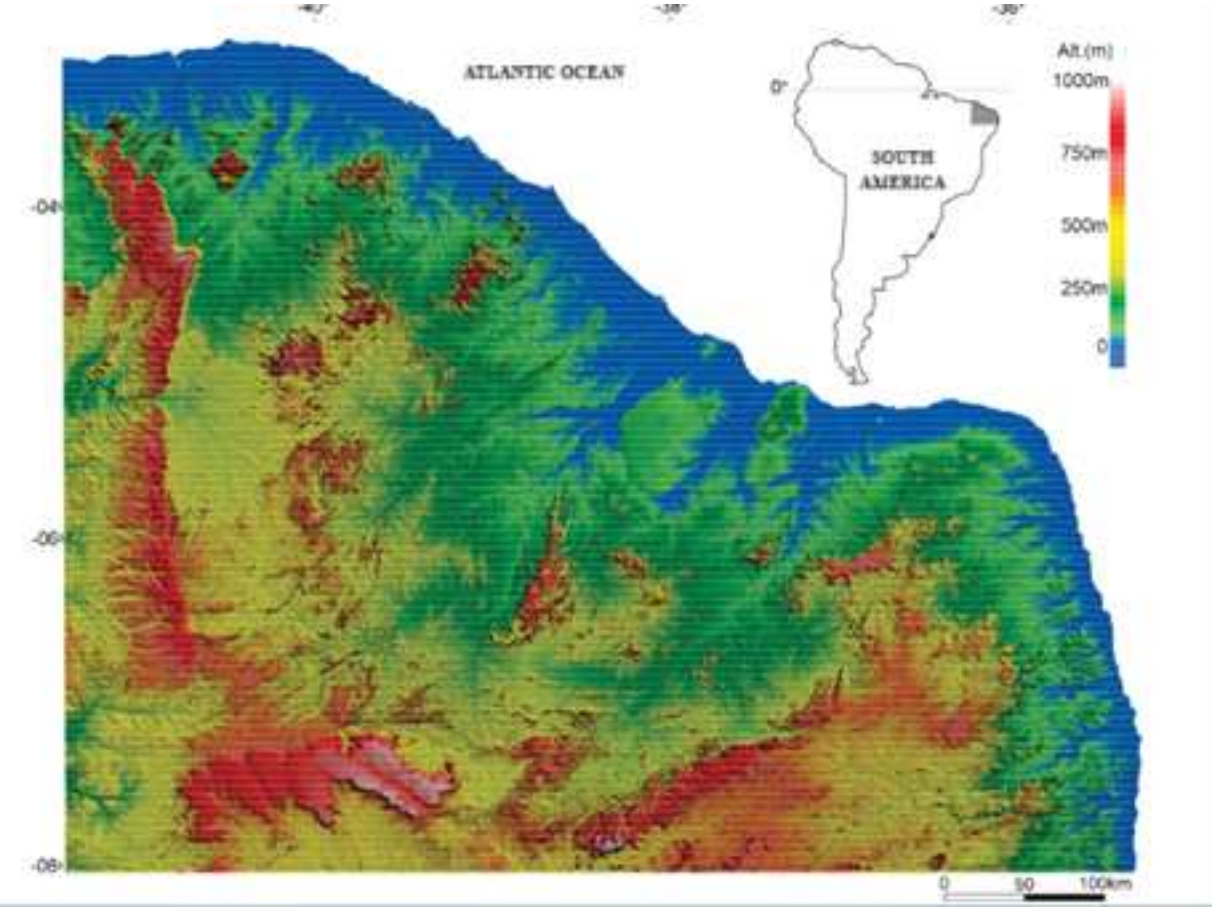
Source: Penteado, 1978.

The second element needed to understand the existence of reliefs on the eastern, southeastern and northeastern edges of the basin sustained by its basal layers - that is, not only the outcropping of Grande Group Mountain range sandstones on the surface, but also in conditions of high topography - is associated with the stages of plate tectonic intervention in the Brazilian Northeast.

The Parnaíba sedimentary basin, being intracratonic, was formed in the central segment of Gondwana, the southern part of the Megacontinent Pangea. Pangea split in the Northeast region of Brazil between 120 and 100 million years ago (Matos, 2000; Nance; Murphy, 2013), through rift-type extension processes. This geological action initially created the Apodi and Araripe rifts (which were aborted and evolved to form sedimentary basins), followed by the opening of the Atlantic Ocean.

The rifting process in the north-east of Brazil, associated with the division of Pangea, represented a geological effort of major proportions, which opened up tectonic pits (rifts) in the interior of the continent, while the lateral areas were uplifted (Peulvast; Claudino-Sales, 2004). This uplift was represented by the rise of the land on the sides of the Araripe-Apodi structural axis, which created the Borborema Plateau to the east and the high reliefs of the state of Ceará to the west (Peulvast; Claudino-Sales, 2004; Peulvast et al, 2008) (Figure 13).

Figure 13 - Elevated topography on the border between Ceará and Piauí, created by Cretaceous uplift

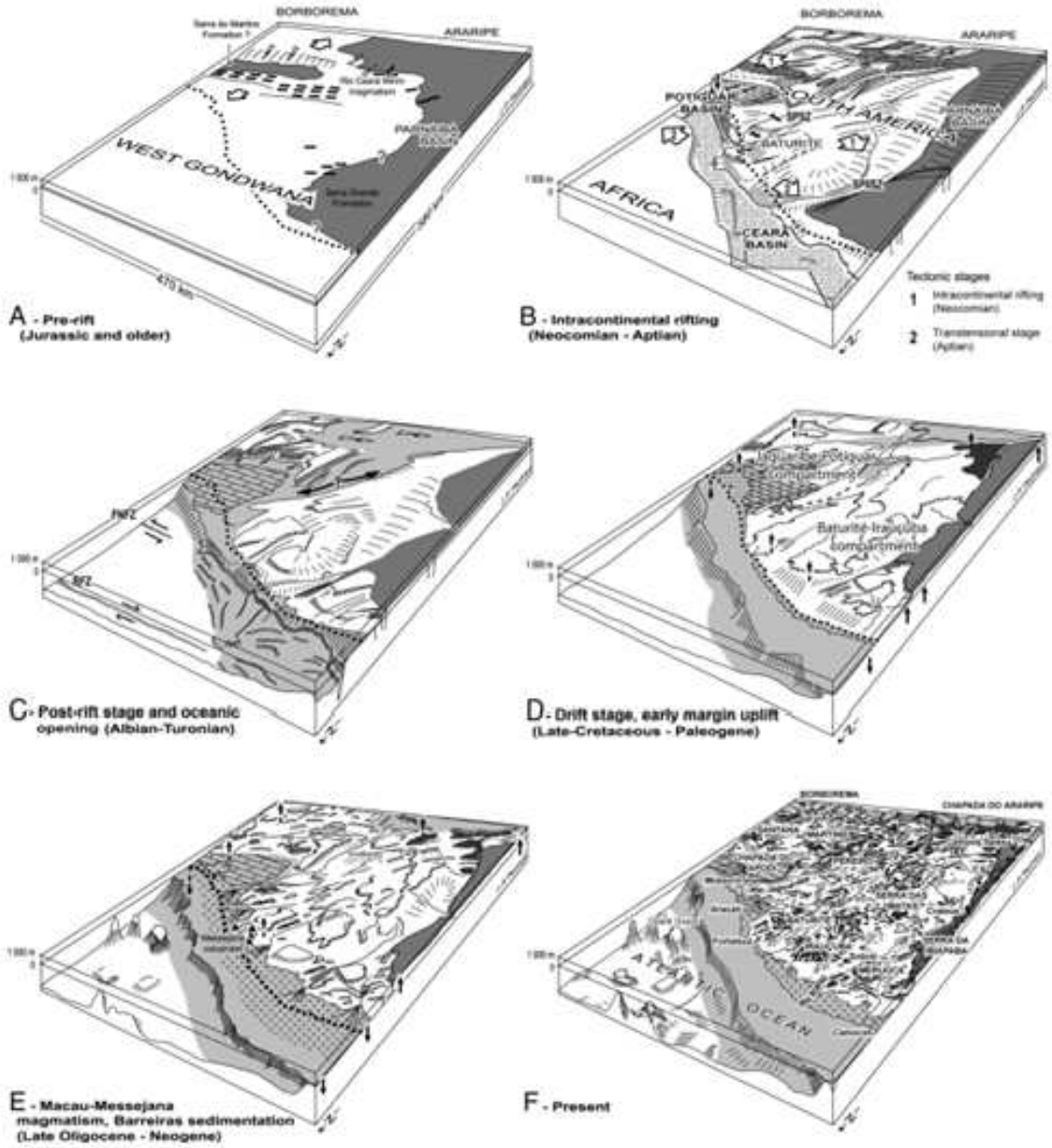


Source: Costa et al., 2020.

Here, it is necessary to emphasize a fundamental moment in this morphostructural evolution: the uplift of the crystalline terrains of the state of Ceará also uplifted, in solidarity, the edge of the Parnaíba basin, formed by the Grande Mountain range Group (Claudino-Sales, 2002, 2016; Peulvast; Claudino-Sales, 2004; Claudino-Sales; Peulvast, 2005, 2007; Peulvast et al., 2008; Peulvast; Betard, 2021, 2015) (Figure 13).

This uplift was responsible for the formation of an elevated relief, the so-called Ibiapaba Plateau (Ibiapaba mountain range), which evolved in the sequence through circumdenudation, a process responsible for the plateau's current forms (Costa et al., 2020) (Figure 14). Thus, the primordial uplift of the Ibiapaba Plateau is associated with the division of Pangea in the Cretaceous, which placed the basal terrains of the Grande Mountain range Group in a condition of high topography.

Figure 14 - Division of Pangea/Gondwana, with subsequent evolution of the relief of the Northern Northeast



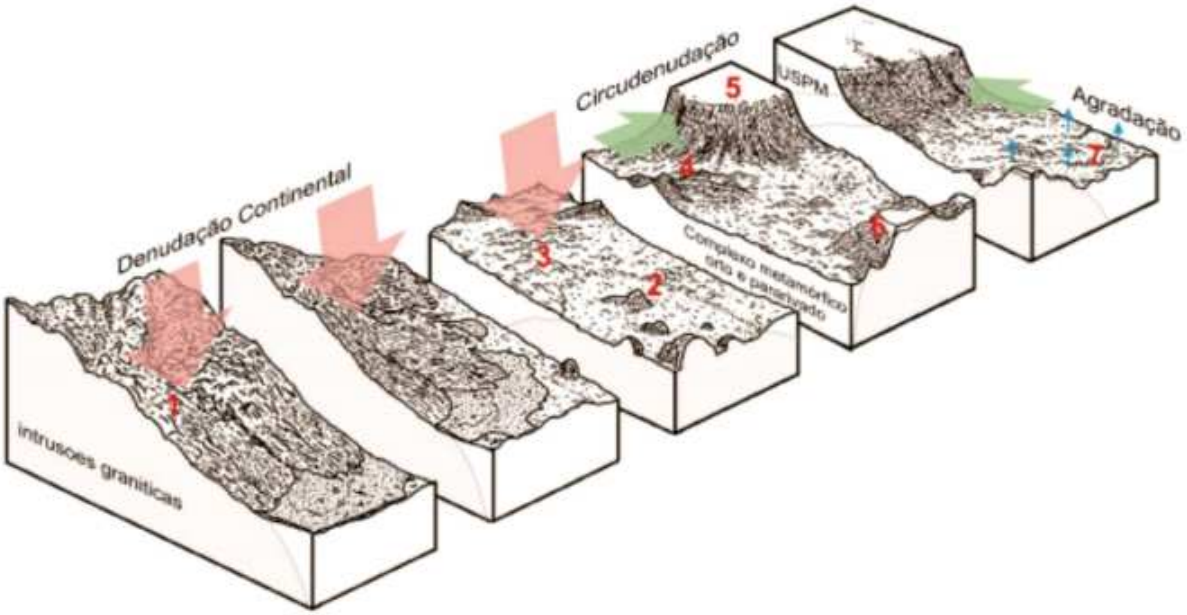
Source: Peulvast et al., 2008.

In this sense, the limits of the Ibiapaba Plateau coincide with the limits of the surface outcrops of Grande Mountain range Group, both to the east (in the state of Ceará) and to the west (in the state of Piauí). The rifting of the first stage of the division of Pangea uplifted the edges of the Parnaíba Basin, explaining how a basal feature (Grande Mountain range Group) could have been placed in conditions of high topography.

The Paleogene/Neogene (Tertiary) erosion process, which differentially attacked the rock layers of this geological group, finally shaped the reliefs in the form of glints, cuestas and chapadas,

which are the forms of relief that exist between the boundaries of the states of Ceará and Piauí (Claudino-Sales et al., 2020; Moura-Fé, 2018; Santos and Nascimento, 2016), as can be seen in Figure 15.

Figure 15 - Illustration of the Circumdenudation Process

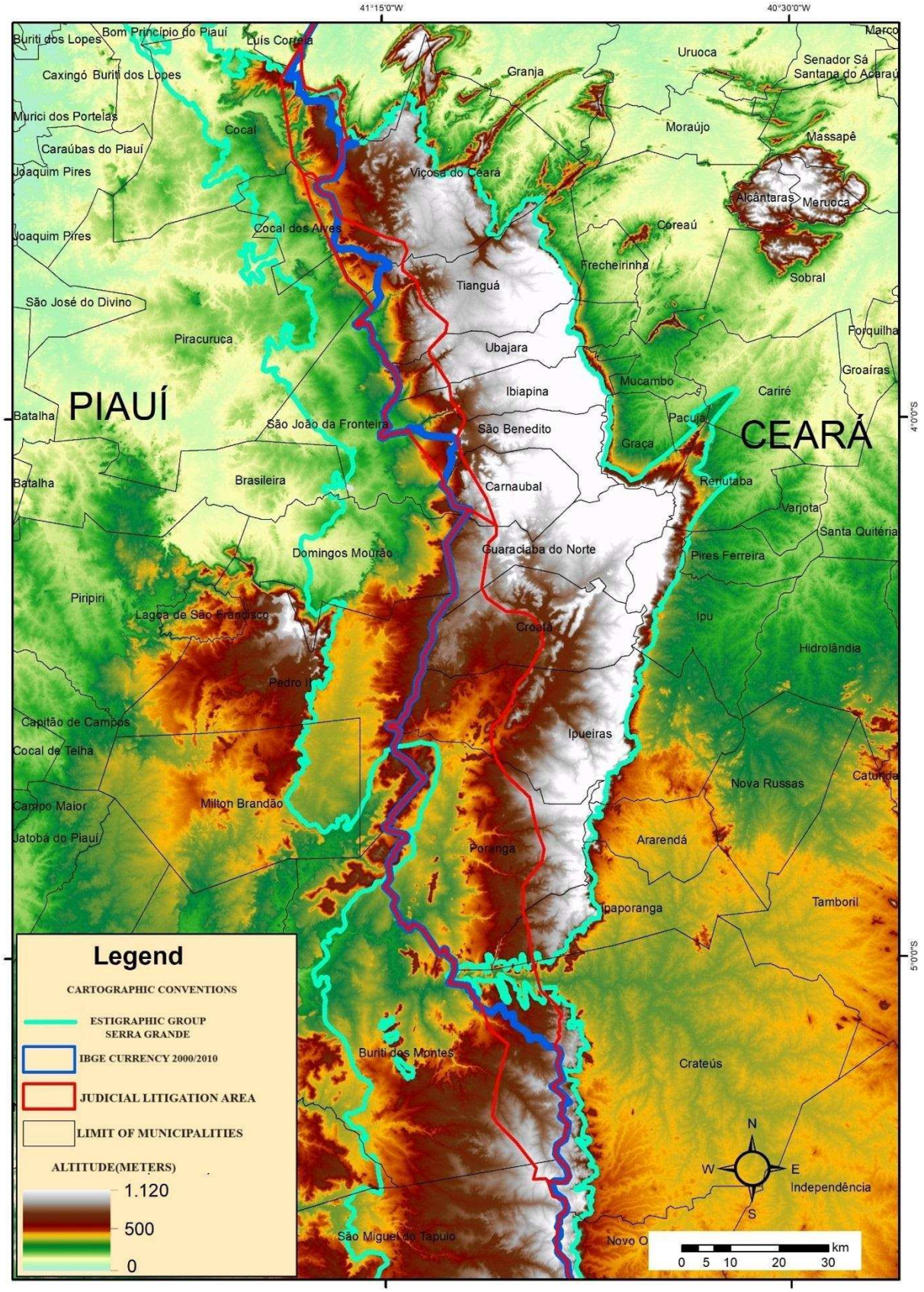


Source: Claudino-Sales et al., 2020.

In conclusion, the western limits of the Ibiapaba Plateau - which can be considered the foothills or roots of the Ibiapaba mountain range relief, in other words - undoubtedly coincide with the surface limits of the "Grande Mountain range" stratigraphic group.

Figure 16 shows the mapping of the Grande Mountain range stratigraphic group in the context of the disputed area and the boundary currently practiced by the IBGE. This figure also incorporates the Digital Elevation Model (DEM), generated using data from the SRTM (*Shuttle Radar Topography Mission*) project (NASA, 2024). It should be noted that the Grande Mountain range Group mapping data comes from the national geological map developed by the Geological Survey of Brazil (CPRM, 2023).

Figure 16 - Digital Elevation Model (DEM) in the context of the CE/PI dispute area and delimitation of the Serra Grande stratigraphic group



Source: Prepared by the authors.

When analyzing this figure, it is worth pointing out that Ibiapaba mountain range has a “glint cuestiforme” geomorphological feature, characterized by a steep slope on one side (escarpment) and a more gently sloping area on the other side (plateau).

Figure 16 clearly shows that the escarpment of this mountain range is positioned on the eastern side of the Grande Mountain range stratigraphic group, corresponding to the region with the highest altitudes, indicated by the white colors on the map. Similarly, the lowest altitudes, marked in green, are found on the western side of Ibiapaba mountain range, characterizing the western foothills of this mountain range.

Figure 17 highlights the detailed mapping of the western foothills of Ibiapaba mountain range, revealing a location substantially distant from the area of litigation claimed by the state of Piauí (red line on the map), in the context of Original Civil Action 1.831. This finding, supported by geographical and topographical data, shows that the boundary currently practiced by the IBGE between the states of Ceará and Piauí should be moved considerably further to the west. At some points, this relocation could imply a distance of more than 25 km as the crow flies.

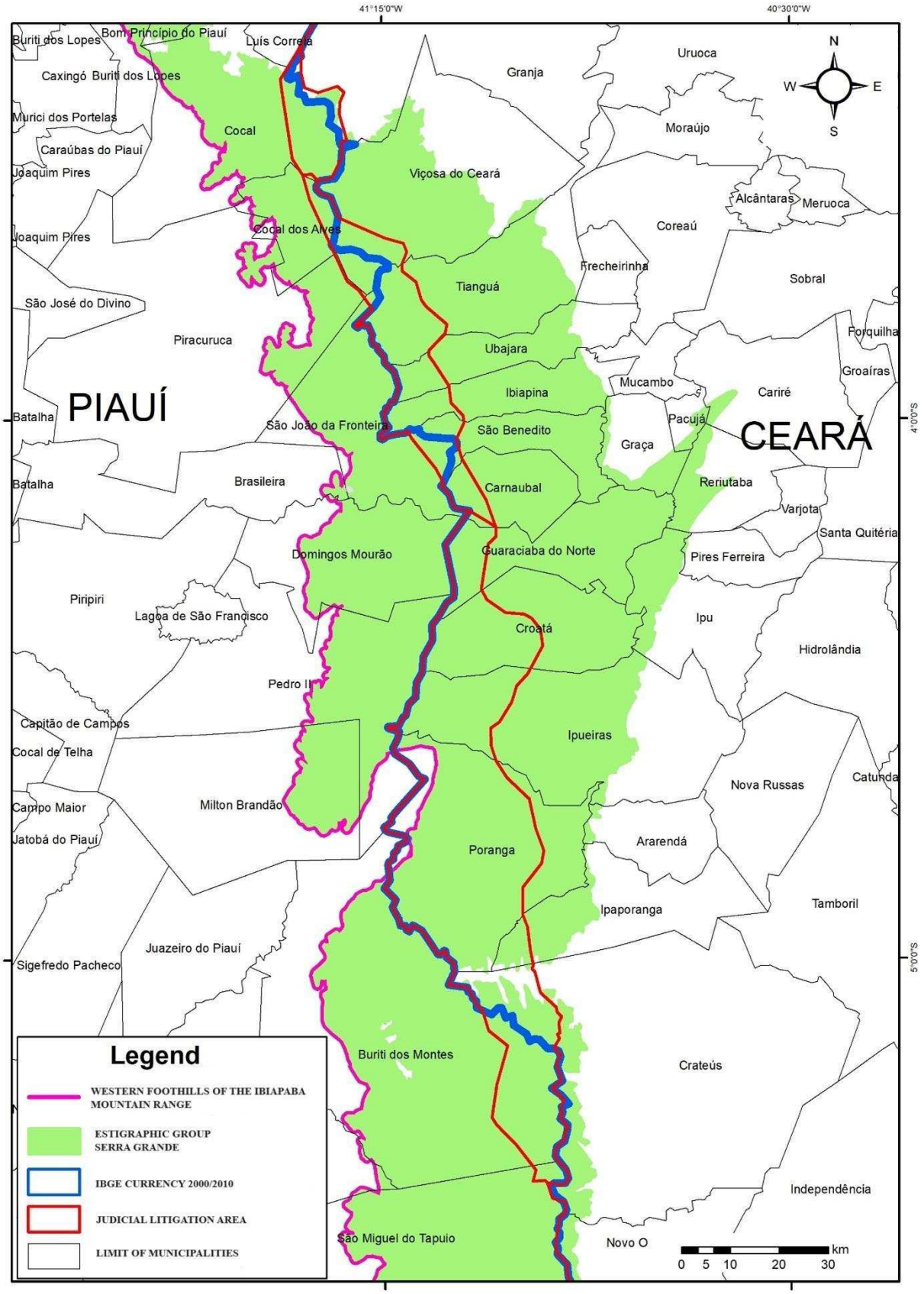
In this sense, it can be seen that over time part of the territorial area relating to the western foothills of Ibiapaba mountain range belonging to Ceará (around 3,460 km²) was occupied by the state of Piauí. Currently, this region is under consolidated occupation by the state of Piauí, and the resident population's sense of belonging should prevail.

The state of Ceará's defense of the disputed area delimited in ACO 1.831 is backed by historical documents dating back centuries. The historical legitimacy is complemented by the strong sense of belonging of the local population, whose cultural and social roots are intrinsically linked to Ceará.

It is important to note that a large part of the area in dispute is under the administrative jurisdiction of the state of Ceará, which has a history of providing services, with dozens of public facilities, to the population over decades (IPECE, 2023).

In summary, the robust technical analysis, backed up by historical, geological, geomorphological and cartographic data, substantially strengthens the arguments in favor of the state of Ceará in the territorial dispute in question. The combination of these elements provides a solid basis for redefining the border between the states, ensuring a fair delimitation that meets the local population's sense of belonging.

Figure 17 - Western foothills of Ibiapaba mountain range in the context of the CE/PI dispute area

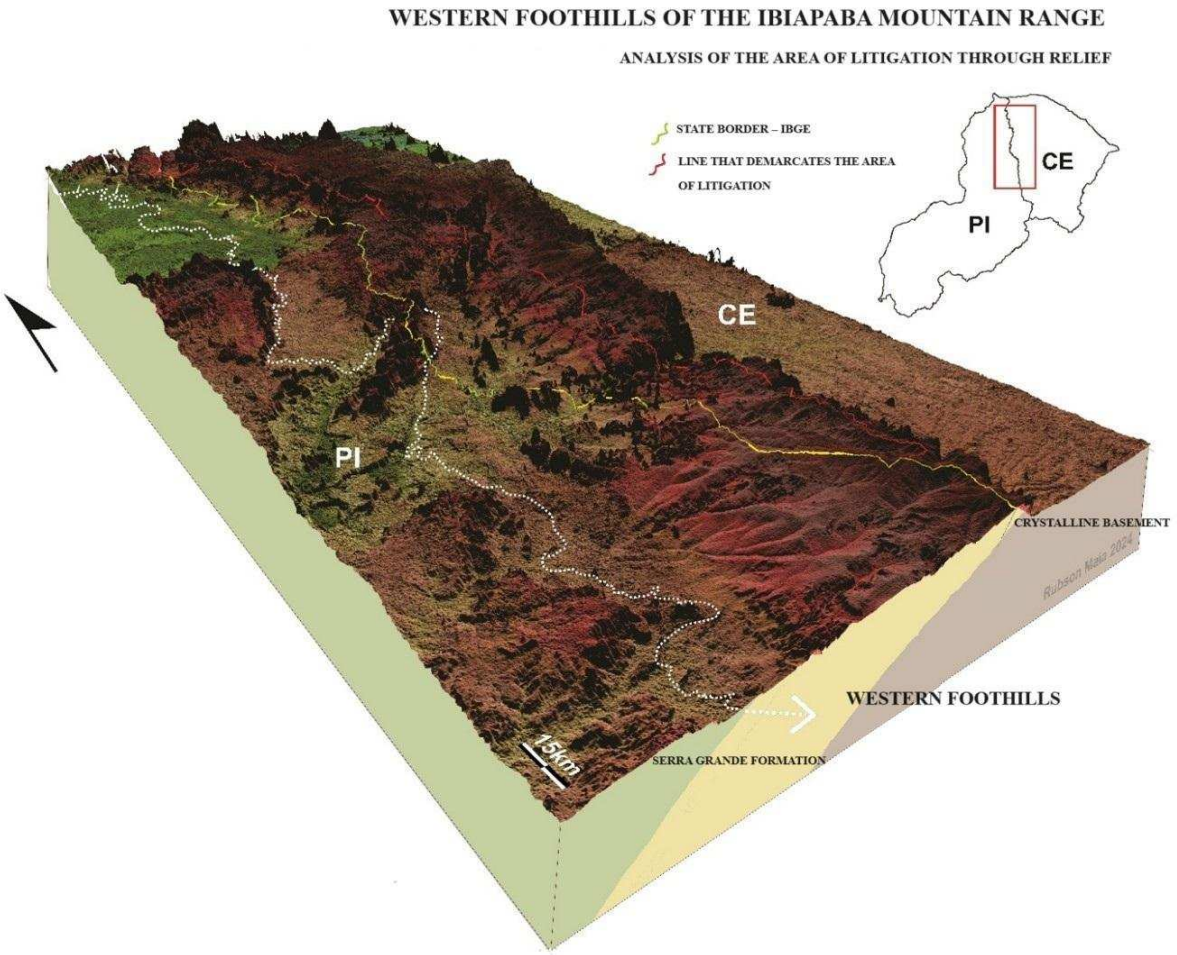


Source: Prepared by the authors.

Figure 18 shows the mapping of the western foothills of Ibiapaba mountain range using a block-diagram. As can be seen in this figure, the western foothills are completely visible geomorphologically, and are characterized as the lower portion, from an altimetric point of view, of the geomorphological compartment that comprises the reverse side of Ibiapaba mountain range cuesta.

Considering that the Ibiapaba mountain range is, in essence, a glint relief, which is a dissymmetrical relief form, it is clear to see *in loco* and in remote sensing products (derivation of contour lines in a Geographic Information System environment) that there is a bump in the relief, clearly showing a more significant altimetric increase from west to east, i.e. from the then State of Maranhão to the Province of Ceará.

Figure 18 - Block-diagram mapping the western foothills of the Ibiapaba Plateau, in the context of the dispute area



Author: Rubson Pinheiro Maia.

Final considerations

Given the complexity of territorial disputes between states, this research has played a crucial role in providing a robust technical analysis, based on historical, geological, geomorphological and cartographic data, with the aim of contributing to the resolution of the territorial controversy between the states of Ceará and Piauí.

When mapping the western foothills of Ibiapaba mountain range, the undeniable coincidence between the western limits of the Ibiapaba Plateau and the surface limits of the "Grande Mountain range" stratigraphic group stood out. The Grande Mountain range Group, deposited 420 million years ago, represents the base of a sedimentary package around 3,500 km thick. Although it forms the bottom of the basin, it emerges at the edges due to the initial process that caused the central part to sink and the edges to rise.

This process has continued for approximately 120 million years, since the beginning of the division of Pangea in the Northeast. A new uplift generated the high reliefs of Ceará, in solidarity with the Grande Mountain range Group, forming the early Ibiapaba mountain range. Subsequent erosion shaped the region into the current contours of the Ibiapaba Plateau. Therefore, the entire area with elevated outcrops of Grande Mountain range Group corresponds to this relief.

The geological mapping of Grande mountain range Group reveals its contact with the crystalline basement in Ceará and with other formations of the Parnaíba basin in Piauí. This western contact goes tens of kilometers into the state of Piauí, far from coinciding with the boundary proposed by Piauí in the context of ACO 1.831, which, if accepted, would grant a significant part of Ceará's territory to that state.

In view of these findings, the need to review the border between the states is highlighted, considering the technical analysis presented. The observation of a substantial distance, in some places more than 25 km as the crow flies, between the disputed area claimed by Piauí and the western foothills of the Ibiapaba mountain range, indicates the need for a fair and precise relocation of the border, directing it to the west towards the foothills Ibiapaba mountain range.

However, it is crucial to carry out this analysis in an integrated manner, taking into account that the affected areas (around 3,460 km²) may currently be occupied by a population that identifies with the state of Piauí, and that a sense of belonging must prevail.

In this sense, it should be noted that, given the historical territorial advance of Piauí over Ceará lands and the lack of a technical basis, the additional request made in ACO 1.831 has no justification. It should also be noted that almost the entire area of legal dispute is under the administrative jurisdiction of the state of Ceará, which has been providing public services to the local population for decades.

In this context, it is imperative to respect the population's right to be heard, in accordance with the constitutional precepts set out in Article 1 of the 1988 Constitution, which establishes the fundamental principles of the Federative Republic of Brazil, including citizenship and the dignity of the human person.

Thus, it is considered fundamental to respect the sense of belonging of the local population, whose cultural and social roots are intrinsically linked to Ceará, reinforcing the importance of a decision that reconciles historical, cultural and social factors in the resolution of ACO 1.831. In addition, this study contributes to the precise delimitation of the western foothills of the Ibiapaba mountain range, showing that Piauí has advanced into Ceará's lands over time.

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