

PATRIMONIO GEOLÓGICO, GESTIONANDO LA PARTE ABIÓTICA DEL PATRIMONIO NATURAL



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Autor: F. de Pablo (Agencia Menorca Reserva de Biosfera).

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GEOMORPHOSITES IN THE CEARÁ CENTRAL DOMAIN, BORBOREMA PROVINCE: POTENTIAL FOR SUSTAINABLE DEVELOPMENT OF THE NORTHEASTERN SEMIARID OF BRAZIL

LUGARES DE INTERÉS GEOMORFOLÓGICO DEL DOMÍNIO CEARÁ CENTRAL, PROVINCIA BORBOREMA: POTENCIAL PARA EL DESARROLLO SOSTENIBLE DE LA REGIÓN SEMIÁRIDA DEL NORDESTE DE BRASIL

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Abstract: The inventory of the geoheritage of the Ceará Central Domain, Northeastern Brazil, encompasses geosites showing many geological interests, distributed in eight geological frameworks. Five of these geosites represent the framework "Geomorphological Units" and were selected due to their potential for educational and geotourism uses. These geosites are composed of crystalline lithologies and comprise relevant features of the local landscape, normally associated to both cultural and ecological values and located in legally protected areas. This work brings up the characterisation of these geosites and highlights some features that can be used in geoconservation strategies aiming the sustainable development at the semiarid of Brazil, mainly by means of geotourism and educational practices.

Key words: Ceará, geoconservation, geoheritage, geomorphosites, geotourism

Resumen: *El Inventario del Patrimonio Geológico del Dominio Tectónico Ceará Central, en la región nordeste de Brasil, se compone de geosítios de intereses geológico diversos, repartidos en ocho categorías geológicas. Dentro de ese conjunto, cinco geosítios englobados en la categoría de Unidades Geomorfológicas y han sido seleccionados para este estudio debido a su potencial para el uso educativo y geoturístico. Los geosítios presentan litologías ígneas y metamórficas y revelan las principales características del paisaje del Dominio. De modo general, los geosítios están asociados con valores culturales y ecológicos y se encuentran en áreas legalmente protegidas. Este trabajo presenta la descripción de los geosítios destacando algunas características que pueden ser aplicadas en estrategias de geoconservación que promuevan el desarrollo sostenible de la región semiárida de Brasil, centrado principalmente en el geoturismo y en prácticas educativas.*

Palabras clave: Ceará, geoconservación, geomorfositos, geoturismo, patrimonio geológico

INTRODUCTION

Geomorphosites are locations whose main values are associated with relief forms and geomorphological dynamics processes. The set of these sites constitutes the geomorphological heritage, which may have scientific, cultural, historical, aesthetic, social or economic value (Panizza, 2001, Reynard *et al.*, 2007). As important records of landscape evolution and frequently associated with people's belonging feelings, these places may act as powerful tools in actions on sustainable land use.

In this context, this paper aims to characterise the geomorphosites that compound the inventory of geoheritage of the central-northern portion of Ceará Central Domain (CCD), Borborema Province, Northeastern Brazil (Figure 1). The inventory was carried out during 2015-2016 and was based on Brilha's (2016) inventory method and Wimbledon's (1999) frameworks approach. The selected geosites are intended to be used to reconstruct the geological history, as well as to propose geoconservation-based possibilities for sustainable development in this semiarid part of Brazil. Among the geosites, there are five geomorphosites comprising features that may be applied in geoconservation strategies such as geotourism and educational practices.

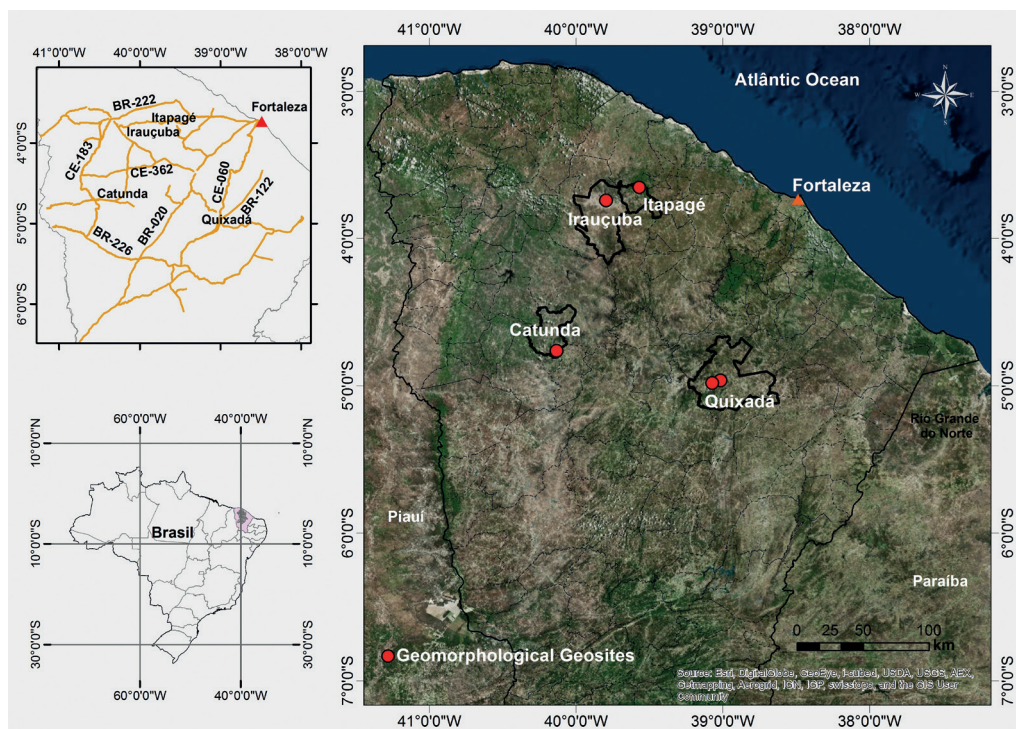


Figure 1. Location of the study area and geomorphosites (Source: Landsat Image available on the Google Earth, 2016).

Socioeconomic Setting

In the study area, the Human Development Index (HDI) ranges from 0.605 and 0.659, below Ceará State (0.682) and Brazil (0.727) averages. Local economy is strongly based on public resources and people earn their living as government employees or by means of social assistance programmes. Almost 70% of the population lives in a situation of vulnerability to poverty (PNUD, 2013).

Geological, Geomorphological and Environmental Setting

The CCD comprises a strongly deformed and intensely migmatized crystalline rock assemblage, with ages between ca. 2.9 Ga and 467 Ma, mainly resulted from West Gondwana collage: *i*) Archean Nuclei; *ii*) Paleoproterozoic juvenile gneissic basement; *iii*) Neoproterozoic volcano-sedimentary supracrustal sequence; and *iv*) Neoproterozoic plutonic rocks with magmatic arc isotopic signatures (Santa Quitéria Magmatic Arc) (Fetter *et al.*, 2003; Arthaud, 2007). Alkaline granitoid bodies also occur with lithological composition ranging from granodiorites, sienites, sienogranites, monzonites to monzogranites and granites with ages between 590 and 470 Ma (Almeida *et al.*, 1999, Castro *et al.*, 2012). These comprise the main lithotypes that compound the geomorphosites presented in this study.

The CCD landscape is dominated by hinterland depressions represented by a flat, slightly wavy relief whose elevations range between 130 and 150 meters. Residual massifs formed by ca. 600 meters-high acute-convex dissection patterns with mostly NNE-SSW-oriented inselbergs and areas with widespread saprolite remnants also compound the landscape (Lima *et al.*, 2000; Meireles, 2007; Maia *et al.*, 2015). Tropical climate predominates with temperatures ranging between 26 and 28°C and rainfall regime under 800 mm/year, alternating prolonged dry and short rainy seasons.

GEOMORPHOSITES

The geomorphosites described here represent relevant features of CCD's relief, considering the main geomorphological units and landforms (Table 1).

Geomorphosite	Geomorphological Unit	Landform Pattern	Associated Values
Inselbergs of Irauçuba	Residual Massif	Inselberg	NLP/Cult
Pedra do Frade	Residual Massif	Humid mountain ridge and flat plain	APP/Cult/Tour
Pedra do Cruzeiro Inselberg	Sertaneja Depression	Inselberg	DM/Cult/Tour
Inselberg Fields of Quixadá	Sertaneja Depression	Inselberg and flat plain	UC/Cult/Tour
Serra Branca Peak	Residual Massif	Dry mountain ridge	APP/Eco/Tour

Table 1. Main characteristics of the geomorphosites included in the inventory of geological heritage of the CCD. **APP**: Permanent Protected Area, **DM**: Municipal Decree, **NLP**: No Law Protection, **UC**: Unit of Conservation. **Cult**: Cultural, **Eco**: Ecological, **Tour**: Tourism.

Inselbergs of Irauçuba

It comprises an inselberg field composed of porphyritic granites associated to the Santa Quitéria Magmatic Arc and occurs in the northern portion of CCD, mainly in the town of Irauçuba. These inselbergs show similar fracture patterns and medium- to small migmatized-gneiss blocks can be found surrounding the site. The area has potential to be classified as Conservation Unit according to Brazilian Federal Law n. 9.985/2000, being necessary more detailed studies to define a proper territorial ordering (Figure 2A, B).

Pedra do Frade

Located in the town of Itapagé, this geosite represents the *Uruburetama* Residual Massif, being also one of the best viewpoints for observation of Ceará's semiarid landscape. The main lithology is essentially composed of porphyritic grey monzogranites with elongated feldspar phenocrysts associated to the Santa Quitéria Magmatic Arc. The area can be classified as Permanent Protected Area (Article IV of Brazilian Forest Code), being a private property with infrastructure for camping. The name has its origins due to a legend about a friar (in Portuguese, frade) who was petrified after falling in love with a nun (Figure 2C, D).

Pedra do Cruzeiro

Inselberg of Pedra do Cruzeiro is about 190 meters high and is characterised by dissolution features, such as flute types. It is composed of porphyritic calc-alkaline granite with plagioclase phenocrysts and dykes and mafic enclaves, representing the central portion of the Inselbergs Fields of Quixadá. Although being legally protected as Environmental Protected Zone (Quixadá Municipal Law 1903/2000), radio and telephony antennas have been installed on its top, as well as a cruise where religious events used to be held in the past. Located in the middle of the urban zone, the site represents one of the most relevant tourism spots at Quixadá (Figure 2E, F).

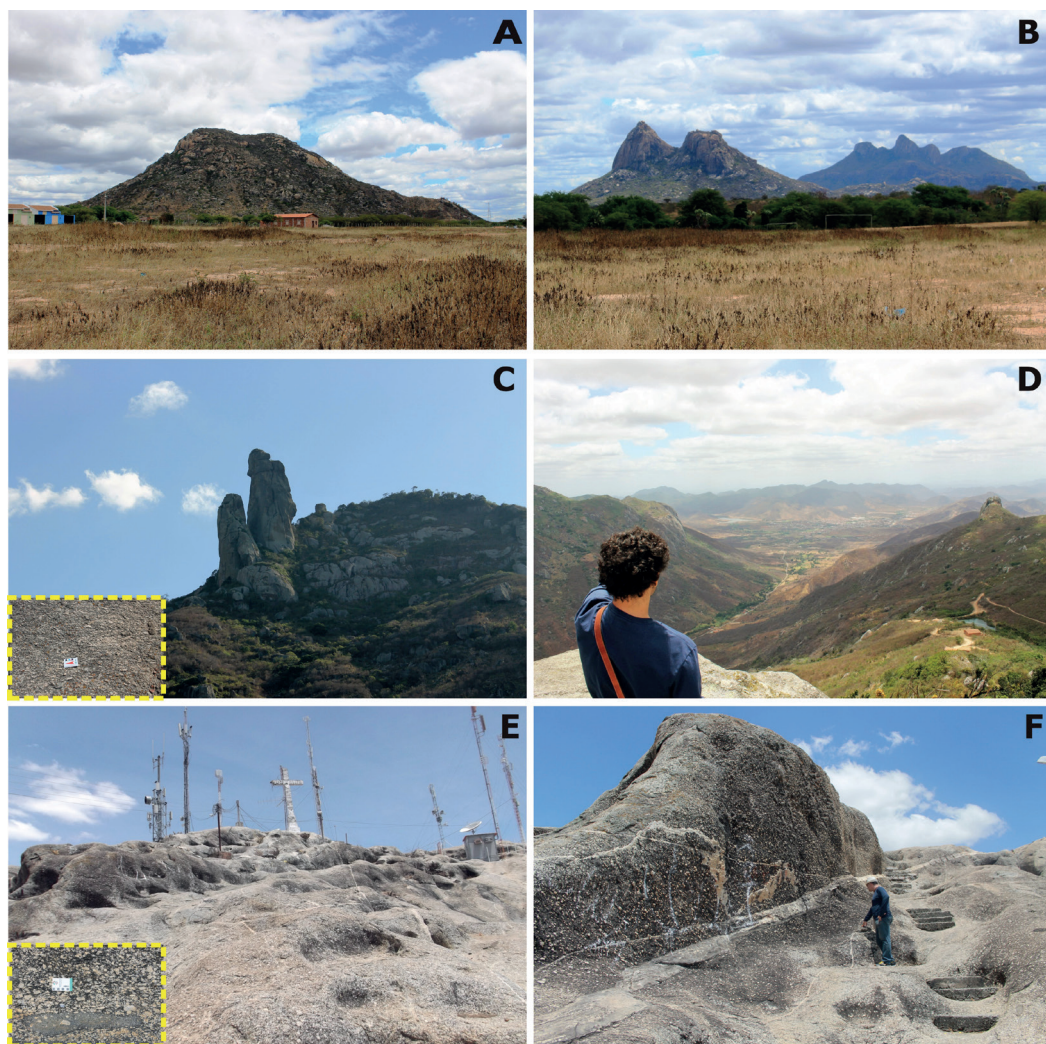


Figure 2. *Inselbergs of Irauçuba Geosite (A/B) Pedra do Frade Geosite (C/D) Pedra do Cruzeiro Geosite (E/F).*

Inselbergs Fields of Quixadá

This geosite represent the most relevant inselberg fields of the CCD and one the most known of Brazil. Porphyritic calc-alkaline granite with plagioclase phenocrysts, several dykes and mafic enclaves, besides small leucocratic portions are the main lithotypes of these inselbergs. The *Galinha Choca*, with around 320 meters high, is the largest one, but many other inselbergs crosscutting the hinterland depression can be observed from its top. Regarding legal protection, this area is located on the historic *Cedro Reservoir*, protected as

Cultural Heritage according to the Brazilian Federal Law n 25/1937 and also classified as protected area by Ceará State Law n 26.805/2002. The whole set is the traditional postcard of the city of Quixadá, receiving many tourists each year (Figure 3C, D).

Serra Branca Peak

This peak constitutes the CCD's highest elevation, with 1154 meters high. The outcrop is located in the town of Catunda and represents a relevant residual massif named *Serra das Matas*. It is predominantly composed of K-feldspar granite with small quartz veins, associated to the Santa Quitéria Magmatic Arc. Highlands with average elevations between 500 and 600 meters can be observed from its top. The site is located in an area that can be classified as Permanent Protected Area, according to Article IV of Brazilian Forest Code (Figure 3A, B).



Figure 3. *Inselbergs Field of Quixadá Geosite (A/B) Serra Branca Peak Geosite (C/D)*

CONCLUSIONS

The geomorphosites selected in the inventory of geoheritage of the Ceará Central Domain represents valuable landscape features associated with both scenic and cultural aspects. All the selected sites have potential to be used to promote local geotourism and educational practices, taking into account security and accessibility conditions. From the features here described a set of priority conservation actions were delineated:

- i) Quantitative evaluation of educational and tourism potential uses;
- ii) Development of geotourism plans regarding the geosites located in Quixadá, Irauçuba, Itapagé, and Catunda;
- iii) Development of interpretative panels for all geomorphological geosites;
- iv) Proposal of a protected area surrounding the Inselbergs of Irauçuba Geosite, according the Brazilian Federal Law n 9.985/2000;
- v) Incentive to the academic community to develop new and detailed research about the Inselbergs of Irauçuba, Pedra do Frade and Serra Branca Peak geosites.

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