



Promotion of the Geological Heritage of Araripe Unesco Global Geopark, Brazil: the Casa da Pedra Reference Center

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Abstract

The valuing of geological heritage is a crucial task in geoconservation, and particularly relevant in geoparks' activities. In geoparks displaying a permanent tension between geological resources exploration and geoconservation, valuation practices based on community involvement represent an effective way of accomplishing the geoparks' goals. This work reports the design, implementation, and preliminary qualitative assessment of an innovative project conducted by the Geosciences Institute of the Federal University of Rio de Janeiro (Brazil) developed at the Araripe Unesco Global Geopark (Ceará State, NE Brazil): the Casa da Pedra Reference Center. Since its opening in 2016 the Casa da Pedra is engaged with the promotion of links between geological heritage and all other aspects of the Araripe's natural and cultural heritage, in a mutually beneficial way. This infrastructure was built at Inhumas, Santana do Cariri. It is placed in a strategic location known as Araripe Basin for those who want to develop research and training activities on geosciences, and it fills the previous lack of basic logistic facilities in the region. It offers accommodation for 60 people, mainly university students from Brazil and abroad, but it is open to local communities for other activities, whether of a cultural or religious character.

Keywords Geoconservation · Valuation · Casa da Pedra Reference Center · Araripe Unesco Global Geopark · NE Brazil

Introduction

The main purpose of geoconservation is the conservation of the geological heritage through the implementation of specific inventory, evaluation, conservation, valuation, and monitoring procedures (Henriques et al. 2011). Effective protection of geological heritage requires the local community's involvement in all geoconservation actions, including valuation procedures (Tavares et al. 2015; López-

Otálvaro 2019). The valuing of geological heritage plays a decisive role on the conservation of geosites previously subject to inventory and evaluation procedures and are particularly important in those territories corresponding to single, unified geographical areas where sites and landscapes of international geological significance are managed with a holistic concept of protection, education, research, and sustainable development, i.e., Unesco Global Geoparks (UNESCO 2017a).

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The Araripe Unesco Global Geopark, the first Unesco Geopark of the Americas, is located in the south of Ceará State, NE Brazil. Due to the worldwide importance of the geological and paleontological heritage of this area, it was included within the Global Geopark Network in 2006 and designated as a Unesco Global Geopark in 2015 (UNESCO 2017b).

The relevance of its geodiversity extends to geomorphodiversity, pedodiversity, and hydrodiversity (Bétard et al. 2017, 2018; Araújo and Ínsua 2018), being considered as a fundamental landmark for the understanding of the morphotectonic evolution of northeast Brazil (Peulvast and Bétard 2015). The Araripe Unesco Global Geopark also includes the first National Forest of Brazil, established in 1946. National Forest is a category of protected area included in the national conservation system.

Management, visibility, and networking are among the main features of a Unesco Global Geopark (UNESCO 2017a). Such goals require strong cooperation, not only with the local people living in the Unesco Global Geopark area, but also with other partners, namely scientific organizations like universities, in order to provide qualified assistance in conservation, management, and communication to society of the Earth heritage as an integral part of the world's natural and cultural heritage.

This work reports goals and activities developed at the Casa da Pedra (“Stone House”) Reference Center, located at Santana do Cariri municipality, a project conceived and conducted by the Geosciences Institute of the Federal University of Rio de Janeiro (UFRJ-IGEO) in order to host training activities and support research projects at the Araripe Basin, but open to local communities for other activities, thus engaged in a mutually beneficial and safe way.

As in many other places where mineral and geological heritage resources co-exist, at the Araripe Unesco Global Geopark, there is a complex tension between conservation and development, which affects the management of the natural resources (Bétard et al. 2017). In fact, there are numerous quarries in the region where laminate limestone, also known as Pedra Cariri (“Cariri Stone”), can be exploited, as it is very well accepted as a good coating in civil construction, thus representing a combined mineral and geoheritage resource (Ruban et al. 2018). This activity represents the basic economy of the region, since farming and most agriculture are insufficient to earn a livelihood. Therefore, the exploitation of mining sites in the region has to be more balanced to allow geoconservation activities within the Geopark without any serious interruption of the extraction activities of the Cariri Stone. To face this problem, the Casa da Pedra Reference Center, as partner of the Araripe Geopark, aims at contributing through education and geotourism, to promote the links between geological heritage and all other aspects of the area's natural and cultural heritage, and therefore enhancing the local

sustainable development (Piranha et al. 2011; Farsani et al. 2011).

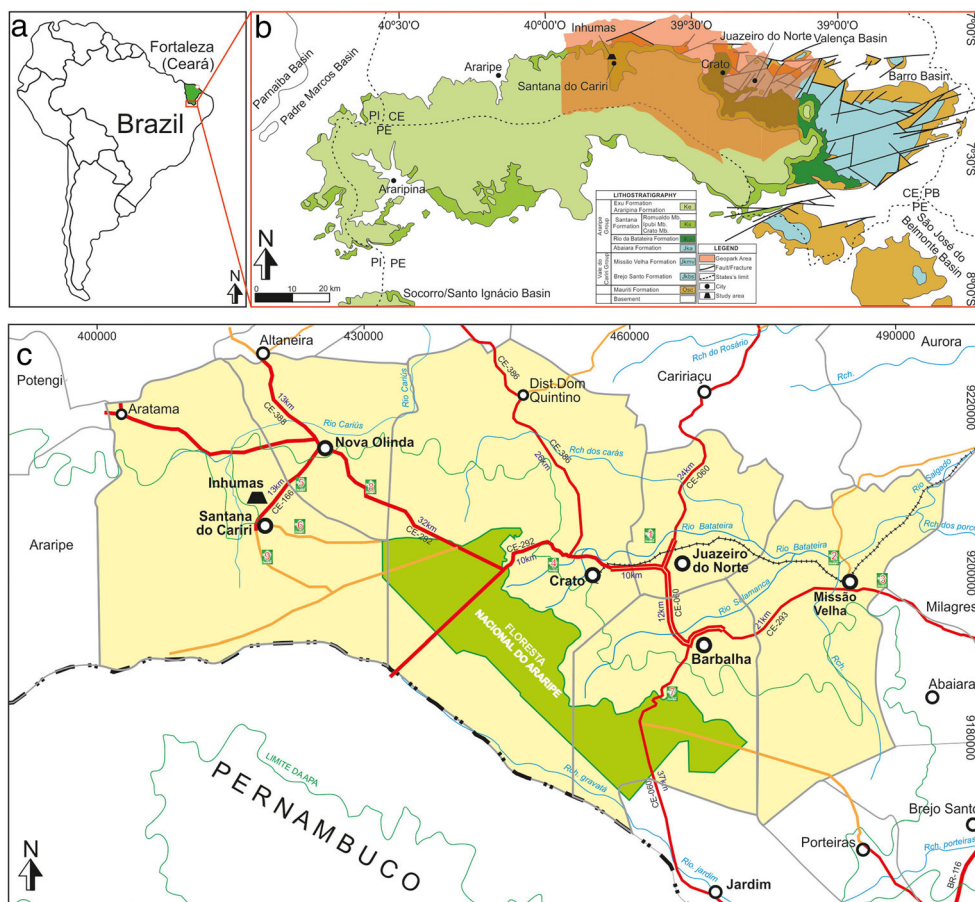
The Geological Heritage of the Araripe Basin (NE Brazil)

The Araripe Unesco Global Geopark is a large territory (3441 km²) located in the Araripe Basin (S07°13'46", W039°24'32"; Fig. 1). The Araripe Basin is a Northeastern Brazilian interior basin (12,200 km²) related to a first Neocomian tectonic phase of the South Atlantic opening (Matos 1992), with two depositional areas—Feira Nova and Cariri—bordered by transfer faults. Its Early Cretaceous history spans from Berriasian to Albian times (Carvalho et al. 2015b).

The geological record of the Araripe Basin (Beurlen 1971; Cavalcanti and Viana 1992; Ponte 1992; Martill and Wilby 1993, Viana and Neuman 2002; Carvalho 2004; Assine 2007) is composed of clastic and chemical rocks, deposited in alluvial fans, shallow lakes, braided and meandering rivers (Carvalho 2000; Carvalho and Melo 2012; Carvalho et al. 2012). During the Late Aptian and Albian, the main environments were anoxic and saline lakes, in which the deposition of carbonates and sulfates (Santana Formation), produced two “Fossilagerstätten”—Crato and Romualdo—probably the most well-known terrestrial flora and fauna from the Aptian time, due the large amount and quality of its fossils, including specimens preserved three-dimensionally or at least with minor compaction (Depeche et al. 1990; Pons et al. 1990; Maisey 1991; Viana and Neumann 2002; Arai et al. 2004; Martill et al. 2007; Carvalho et al. 2012; Selden and Nudds 2012). Accordingly to Heimhofer et al. (2010) and Catto et al. (2016), the bulk of the limestone was formed via authigenic precipitation of calcite in a lacustrine system, hydrological closed with a negative hydric balance, developing hypersaline lakes. This stressing environment was a favorable context to the development of algal mats and microbial communities, which are characterized by high metabolic activity and extensive biologically induced carbonate mineralization (Catto et al. 2016), a favorable environment to exquisite preserved fossils. These can also include high-quality soft-tissue preservation, color patterns, and articulated skeletons (Menon and Martill 2007; Maisey 1991; Carvalho et al. 2015a,b; Osés et al. 2017; Fig. 2). Fossilagerstätten are essentially paleontological heritage but by enabling paleoecosystems to be studied in detail and allowing evaluation of paleoenvironmental and preservation conditions assigned to fossil assemblages, they meet the complex concept of paleogeographical geosite proposed by Bruno et al. (2014) and are assignable both to the paleoecosystem and the taphonomical subtypes.

However, all around the Araripe region, other sedimentary areas such as the Rio do Peixe basins, the Cedro carbonate

Fig. 1 Geographical location of the Casa da Pedra Reference Center at Inhumas, Santana do Cariri municipality (Araripe Unesco Global Geopark; State of Ceará, NE Brazil)



successions, and the Borborema Province basement are excellent elements for the training of new geoscience

professionals. This was the grounding principle that guided the project of the UFRJ-IGEO to establish a host house for its undergraduate and graduate students and the development of extension activities in the municipality of Santana do Cariri. Thus was born the Casa da Pedra, a reference center of the UFRJ-IGEO at Inhumas, Santana do Cariri municipality, as a result of a fruitful dialog between local leaders and the population with the scientific community, where everyone can benefit.

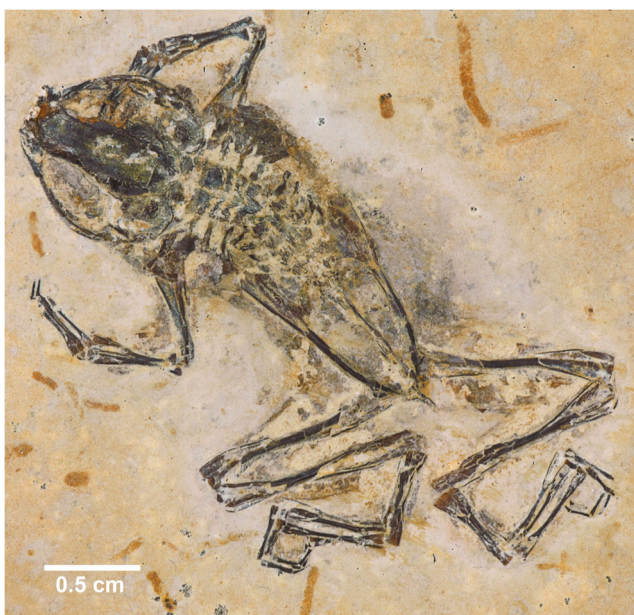


Fig. 2 *Cratopipa novaolindensis*, an amphibian of Aptian age of the Crato Member (Santana Formation; Araripe Basin) showing the exquisite state of preservation

The Casa da Pedra Reference Center: Goals and Activities

Since 1969, the UFRJ-IGEO conducts teaching, research, and extension activities in southern Ceará, especially in the region of Santana do Cariri, due to the exceptional geological record of the region. Santana do Cariri municipality is a low density and economically depressed region with less than 17,700 people, of which 600 are settled in the Inhumas district (IBGE 2019). Inhumas district is located approximately 2 km from the municipality of Santana do Cariri. Although small, with only 200 residences and about 702 inhabitants, it has unique characteristics, such as the technique employed for the

construction of houses. This is because there is in this region, a very specialized workforce in working with Cariri Stone, which is slowly falling out of use (Cidrão 2010). The region lacks accommodation and food; the incidence of poverty in the municipality is over 71% and it is common for a family to support itself with one minimum wage per month, mainly from retirement or federal government programs. With no prospect of work, young people end up leaving the region in search of better opportunities. So, from the creation of the Casa da Pedra at Inhumas, students from the UFRJ (and partner institutions; Table 1) began to have a place to accommodate during their fieldwork, which is currently performed at least twice a year and has duration of at least 10 days. Moreover, the place can be used by other universities that carry out teaching and research activities in the area, as well as in other areas of knowledge, for geotourism purposes and for local needs, in order to be occupied as long as possible during the year. Such strategy of financial sustainability allows maintaining the facilities and also the relations with the economic sectors impacted by the project at Inhumas.

Space, Time, and Culture as a Starting Point

The Casa da Pedra at Inhumas is grounded on three pillars—space, time, and culture—and the activities developed from it enables to realize the importance of the local stone for the

economy, tourism, and the identity of a people. Thus, geoconservation has particular prominence, since the place is full of territorial identity; the interaction with the local population allows unique educational experiences, encompassing both the understanding of environmental transformations and the diversity of life over geological time, as the construction of a critical citizenship, focused on the understanding of the Brazilian identity itself.

Through this holistic approach, the Casa da Pedra assumes several specific goals:

- To enable the consolidation of a “education through stone” program, which is already a reality for the UFRJ-IGEO in the region, in order to know and protect geodiversity while encouraging the recovery of citizenship in our young people
- To reinforce the importance of fieldwork in the students’ formation, as it leads to critical thinking in obtaining proxies data, the perception of the relevance of collaborative work, the understanding of phenomena and the magnitude of natural events, and the construction of a critical citizenship (Henriques et al. 2012)
- To create the opportunity for UFRJ students to experience and know a new environment, distinct from their reality, and thus integrate scientific research, professional qualification, social work, and geoconservation

Table 1 List of partner organizations involved with the creation of the Casa da Pedra Reference Center at Inhumas, and their relation with the three pillars of sustainability (social, economic, and environmental)

Sustainability pillar	Organization
Social	Serviço Social do Comércio/Estado do Ceará
	Serviço Nacional de Aprendizagem Comercial/Estado do Ceará
	Serviço Brasileiro de Apoio às Pequenas Empresas/Estado do Ceará
	Fundação Casa Grande—Memorial do Homem Kariri
	Prefeitura Municipal de Santana do Cariri/Estado do Ceará
	Poder Legislativo Municipal de Santana do Cariri/Estado do Ceará
	Diocese de Crato/Estado do Ceará
	Universidade Federal do Cariri
	Universidade Regional do Cariri
	Museu de Paleontologia Plácido Cidade Nuvens
	Instituto Santa Cecília
	Instituto Kariús
	Conselho de Desenvolvimento Turístico do Cariri
	Associação Brasileira de Geologia do Petróleo
	Conselho Nacional de Desenvolvimento Científico e Tecnológico
Fundação Carlos Chagas Filho de Amparo à Pesquisa do Estado do Rio de Janeiro	
Economic	Agência Nacional de Mineração
	Iuá-Hotel
	Centro de Tecnologia Mineral
	Turismo de Base Comunitária—Fundação Casa Grande
	FGF Confeções—marca Ciências da Terra
	ARBISC—Associação das Rendeiras de Bilro
Environmental	Araripe Geopark
	Agência Nacional de Mineração
	Centro de Tecnologia Mineral

- To promote awareness of the sustainable use of water resources, a particularly sensitive issue in the context of the Araripe region which is subject to severe arid climate conditions (Araújo and Ínsua 2018)
- To understand the occupation of the Brazilian territory, as well as know the traditional methods of land use, including family farming
- To enable the use of renewable energy sources
- To make astronomical observations
- To evaluate traditional music as an instrument of environmental education
- To know popular literature as a tool of heritage education
- To respect local religious beliefs
- To value cooking, natural resources, and the construction of territoriality, thus meeting the geopark's general goals of trying to involve local artists and producers in workshops and also, during seasonal religious events such as "romarias" at the Juazeiro do Norte or at Inhumas, and attempting to provide some new jobs for local communities (Farsani et al. 2011)

By developing a wide range of activities based on the geological heritage of the Araripe Basin, the Casa da Pedra aims at fostering economic sustainable development of local communities through the promotion of geotourism and education—thus representing a successful path to global sustainability (Henriques and Brilha 2017). Moreover, it aims at contributing to meet some of the 17 UN Sustainable Development Goals to Transform Our World, namely to help ending poverty in one of the most vulnerable regions in Brazil, hand-in-hand with strategies that build economic growth and address a range of social needs including education, health, social protection, and job opportunities, while tackling climate change and environmental protection (UN 2019).

Convergences Around the Cariri Stone

The construction of the Casa da Pedra and the planting of vegetation, in particular of species typical of the Brazilian backlands ("sertão"), ended in 2016. It followed the recovery of the traditional methods of the region, based on the use of the Cariri Stone, which had already fallen into disuse (Fig. 3). An important aspect for the implementation of the project was the involvement of the residents of Inhumas themselves, with the donation of the Cariri Stone for the construction of the buildings. The walls and ceilings were erected using local labor and materials and, just like the interior furnishings, such as benches and tables, they all are made of stone, encouraging the work with the Cariri Stone and a possible transformation of Inhumas in the "City of Stones" in the future. On the other hand, the reuse of the region's abundant quarry mining waste reinforced the sustainability of the project (Fig. 4) and helped to stimulate locals to perpetuate the tradition of using the

Cariri Stone for the construction of their houses with stone instead of paint-coated cement. As a result, nine old houses have already been rehabilitated so far, using mining waste. This rescue is extremely relevant for local memory and identity as it encourages current workers to continue in the region and to transfer their knowledge in order to qualify new pavers. In this way, employment is created while preserving the culture and integrity of neighborhood buildings.

The Casa da Pedra displays for accommodation 13 apartments with bathroom, with a total occupancy of 60 beds, plus a multifunction main hall with kitchen and a wide living area. This open space displays several hammocks, the typical way of resting in region, in particular during the hottest hours of the day, which are of great help for nightly sky observations (Fig. 5).

The report of activities records almost 13,000 Guest Book signatures as a result of different actions developed during 2016–2019, besides university extension initiatives. Since its opening in 2016, the Casa da Pedra has hosted 350 students from the UFRJ, but other academic institutions from all over Brazil have already carried out research and advanced training missions in the region and used the facilities provided by the Casa da Pedra: a total of 27 universities, including 19 Federal universities, six State universities, and one Federal institute, involving people from 19 states—corresponding to the five regions of the country—and eight states only from the Northeast Brazil, coming from 51 different Brazilian cities. In Inhumas and the surrounding area, students can get to know a different Brazil and see how closely geodiversity is important to society. The quarry work, the construction of the houses, the paving of the squares, the stone crafts, and the fossils are all part of the residents' life and drive the region. Students will realize that working with Cariri Stone is what marks the identity of this population.

Regarding foreign universities, the Casa da Pedra records so far the housing of researchers from Germany, Paraguay, UK (Scotland and England), USA, and Uruguay. The National Symposium on Geomorphology (June 2018) attracted 36 Brazilian and foreign institutions, and it was attended by 80 people who visited Casa da Pedra. Geotourism has also attracted people from Brazil and abroad (nine universities from Cape Verde, East Timor, France, Germany, Guiné-Bissau, Italy, Portugal, Scotland, USA).

But apart from these activities mainly yielded by external people, local communities currently use the Casa da Pedra for other purposes, e.g., educational activities with teachers and pupils from local schools (21 in total), capacity building of artisans, artistic performances, parish meetings, etc., thus representing an important meeting and socializing point for local communities and a reference center in a low-density territory and far from urban centers. During 2014–2016, 24 events were organized, which have mobilized more than 6000 people. They include nine theater performances attended by 1800

Fig. 3 The exploration of laminate carbonates from the Nova Olinda quarries at Araripe Basin (State of Ceará, NE Brazil)



people, seven musical performances attended by 700 people, two movie screenings attended by 74 people, two themed exhibitions attended by 1400 people, eight training courses attended by 300 people, 11 reporting teams involving 30 people, a seminar attended by 123 people from 14 institutions, 14 diversified meetings attended 200 people, six photo book recordings involving 17 people, four Joanine Gang Shows mobilizing a total of 180 participants and 1000 spectators, and even a wedding with 400 guests.

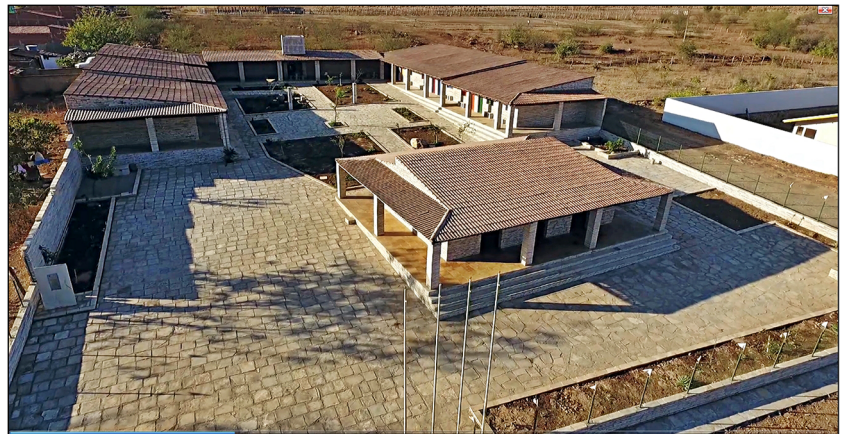
Only 3-year-old Casa da Pedra records an average usage of 29,000 to 30,000 people/year; the numbers and the diversity of actions developed there allow us to highlight the great social relevance of Casa da Pedra for the life of the population of Cariri which transcends its role as a support infrastructure for

students' curricular activities. The Inhumas community involvement in the project, and its social impact is the aim of a future research; the assessment of the impact on student's perspectives after and before visiting Casa da Pedra is also in progress. But the knowledge built on this experience so far can be used as an instrument for each of the actors involved to think about their being in the world and their relationship with the region's natural heritage. Knowledge, while socially produced, is vital for the social insertion of each citizen, allowing acting on reality in a critical and constructive way. It is thus an educational instrument of great social importance for teaching in the areas of knowledge involved and for the popularization of science among the general public. The building of strong links between the community, researchers,

Fig. 4 The initial stages of construction of the Casa da Pedra Reference Center using the laminated limestones of "Cariri Stone" from the quarry mining waste



Fig. 5 Aerial view of the Casa da Pedra Reference Center showing the overall logistic facilities to host the guests



teachers, and students allows everyone to feel as co-responsible for this richness, working to strengthen collective identities and citizenship.

Final Remarks

Valuation of the geological heritage plays a crucial role in geoconservation. It is particularly important in Global Geoparks as key tools to conserve and enhance the value of areas of geological significance in Earth history and to promote sustainable development through geotourism and education. In fact, application, designation, and revalidation processes of Unesco Global Geoparks depend on the effective implementation of a geopark's management plan, agreed upon by all the partners. It is required that it provides the social and economic needs of the local populations, protects the landscape in which they live and conserves their cultural identity, including appropriate infrastructure to meet its mission (Unesco 2017a).

The Araripe Unesco Global Geopark is located in the Araripe Basin (State of Ceará, NE Brazil), and it displays a worldwide known paleontological heritage of Early Cretaceous age. The absence of a well-located infrastructure to assist fieldwork activities within the Araripe Basin currently turns difficult the development of teaching actions, research, and extension activities, as well as the promotion of geotourism. The Casa da Pedra was created in 2016 by the UFRJ-IGEO and with the support of other partners, and it is located at Inhumas, in the municipality of Santana do Cariri. This project was conceived around the need of valuing the geological heritage of the Geopark but involves different dimensions around the local Cariri limestone, internationally known by its exceptionally well-preserved fossil content. Due to the interest in the rocks that outcrop in the Santana do Cariri region and the cultural richness of this northeastern backcountry region, the facilities provided by the Casa da Pedra plays a major role in the expansion of academic and

technical exchanges with other national and international research institutions, and it records so far an average usage of 29,000 to 30,000 people/year. But it also offers multiple facilities for the development of geotourism and other activities which enhance of regional and local sustainable development, representing a model of good practice that can inspire similar initiatives in other geoparks of the Global Geoparks Network (GGN 2020).

Based on the need to bridge the gap in awareness between local actions and global effects, and on the promotion of culturally differentiated ways to achieve global sustainability (Werlen et al. 2016), the Casa da Pedra assists the dialog between local leaders and the population with the scientific community, where everyone can benefit. Its mission meets the Unesco Araripe Global Geoparks goal of promoting the links between geological heritage and all other aspects of the area's natural and cultural heritage, clearly demonstrating that geodiversity is the foundation of all ecosystems and the basis of human interaction with the landscape (Unesco 2017a).

The relative isolation of Cariri region in relation to major Brazilian cities created a distinct cultural identity with particular folkloric dances, songs, religious, and artistic expressions (Unesco 2017c). As so, besides geoscientific-based initiatives, most of them conducted by people from outside the region, the Casa da Pedra is also widely used to decrease the relative isolation of Cariri, as well as to keep alive its own cultural identity.

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