



Promoting sustainability in a low density territory through geoheritage: Casa da Pedra case-study (Araripe Geopark, NE Brazil)

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ABSTRACT

After being exploited from the Earth's crust, raw materials and geodiversity elements of economic value are traditionally used for the benefit of society. However, geodiversity elements may provide other types of benefits to society, namely scientific, cultural, educational, and tourist services, as they currently happen in geoparks. Geoparks can be seen as a culturally differentiated way of transferring scientific insights into social practice and vice versa, as well as an effective path of achieving global sustainability. This work aims at contributing and analyzing the role played by geoparks to improve the living conditions of local populations. The research is qualitative in nature, a study case type, which describes and assesses a pioneering experience developed at the Casa da Pedra ("Stone House") Reference Center. Built in 2014, Casa da Pedra is located in Inhumas, the municipality of Santana do Cariri which integrates the UNESCO Araripe Global Geopark (State of Ceará; NE Brazil). The activities performed at this center aim to bridge academic knowledge and responsibility to a low density region subject to arid climate conditions. By fulfilling the social needs of a low-income community, the project results provide positive social impacts in the Inhumas community, and can inspire similar initiatives in other geoparks and/or other low density territories displaying relevant geological heritage. Moreover, by integrating natural, social and humanistic scientific awareness with non-scientific and non-Western forms of knowledge, these also serve as a catalyst tool to achieve global sustainability.

1. Introduction

The challenges faced by the world's natural systems, economic order, and socio-cultural well-being require a global level of understanding of scientific insights into Earth's system processes (Werlen et al., 2016). This is particularly relevant for the extractive industry, whose activities frequently threaten geological elements with exceptional scientific, educational, touristic or cultural value — the geological heritage of the Earth (Henriques et al., 2011; Reynard and Brilha, 2018) —, besides the hydric resources that native people depend on for their traditional livelihood activities.

Low density territories - holding feeble demographic and economic density (Ramos and Fernandes, 2016) - which are subject to severe arid climate conditions, are most vulnerable to negative impacts resulting

from the unbalanced use of natural resources. The south of Ceará State (NE Brazil) is worldwide known for the exceptional geological and paleontological record of Early Cretaceous age which led to the designation of the Araripe territory as a UNESCO Global Geopark in 2015 (UNESCO, 2017a). Like any geopark, the Araripe's aims at preserving and valuing the geological heritage outcropping in the territory; however, one of the main economic activities within the geopark is the exploration of the "Cariri Stone", a laminate limestone of beige color where most of the best well-preserved fossils of the Crato Formation can be found (Selden and Nudds, 2012; Carvalho et al., 2015a,b).

As pointed by Ruban (2017 and references therein), similarly to mining, benefits from the geodiversity of a given territory can be obtained via its effective exploitation for the scientific, educational, and tourism purposes. Geoparks are ideal training scenarios for excursions,

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university students and professionals (Ruban and Yashalova, 2018 and references therein), as well as powerful resources to promote significant and relevant learning in geology and geoconservation (Henriques et al., 2012). Their use for geoeeducational purposes appeal to the academies' social responsibility that must assume their mission of engaging science and local communities in a mutually beneficial way (UNESCO, 2015), namely through a fruitful and permanent communication between representatives of geoparks and scientists. Science-based knowledge and teaching practices can help the Araripe community to improve the methods of exploration of the "Cariri Stone", as well as to enable and promote their sustainable use (Henriques et al., 2011). But this requires the implementation of targeted local projects with global impact rooted in culturally specific values, norms, beliefs, and attitudes directed at changing ecologically harmful habits (Werlen et al., 2016). The implementation of bottom-up initiatives *i.e.*, everyday local choices towards sustainability, are the most appropriate strategies to overcome global changes towards global sustainability (Henriques and Brilha, 2017).

Since 2016 the Geosciences Institute of the Federal University of Rio de Janeiro (IGEO-UFRJ, Brazil) runs a set of pioneering activities in Inhumas, a small location in the municipality of Santana do Cariri, at Casa da Pedra ("Stone House") Reference Center (Carvalho et al., 2020).

Founded in 2014, this multi-purpose infrastructure provides facilities to host training activities and support research projects at the Araripe Basin, and to satisfy the diversified geotourism needs (Gordon, 2018), completely non-existent in this sector of the geopark until then. But beyond that, Casa da Pedra is playing a decisive role as a focal point for the meaningful community engagement in the geopark's goals, as well as a catalyst tool for local people to face current challenges within the Araripe region: the preservation of the geological heritage as an economic and educational resource, and the sustainable use of water as a basic requirement to assist the population.

This work describes the activities developed at the Casa da Pedra Reference Center since 2016 and reports major impacts recognized by the Inhumas community (Santana do Cariri, State of Ceará, NE Brazil). By referring to empathy as a key emotional connection between humans and the non-human biosphere (Brown et al., 2019), these activities seek to promote good sustainability practices through the geological heritage of the UNESCO Araripe Global Geopark based on the Inhumas community involvement, and can assist on the need of inspiring other strategies on targeting local projects with global impact in other geoparks and/or other low density territories displaying relevant geological heritage.

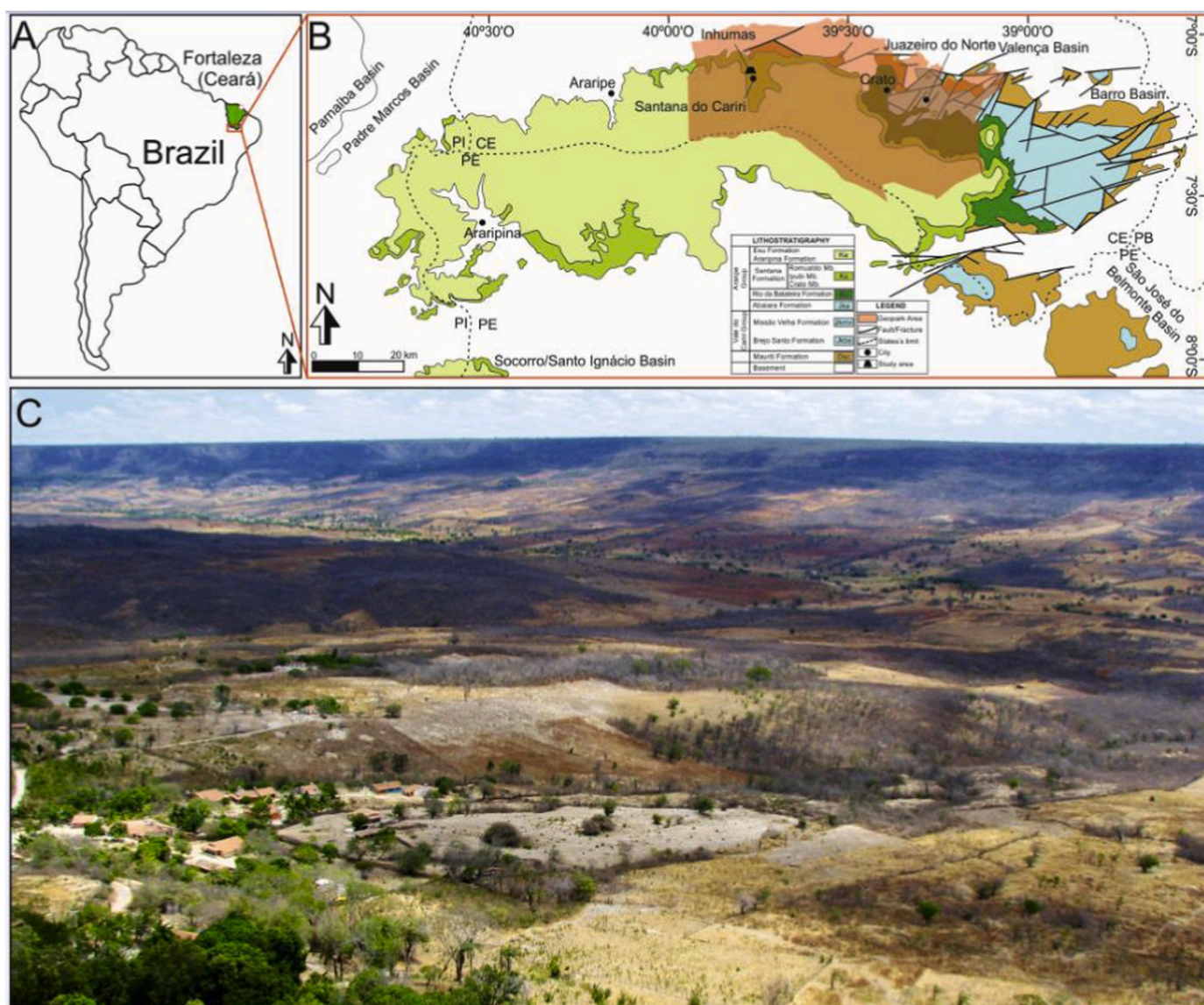


Fig. 1. A. Geographical location of the State of Ceará (NE Brazil); B. Geological map of the Araripe Basin and location of the Araripe Unesco Global Geopark; C. A panoramic view of the Inhumas landscape representing the typical Brazilian backlands ("sertão").

2. The natural and social contexts of santana do cariri

The Araripe Geopark is the first UNESCO Global Geopark of the Americas and it emerged of a proposal submitted by the State of Ceará, and coordinated by the Regional University of Cariri; it is an effective member of the Global Geopark Network where is officially integrated since 2006 (Bétard et al., 2018), thus representing a successful case for Brazil and Latin America.

The UNESCO Araripe Global Geopark is located in the Brazilian Northeast inland extending over approximately 5,000 km on the south area at the of the State of Ceará, northwest of Pernambuco and east of Piauí (Fig. 1A). The State of Ceará presents semiarid climate with significant variations, characterized by prolonged periods of drought in about 92% of the territory; watercourses normally flow in the rainy season and dry in the drought season (Brandão et al., 2014). Such severe arid climate conditions are a sensitive issue in the context of the Araripe region, where the Geopark is located, subject to a hydrological regime characterized by the intermittence of the watercourses (Araújo and Ínsua, 2018).

The UNESCO Araripe Global Geopark records significant geological evidences of the break-up and separation of Northeastern Brazil from the African continent, which began in the Lower Cretaceous (Aptian), some 113–125 million years ago, and provides exceptional opportunities of implementing advanced training activities in the context of hydrocarbon-exploration models. The Santana Formation fossils, produced as a result of sedimentation of sandstones, laminated limestones, evaporitic bedded or massive gypsum and shales with carbonate concretions under fluvial and lake/lagoon depositional contexts are compelling testimonies of a continental link between Brazil and West Africa during Aptian times (Herzog et al., 2008, Fig. 1B).

The Araripe Geopark extends over six municipalities of State of Ceará (Crato, Juazeiro do Norte, Barbalha, Missão Velha, Nova Olinda and Santana do Cariri); there are nine geosites in this territory that are open to the public for visitation and display relevant geological, paleontological, archaeological and historical value. Moreover, the Araripe Basin besides attracting general visitors, also attracts a particular group of geotourists, that is, geospecialists and geoexperts in exploration-oriented training activities focused on petroleum system elements and processes, thus displaying geological heritage of economic type (Ruban, 2010; Ruban and Kuo, 2010; Pena dos Reis and Henriques, 2018).

The limestones of the Crato Member (Santana Formation) extensively crop out in Santana do Cariri municipality, where they are explored as raw material (“Pedra Cariri”) in many small quarries. Its exceptionally well preserved fossil content displays international scientific interest (Maisey, 1991; Martill and Wilby, 1993; Martill et al., 2007); the Crato Member is the world’s most remarkable Cretaceous “Fossil-Lagerstätten” for the insect faunas and the early flowering plants, as well as for a diverse and huge quantity of other groups like amphibians, turtles, crocodiles and pterosaurs (Carvalho et al., 2015a,b; Herzog et al., 2008). The paleontological heritage, including silicified trunks, impressions of ferns, conifers and flowering plants, foraminifera, mollusks, arthropods, amphibians and reptiles is the most distinctive feature of the Araripe Geopark, which presents fossils as an attraction for most of its geosites (Viana and Carvalho, 2019). They collectively possess different contents - indicial, iconographic, documental, scenic, symbolic and conceptual *sensu* Henriques and Pena dos Reis (2015) -, thus increasing their global heritage value (Schemm-Gregory and Henriques, 2013).

As stated by the UNESCO (2017b), a geopark must demonstrate geological heritage of international significance, but the purpose of a UNESCO Global Geopark is also to explore, promote and assess the links between that geological heritage and all other aspects of the natural, cultural and immaterial heritages of the area. To become a UNESCO Global Geopark it is crucial to demonstrate the extent to which its geodiversity, biodiversity and intangible cultural heritage actually contribute to promote sustainable regional development based on the

appreciation of traditional communities and their social, ethnic and cultural elements and manifestations. These are interactive and inseparable, and give them the unique characteristics of the territory in which the geopark is inserted (Guimarães et al., 2018).

Santana do Cariri is one of the poorest municipalities in the State of Ceará, with a Human Development Index (HDI) of 0.612 (IBGE, 2017). The HDI of a territory can partially represent a picture of the territory’s human development level, as it measures the health dimension (assessed by life expectancy at birth), the education dimension (measured by means of school years for adults aged 25 years or more, as well as expected years for children schooling at their starting age), and the standard of living dimensions (measured by gross domestic income per capita); it is a summary measure of average achievements in key dimensions of human development – a long and healthy life, being knowledgeable and having a decent living standard (UNDP, 2019).

The region does not offer many work opportunities, income generation and study. This situation causes the emigration of younger people, who travel to the main cities in search of better living conditions. Therefore, thinking on appealing ways to prevent these young people from leaving is a big challenge. But the region has natural resources that can promote transformations which in turn can result in the improvement of the HDI, namely the Geopark, with direct impacts on the education dimension and standard of living dimension of the local inhabitants. However, the geopark by itself does not promote such transformations unless it develops a community engagement strategy (Farsani et al., 2011). Santana do Cariri region is internationally known for its extraordinary fossil record of the local “Cariri Stone”, being this natural resource a driving spring in promoting transformations that can derive in the improvement of the HDI.

Involving the community implies knowing and appreciating traditional methods of using the natural resources, e.g., the geological and water resources, as well as manifestations of the local mysticism, all related to different meanings of the Cariri Stone attributed by different interpreters (Henriques and Pena dos Reis, 2019). As pointed by Kiernan (2015), committing to the protective management of a place is unlikely to be successful if the specific values that underlie that importance are not clearly understood, or if management strategies are not explicitly based on values and held at a variety of scales — individuals, families, community groups, entire societies —, and finally, if they are not acknowledged and its legitimacy is not recognized. Brown et al. (2019) recently argued that empathy with others and empathy with nature, mediated through place and identity, can bring significant advances to understanding sustainability challenges, and whether empathy leads to sustainability depends on whether empathic responses transcend differences between groups within a place (e.g. ‘incomers’ vs. ‘natives’) and across spatial boundaries (proximate vs. distant).

Throughout the Brazilian northeastern backlands, religiosity is an important aspect of the daily life of the population. The Cariri region, marked by social and economic conditions aggravated by periods of drought, has a strong influence of Catholic precepts in its formation. Most important is the great public devotion to the “little saint of Inhumas”- Benigna Cardoso da Silva- peasant, who at age 13, in 1941, defended herself from an attempted rape and being a victim of femicide. Reportedly, the girl left the house to fetch water a few meters away, as she customarily used to. The crime occurred on the surface of a laminated limestone slab and popular devotion led to the construction, in 2004, of a chapel in her honor through a collective initiative that included the donation of materials and labor. On the date of Benigna’s death is a holiday in the municipality of Santana do Cariri, and there is a pilgrimage (from the 15th to the 24th October, with the participation of 30,000 people) in her honor. The Ceará State Assembly recently approved three projects inspired by the martyr. The first made the figure of Benigna an official symbol of femicide and a day of struggle for the cause was set; a second project included the date of pilgrimage in the official calendar of state events; and the third project made the annual pilgrimage a cultural heritage of immaterial nature for the State of

Ceará. On October 2019, Pope Francis authorized the beatification of Benigna Cardoso da Silva, called the “heroine of chastity”.

Benigna’s chapel was built in Cariri Stone in Inhumas, being a symbol for the identity of the municipality of Santana do Cariri, as it brings together in one place the religiosity and the geodiversity (Fig. 2A). The term benign, as it is often associated with cancer, gave rise to the belief that water from the well Benigna used would have anti-cancer properties. The collection of water from this well, located in Inhumas and close to the chapel, is part of the itinerary that pilgrims usually follow (Fig. 2B).

The rural area of Inhumas is located approximately 2 km from Santana do Cariri (Fig. 1C) and it is composed of 200 residences and about 702 inhabitants. It has unique characteristics, such as the technique used to build the houses. This is because this region concentrates a very specialized workforce in working with the Cariri Stone, which has slowly been replaced by paint-coated cement (Cidrão, 2010). The name Inhumas has indigenous origin and means “anhuma”, a bird of nocturnal habit that occurs in the swamps. Inhumas has electricity and water supply networks, the latter opened in 1984. In the surrounding areas there are several outcrops of limestone, which resulted in the installation of quarries and sawmills for the extraction and treatment of this rock (Fig. 3A). Limestone extraction contributes significantly to the local economy, as well as being the material where the Santana fossils occur (Fig. 3B). The exploitation of these rocks is a mean of survival for many in the municipality. These workers are usually between 18 to 50 years old and claim there are not many alternative jobs in the region, but they

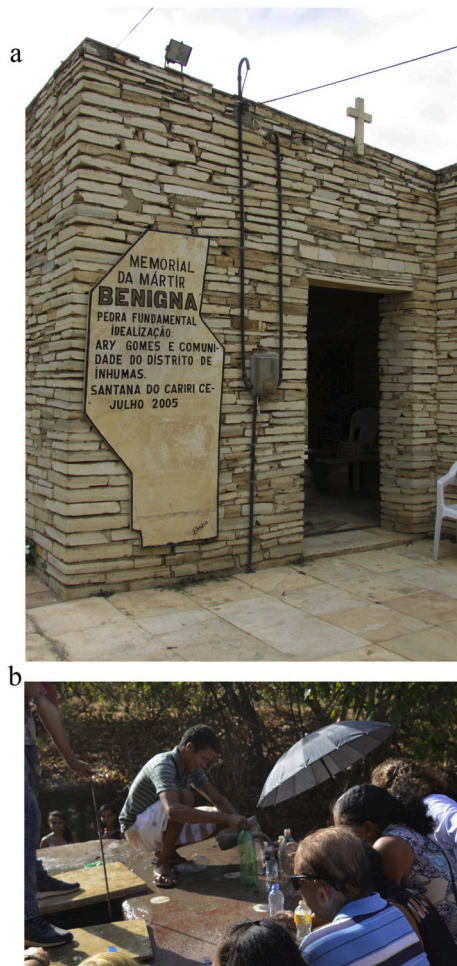


Fig. 2. A. The Benigna’s chapel in Inhumas built in 2005 using the Cariri Stone; B. Benigna’s devotees and their belief that the water from the well she used prevents oncological diseases.



Fig. 3. A. Extraction of the Cariri Stone from a quarry located in the Inhumas region. The local population is being encouraged to use the waste from the exploitation of the stone in the coating of their own houses, like it has been done at the Casa da Pedra (see also Fig. 12); 3B. *Cratoavis cearensis*, the earliest Brazilian bird, collected from the Cariri Stone, the laminated limestone of the Santana Formation (Crato Member).

like their work. In the extraction of the rock, the workers perform different actions such as: cutting (square) the rock, removing the rock, “opening” the slabs, and those who saw and give the final finishing. All this work is done by contracting services and by doing it contractors receive about one minimum wage per month (\$ 200). For them, the scorching sun is the biggest obstacle at work; nevertheless, one of the best moments of their lives is to receive their paycheck at the end of the month.

One of the important aspects of land use in the Inhumas region is the water issue. Rainfall is low, with an average of 966.3 mm over the period of time from 1912 to 1985, but with great variability (Sousa, 2018). Extreme annual variability is directly related to Atlantic and Pacific TSM anomalies (Ferreira et al., 2018). Water scarcity leads to the existence of only family farming and the limited use of water resources. Water is distributed through a private company (CAGECE), with treated water available in the urban area of the municipality. In the surrounding rural communities, water is supplied through water trucks and wells. Another important aspect is the water conservation, using traditional techniques of rainwater capture and controlled use of wells (Fig. 4).

Regarding the sewage network, there is no treatment or collection, the same being thrown in nature in streams, or disposed in septic tanks. There is only one restaurant, offering trivial food, with regional foods. And there is no offer for accommodation in inns or hotels. The communication system is made through a mobile and fixed telephone network, with 3G system and low speed connections. There is no availability of a wired public internet network, only some private points, with radio operation. Transportation is carried out by private vans, available twice a day to connect to larger urban centers.

One of the problems highlighted by the Santana do Cariri population and also demonstrated in the analysis of socioeconomic data refers to education, especially higher education. Many commute to other cities for the purpose of studying. In a survey completed in 2014 it was found that there is a need for closer proximity of the scientific community and



Fig. 4. The local population is being encouraged to use the traditional techniques of rainwater capture in order to overcome the region's water scarcity, a typical feature of the Brazilian backlands ("sertão").

universities to the municipality (Castro, 2014). Many educational institutions from various regions of the country visit Santana do Cariri, especially the local museum and the paleontological outcrops, but there is a low contribution to the region from a social (Museu de Paleontologia Plácido Cidade Nuvens de Santana do Cariri; <https://www.museudepaleontologiaplacidocidadenuvens.com/>), cultural, educational or economic perspective.

These factors led the Federal University of Rio de Janeiro to advance in the creation of an infrastructure in the Municipality of Santana do Cariri; although aimed to the university's extension, it simultaneously contributes to the local development: the Casa da Pedra Reference Center (Carvalho et al., 2020). The area includes the main house with 200 m², with kitchen and 13 rooms with bathrooms, 60 beds and 160 m² for hammock camping (Fig. 5). The diverse lines of action along with the community seek the empowerment of the region's population, valuing the professional qualification and culture, thus enabling a non-formal education that stimulates the improvement of socio-economic conditions. They aim at promoting positive social impact through social changes processes anchored in the natural potentialities of the community and taking into account the cultural values that define it.

3. Methodology

The creation of geoparks and the development of geotourism as a branch of sustainable tourism can be a solution for the development of rural economies (Farsani et al., 2011). The research methodology used in this work is based on an extensive literature review of existing reports on the role played by geoparks to improve the living conditions of local populations, aiming at assessing the social impact of Casa da Pedra in the Inhumas community since 2016. Social impact assessment includes the processes of analyzing, monitoring and managing the intended and unintended social consequences, both positive and negative, of planned interventions (policies, programs, plans, projects) and any social change processes invoked by those interventions (Vanclay, 2003).

From the methodological point of view, this research is qualitative in nature, a study case type, with data resulting from direct observation, and collected based on stakeholders' statements and content analysis of the Book of Records from Casa da Pedra. Instead of using a well-developed list of social impacts, the issues considered in this social impact assessment have been determined in conjunction with inputs

from the community (Vanclay, 2002), and based on the types of social impacts referred by the Queensland Government (2018). Quantitative data has also been integrated, and presented as descriptive statistics (Cohen et al., 2010).

4. Results

The Federal University of Rio de Janeiro (UFRJ), through the Institute of Geosciences (IGEO), has been operating in the surrounding area of Inhumas and adjacent sedimentary areas of the Santana do Cariri Municipality since 1969. All around the Araripe region, besides the Araripe Basin, other sedimentary areas such as the Rio do Peixe basins, the Cedro carbonate successions and the Borborema Province basement display excellent quality of outcropping elements of petroleum systems and salt tectonics geometries for the formation and qualification of new professionals namely in advanced training for the oil industry (Pena dos Reis and Henriques, 2018). The rocks found in the Araripe Geopark show the phase before the opening of the Atlantic Ocean, deposited in the context of ephemeral rivers and inland lakes, where the weather conditions were hot and dry. This phase can be correlated with other Brazilian sedimentary areas, such as Campos and Santos Basins, important oil and gas production areas in which the pre-salt rocks can be correlated with those outcropping at Araripe Geopark. Students perform field activities and compulsory practice, elective and extension subjects, and are also encouraged to develop undergraduate monographs, master and doctoral theses in the region, as well as scientific studies of theoretical nature and/or applied to existing mineral resources in the area (Fig. 6).

This option is the consequence of the excellent quality of the outcrops and rich fossil content of Cretaceous age. Being a territory of low demographic density, the Cariri region allows students from other socio-economic contexts in Brazil and abroad to know a completely different reality from theirs, as well as to discover new types of geoheritage contents related to the Araripe Geopark, namely emergent natural values, such as amenity, quietness, and night darkness, usually unknown for visitors who are used to urban lifestyles (Pena dos Reis and Henriques, 2009).



Fig. 5. The entire infrastructure of the Casa da Pedra was built with Cariri Stone exploration waste, which had already fallen into disuse. The construction of the Casa da Pedra and the planting of vegetation, particularly species typical of the Brazilian backlands (“sertão”), followed the recovery of the traditional methods in the region.



Fig. 6. Students from the Federal University of Rio de Janeiro - Institute of Geosciences who currently develop training activities at the Araripe Basin and use the Casa da Pedra as a place for accommodation and other provisions.

4.1. Practices at the casa da Pedra Reference Center

With the establishment of the Casa da Pedra in 2014, in Inhumas, there was a real possibility of increasing the number of students involved in research projects in the region, reducing the institutional costs of field training, and at the same time, promoting the transformation of social reality in the region.

Since 2016, in addition to actions associated to formal higher education activities involving 27 national and 9 foreign universities, non-formal education programs have been carried out, mainly for

Inhumas’ residents. The lines of action involve educational, cultural, safeguarding of immaterial culture and religious activities (Fig. 7) and in which approximately 830 people have attended. The parties involved included the first Santana do Cariri - Ceará Tourism Development Seminar, in partnership with the Municipal Secretariat of Culture and Tourism, the Casa Grande Foundation and Kariri Man Memorial, all with the purpose of integrating information and promoting actions for the tourism in Santana do Cariri and other municipalities that compose the Araripe Geopark territory. Events such as this one are considered opportune to stimulate the qualification of professionals and to sensitize

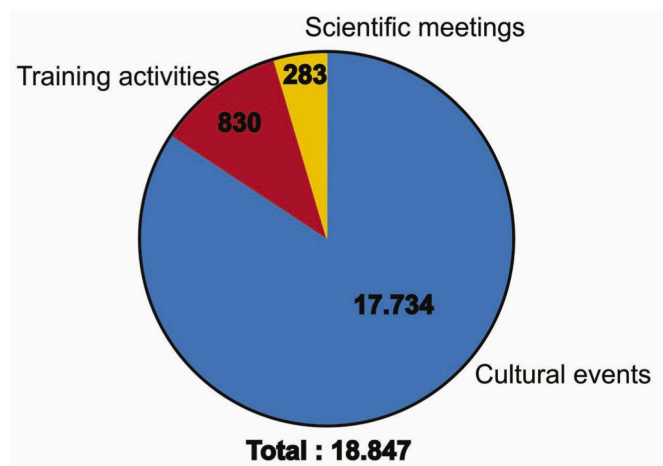


Fig. 7. Typology and relative frequency of scientific, educational and cultural activities that have been developed at the Casa da Pedra since 2016.

the business community and local actors regarding the importance of tourism for the economy, as well as for the socio-spatial development of the Cariri region. Courses such as home budget management, which provides basic guidance on economics, home planning, payroll and personal credit, credit card usage, bank debt renegotiation for sound financial planning, have also been offered allowing the training of 30 local inhabitants so far (see Fig. 8).

In the context of cultural events, several actions are carried out attracting the population into the Casa da Pedra space. They include musical performances, cinema and theater, as well as temporary exhibitions of fine arts. These events are the ones with most interest, and have already involved 17,734 people from the surrounding area. A highlight is the support to the Santa Cecília Music Festival, which is held annually, being a consolidated event in the Santana do Cariri music scene. The attraction of music teachers, musicians and students from the region and neighboring states strengthens the music and musicians of Santana do Cariri region as well as its participants. The holding of this festival is committed to the recovery of instrumental and vocal music, disseminating the composers and their works, valuing the formation of musicians who have the opportunity to contact renowned teachers of music education. At the end of the workshops students give presentations that can mobilize 2,000 people, including participants and spectators. In the field of music, there is also a training course for music bands conductors, which aims to provide necessary tools for the strategic management of corporations, as well as developing action plans with artistic and pedagogical focus. In the fine arts, the concern has been to generate reflections on the relationship between man and nature, with exhibitions that allow a reflection on the importance of preserving the environment, the need for recycling and a more conscious consumption that leads to a reduction in waste generation. Traditional dances, such as religious festival gangs, are also stimulated - a great way to integrate with the community. As previously mentioned, religiosity is an important aspect of the daily life of the northeastern backlands population. In this way, Casa da Pedra has also been used for some of the religious leadership meetings seeking the formation of community agents and social welfare strategies.

4.2. Social changes and impacts of the casa da Pedra (2016–2019)

Social impacts are the issues that affect people and potentially influenced communities in which they live, i.e. all the repercussion of a project. Measurable outcomes of social change processes require analysis and assessment in terms of socio-economic development changes. In Brazil, the required data to build a timeline for demographic or infrastructure aspects are centralized through the IBGE database, which

performs the statistical analysis of populations and other demographic aspects. But such databases, as well as other sources (e.g. dissertations, theses and publications) that could address this issue for the Santana do Cariri region do not provide the necessary information to support a temporal analysis. This situation can be understood in terms of the location of Santana do Cariri. It is an isolated municipality, with no main roads and no direct connection to large urban centers. Economic activity is subsistence, essentially focused on family farming and the provision of resources through the Municipality Participation Fund. These aspects mean that there is no specific interest in the region, making the available and published data practically nonexistent. However several measurable outcomes of social change processes as a result of the activities conducted by the Casa da Pedra include evidences on the social fabric of the community and well-being of individuals and families, and consider that all issues that affect people, directly or indirectly, are pertinent to social impact assessment (Vanclay, 2003):

- changes to community values and/or the way it functions: they are represented by the valorization of Cariri Stone as raw material and the recovery of traditional construction techniques; the building of Casa da Pedra in 2014 was the starting point for local people to obtain a new perception of the identity character of this particular raw material (Fig. 5);
- impacts on how people live, work, play and interact with one another on a day-to-day basis: Casa da Pedra is the community's meeting place for activities that reinforce social cohesion, and a preferred spot for wedding celebrations and similar social events (Fig. 7);
- impacts on culture, history, and ability to access cultural resources: Casa da Pedra welcomes diverse cultural actions (theater, music, cinema, exhibitions), and is particularly attractive for the traditional "joanine" parties which represent a strong cultural trait of the northeastern communities (Fig. 9);
- impacts on communities' physical safety, exposure to hazards or risks, and access to and control over resources: represented by training local teachers on sustainable development issues (Fig. 4);
- impacts on communities' quality of life including liveability and aesthetics, as well as the condition of their environment (for example, air quality, noise levels, and access to water): a weather station for air particulate measurement in the atmosphere was recently installed in Inhumas (Fig. 10);
- impacts on communities' access to, and quality of, infrastructure, services and facilities: the recent installation of a power grid has allowed the establishment for a nursery in the vicinity of Casa da Pedra;
- impacts on communities' physical and mental health and well-being, as well as their social, cultural and economic welfare: the production and sale of geoproducts related to the brand mark of the Araripe Geopark (the Santana fossils) has contributed to the self-esteem of the natives, thus fulfilling an identity function among the community (Fig. 11);
- changes to livelihoods, for example, whether people's jobs, properties or businesses are affected, or even if they experience advantage/disadvantage: Casa da Pedra has created 4 direct jobs and 6 indirect jobs, and has contributed to increase the consumption of local products and services; awareness of the use of the Cariri Stone has encouraged the inhabitants to accept Casa da Pedra's help in the restoration of their houses using local raw materials instead of exogenous coating products (Fig. 12).

5. Discussion

Geoparks aim at promoting respect for the evidence that demonstrates the Earth's history inscribed in landscapes, rocks and fossils. But such natural objects, which may attract the worldwide experts on geosciences, display different heritage contents and are the grounds of other interests for the local communities, namely raw materials. According to



Fig. 8. The protagonists of weddings and similar social events frequently request the Casa da Pedra facilities, making it a space reference in strengthening the region's social cohesion.



Fig. 9. The traditional “joanine” parties currently request the Casa da Pedra facilities for the performances of local artistic groups. In June, celebrating Saint Anthony, Saint Peter and Saint John, the gangs are organized, in typical dance groups of the period when people dressed in colorful clothes to the tune of traditional rhythms, besides the typical meals, like corn and its derivatives (pamonha, hominy, mungunzá), cakes (sweet potato, maize, peanut butter), “paçoca” and “aluá” (MDA, 2010).

Castro et al. (2016), the lack of a regulatory standard to geosites access to the Araripe UNESCO Global Geopark creates difficulties to control the visitation demands and the possible impact due to the vulnerability of its territory. Moreover, mining, excavation and drilling are among the evident negative impacts in the nine geosites integrating the geopark (Guimarães et al., 2018). But the illegal trade of fossils, historical artifacts and others, as well as the uncontrolled redirecting of water sources, represent other major threats in this low density territory affected by very hostile weather conditions. To face the challenges of implementing nature conservation, land-use planning, and sustainable development within the Araripe region, identifying and understanding natural and social contexts that characterized the typical backlands of NE Brazil (“sertão”) are the first steps before conceiving and/or implementing any

successful geoconservation management plan.

Community's involvement in all geoconservation actions, and not only in the final part of the process, when it is expected from local communities that the physical integrity of the geological heritage is guaranteed, is the best strategy for co-management of natural conservation, for the support of local equity and empowerment and for the increase of the general community's resilience (Tavares et al., 2015). Improving the relationships with municipalities and related municipal secretariats, collaborating entities, organized societies and the community in the vicinities of the geosites is a viable alternative in order to monitor areas of interest for geosciences which are visited mainly visited by groups with specific scientific and educational interests (Castro et al., 2016).



Fig. 10. The weather station for air particulate measurement in the atmosphere recently installed at the Casa da Pedra.



Fig. 11. Geoproductions related to the brand mark of the Araripe Geopark (the Santana fossils) – the Odonata regia fossil, an insect from the Crato Member (Santana Formation; Lower Cretaceous) is the symbol of the Paleontology Museum Plácido Cidade Nuvens from Santana do Cariri (<https://www.museu.depaleontologiaplacidocidadenuvens.com/>).

This study explores the positive effect of the Casa da Pedra Reference Center (Araripe UNESCO Global Geopark; Ceará State; NE Brazil) on the Inhumas community participation (Municipality of Santana do Cariri) in a wide range of actions fostering a new paradigm of sustainability, which is rooted in an inextricably cultural and scientific approach through education (Werlen et al., 2016). The results relate to a study case, and cannot, as such, be extrapolated to other geoparks and/or contexts, unless other researchers or readers will recognize their usefulness (Cohen et al., 2010). As pointed by Vanclay (2002), social

a



b



Fig. 12. The restoration of the Inhumas houses by replacing the old coating (A) by the local Cairiri Stone (B).

impacts as a result of a local project likely to be significant will vary from place to place, from project to project, and the weighting assigned to each social impact will vary from community to community and between different groups within a given community. However, in spite of those facts, the research design and the resources produced may be useful for inspiring other researches and local interventions aiming at assessing the effect of geoparks on local communities involvement.

6. Conclusions and implications

Based on a community engagement strategy and anchored in the social traits that characterizes the inhabitants of Santana do Cariri, the Federal University of Rio de Janeiro (UFRJ), through the Institute of Geosciences (IGEO), developed an innovative project in Inhumas – the future “City of Stones” – whose first step was the building of a multi-function infrastructure – the Casa da Pedra Reference Center. It is the outcome of a fruitful dialogue between the scientific community with local leaders and the population, in which everyone can benefit. The Center is mainly used by university students from all over Brazil and abroad, but it is open to local communities for other activities, recording an average usage of 29,000 to 30,000 people/year.

But more important than the occupancy rate, translated into numbers, are the evident social transformations and positive impacts detected in the Inhumas community as a result of the diversified activities promoted by the Casa da Pedra since 2016, which highlights the role of empathy-based approaches to conserve the environment and enhance sustainability (Brown et al., 2019). With special focus on the sustainable use of hydric resources and local “Cariri Stone”, including its fossil record, several positive changes have been recorded in social impact issues that affect people, directly or indirectly: people’s way of life, their culture, their community, their political systems, their environment, their health and wellbeing, their personal and property rights and their fears and aspirations (Vanclay, 2003).

The cultural, scientific, educational, and tourist/recreational services that Casa da Pedra provides fully meet the aims and goals of the International Geoscience and Geoparks Programme (UNESCO, 2017c). They derive from the intensive work carried out by the UFRJ-IGEO with endogenous economic and social agents in order to be able to create/market new products concomitant to the basic symbolism attached to geoparks (Ramos and Fernandes, 2016). But beyond that, it fills a set of recognized social needs in the territory: the absence or lack of contextualized teaching and citizen formation; and the absence of local culture systems and the lack of public facilities for culture and centralization of the few (MDA, 2010).

As so, the activities and social impacts carried out by/at Casa da Pedra reported in this work represent an innovative strategy applied to the UNESCO Araripe Global Geopark aiming at improving the local economy and business, and it can be envisaged as a best practice example of fostering sustainability through the geological heritage (Henriques and Brilha, 2017). As pointed by Vanclay (2003), local knowledge and experience are valuable and can be used to enhance planned interventions within a community. By connecting local actions and global challenges, the social change and impacts recognized among the Inhumas community show the role of local culture as a crucial tool to achieve global sustainability (Werlen et al., 2016). It is expected that they can be useful to assist the creation of similar initiatives in other geoparks and/or other low density territories displaying relevant geological heritage and also a source of inspiration for other global challenges, such as the universal and transformative goals and targets of the 2030 Agenda for Sustainable Development (UN, 2019).

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