



MUSEUMS OF GEOLOGICAL AND MINING HERITAGE. CASE STUDY FOR EL SUSPIRO MINE (CÚCUTA, COLOMBIA)

Museos de patrimonio geológico y minero. El caso de estudio de la mina El Suspiro (Cúcuta, Colombia)

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Abstract: This work provides information on several existing museums in the region of Cúcuta (Colombia), which have elements that can be considered geological or mining heritage. These museums could be integrated into the creation of a mining theme park in conjunction with the closure of the El Suspiro limestone mine. The objective of this study, in addition to disseminating the information, is to show the existing museums at the municipalities of Los Patios and Cúcuta, where there are collections of fossils, minerals and archaeological elements found in the region. Additionally, there are enginery and elements that were used for mining development in the region as well as in the School of Mining Engineering at the Universidad Francisco de Paula Santander (UFPS). The methodology of this study involved an analysis of the topic at global, national and local contexts, visits to the museums and the mine site, as well as photographic records and geo-positioning. It is concluded that it is feasible to implement geotouristic visits at the El Suspiro limestone mine, as well as visits to the existing museums in Agualinda and Vados counties, and the museum of geological and mining heritage of the Universidad Francisco de Paula Santander at Cúcuta, Colombia.

Keywords: geological heritage, geo-tourism, mine closure, mining heritage, paleontology.

Resumen: Este trabajo aporta información sobre varios museos existentes en la región de Cúcuta (Colombia), que tienen elementos que pueden considerarse patrimonio geológico o minero. Estos museos podrían integrarse en la creación de un parque temático minero en la etapa de cierre de la mina de caliza El Suspiro. El objetivo de este estudio, además de difundir la información, es mostrar los museos existentes en los municipios de Los Patios y Cúcuta, donde se encuentran colecciones de fósiles, minerales y elementos arqueológicos encontrados en la región. Además, hay equipos y elementos que se han utilizado para el desarrollo de la minería en la región y también se han utilizado en la Escuela de Ingeniería de Minas de la Universidad Francisco de Paula Santander (UFPS). La metodología de este estudio incluyó un análisis temático en un contexto global, nacional y local, visitas a museos y sitios mineros, registro fotográfico y geo-posicionamiento. Se concluye que es factible implementar rutas geoturísticas con visitas a la mina de caliza El Suspiro, así como visitas a museos existentes en los condados de Agualinda y Vados, y el museo del patrimonio geológico y minero de la Universidad Francisco de Paula Santander de Cúcuta, Colombia.

Palabras clave: patrimonio geológico, geo-turismo, cierre de minas, patrimonio minero, paleontología.



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Introduction

Museums are tools for participatory management of both the natural and cultural heritage of a territory. In many cases, we observe that natural history museums define geology as a central factor of their action: adult and school education on environment, geology, and mining, collective organization of facilities for scholars and visitors, assistance to field research and site protection (Canavese *et al.*, 2018). In the same way, by the elements resting in the museums, the geological evolution and the development of the mining activity of a community can be evidenced (Simeoni *et al.*, 2018). Marescotti *et al.* (2018) conducted a study in the sulfide mining district of Petronio and Gromolo valleys, located on the Eastern Liguria, Italy, with the aim of applying a model for the complete census of derelict mines, also of evaluating the geological heritage, the geo-tourist values, the potential risks, and the environmental impact.

UNESCO Global Geoparks are single, unified geographical areas where sites and landscapes of international geological significance are managed with a holistic concept of protection, education and sustainable development. An UNESCO Global Geopark uses its geological heritage, in connection with all other aspects of the area's natural and cultural heritage, to enhance awareness and understanding of key issues facing society, such as using our earth's resources sustainably, mitigating the effects of climate change and reducing natural disasters-related risks. By raising awareness of the importance of the area's geological heritage in history and today society, UNESCO Global Geoparks give local people a sense of pride in their region and strengthen their identification with the area.

A Geo-miner park is a part of the territory that is rich in minerals and other geological elements; they also contain natural, historical, technological and economic values (Kovacs *et al.*, 2009). These parks also have enginery, trains, furnaces and buildings used for the transformation of minerals. Parks are established to give the land back to people and promote the integral features of heritage and environment (Rago *et al.*, 2007). A Geopark may be the result of a long community-based development process, initiated with a purely local cultural-historical heritage, extended to the surrounding landscape and natural resources, then to a larger territory and eventually to its geological and mining assets. So, for the creation of the geological or mining parks, the geological heritage or that of mining and industrial origin have acted as channelers of the socioeconomic revitalization of certain territories, going from being a resource (cultural, social, economic) to a product (socioeconomic), but preserving its legacy character that previous generations have left us (Canavese *et al.*, 2018). Mines present a great opportunity to become museums and if they have enough attractions in a more or less extensive territory, in theme parks whose main thread is mining (Orche, 2003).

In Colombia and other countries, it is possible to talk of the progressive consolidation of the so-called mine tourism or industrial and mining heritage tourism (Llurdes, 1997), and even geotourism, when geological heritage in mining areas acquires a more important role. The development of post-industrial facilities for industrial tourism purposes is getting more popular. Such activity allows the protection of historical monuments, by setting new roles, providing a creative impact on the lives of local residents, and facilitating the development of new business models. Due to the development of industrial tourism and, above all, sustainable tourism, post-industrial facilities take on a new life. The idea of sustainable development replaces the emphasis on finding a perfect solution with the use of tangible and intangible values, which is important from the perspective of social life and would be lost if other activities are not carried out. Therefore, the process of transforming post-industrial buildings into tourist facilities, including tourist trails, are related to the design of the development of sustainable models and business models (Józwiak and Sieg, 2021). In any case, a type of tertiary activity related to tourism can be feasible in the mines or coal areas properly, closed, restored and rehabilitated, where their heritage attractions concerning the territory are exposed, including the creation of museums (Cañizares, 2011). Today, mining parks are the main exponent of what we have called mining tourism in countries as Spain. These are identified with areas located in mining basins or districts where both the geological and mining heritage are protected and conditioned so that they can be visited by the public interested in education, recreation, research, training, leisure or therapy (Orche, 2002). It is often possible to incorporate visitor centers, museums, and interpretive centers, as well as access to mines, mineral processing facilities, mining trains, and other elements of interest (Fernández *et al.*, 2010) which provide an overall perspective and allow for organizing guided tours. The mining basin becomes an open-air museum, allowing the building to leap into the landscape (Benito del Pozo, 2010). The previous items are an example of how cultural heritage, along with other initiatives, contribute to the generation of economic, social, and cultural wealth, from the transformation of the heritage resource into a tourist product (Valenzuela *et al.*, 2008), thus contributing to sustainable development (Carvajal and González, 2003; Cañizares, 2011).

In Latin America there is also a growing interest in issues related to geological heritage (Palacio *et al.*, 2016). Geoheritage is always associated with geology and the role that human population has in the adaptation and configuration of the landscape. Archaeological research generates a large amount of information about the cultural heritage that is of importance to understand the origin and development of ancient societies. The transmission of this knowledge to the community is the main responsibility of the archaeologist. However, certain populations do not feel a historical

link with the first civilizations of a given territory and do not understand the cultural value of the natural heritage (Valdez, 2018). Little has been studied in Colombia on the mining heritage. However, some museums are found in capital cities where there are findings of the development of ancient civilizations. It is possible to cite: The Salt Cathedral at Zipaquirá, the Nemocón Salt Museum, the Gold and Emerald museums at Bogotá, the Coal Ecological Park in Amagá (Antioquia), and the paleontology research centers and museums at Villa de Leyva.

of the area. Limestone mines such as El Suspiro, which have been a source of raw material for the manufacture of cement, and also as a source of clay used to elaborate stoneware and ceramics, have had a direct influence on the economic development of the region and its municipality. Starting from the previous context, the main objective of this work is to carry out an inventory and identification of places of interest, relics and museums; and then to characterize and to evaluate these elements that could potentially be classified as geological and mining heritage.

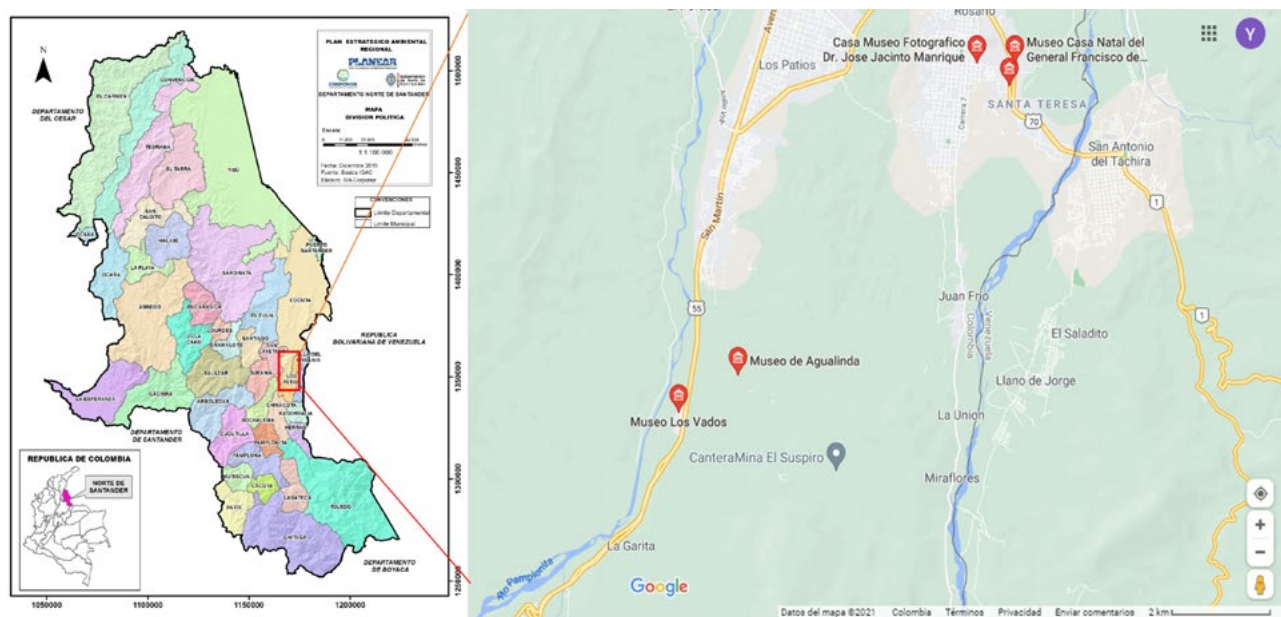


Fig. 1.- Location map of the department of Norte de Santander. Inset indicate the location of Los Patios that appears enlarged to the right with indication of El Suspiro mine and the museums of Agua Linda and Los Vados. Scale 1:100.000 (adapted from Google Maps).

Los Patios is a municipality in the Cúcuta metropolitan area, a border city with Venezuela (Fig. 1). Cúcuta is the second city with the highest unemployment in Colombia and currently has no economic alternatives for its development (La Opinión, 2019). Mining is an activity that helps increase the region's gross domestic product, but it does not offer more job creation due to the stagnation of coal mining, influenced by the international prices of this commodity (Portafolio, 2019). Mining parks could be a further complement to the development projects that arise in a mining area when the mines close, helping to create jobs. In the El Suspiro limestone mine, there are natural structures and relics, which together with some nearby museums, can be considered in the implementation of a mining theme park project. Economic and social development in the region is strongly related to both geological and mining heritage. Sustainable development of the region can be achieved, in part, based on the potential of the geological heritage. According to the aforementioned context, at the municipality of Los Patios, some attractions can be classified as geological and mining heritage, where geotourism projects could be evaluated and developed, which in turn serve to conserve the heritage and to generate activities for the cultural, academic, scientific and commercial development

Colombian Legal framework, cultural and natural heritage laws

Act 397 of 1997, Culture Law, in its fourth article, defines the cultural heritage of Colombia, which is made up of all the cultural assets and values that are the expression of the Colombian nationality, such as tradition, customs and habits, as well as set of intangible and material assets, furniture and real estate, which have a special historical, artistic, aesthetic, plastic, architectural, urban, archaeological, environmental interest, ecological, linguistic, sound, musical, audiovisual, filmic, scientific, testimonial, documentary, literary, bibliographic, museological, anthropological, and the manifestations, products and representations of popular culture. According to the law, state policy will have as main objectives the protection, conservation, rehabilitation and dissemination of this heritage, so that it serves as a testimony to the national cultural identity, both in the present and in the future. In articles 49 and 50 of Law 397, the Ministry of Culture endorses the National Museum to promote museums and research regarding paleontological and archaeological collections. Law 1185 of 2008, describes the integration of the nation's cultural heritage, and highlights that the assets that make up the archaeological

heritage belong to the Nation and are governed by special rules on the matter.

In Law 1185 of 2008, the classification of both movable and immovable material cultural heritage are those of an archaeological nature, which is due to the fact that according to the Ministry of Culture “the remains of materials left by societies human beings that inhabited the territory in the past, such as metal, bone or ceramic artefacts, cut down monuments, goldsmithing and rock art among other things”, are considered movable material cultural heritage; while areas that include remains such as those described previously are considered archaeological sites (Caicedo, 2018).

In articles 30, 31 and 32 of agreement 022 of 2019 (land use plan of Cúcuta), the objectives and strategies are established to carry out an inventory and preserve the cultural heritage of the municipality of Cúcuta.

In Chapter VI of agreement 017 of 2002 (land use plan of the municipality of Los Patios), the cultural heritage is incorporated as part of the historical development of the municipality and considers the areas where archaeological finds have been made and validated. In this agreement, the conservation and protection of the historical and cultural heritage is understood as a process in continuous movement that is directly related to municipal development and must be incorporated as part of the local culture.

Methodology

For this work, the identification, characterization, and evaluation of sites that could potentially be classified as geological or mining heritage were performed. This was developed considering the scientific, educational and tourist values of the considered sites. The methodology included visits to three museums, limestone and clay mines, and photographic records. At El Suspiro mine area there are relics and abandoned structures which were evaluated to analyze if their use is potentially viable for the adaptation of a theme park. It is concluded that it is feasible to implement geological tours in the limestone mine, as well as visits to museums located in the districts of Agua Linda and Los Vados, and the Museum of Geological and Mining Heritage of the Universidad Francisco de Paula Santander (UFPS) at Cúcuta. The development of the theme park seeks to preserve the geological and mining heritage once the mine is closed.

The methodology used for the valuation of the inventory of Geological Sites of Interest (LIG, from the acronym in Spanish) was the one proposed by Vegas *et al.* (2012) and published by IGME. This guide offers a methodology for the valuation of sites of geological interest considered geological heritage, in order to ensure their conservation.

The methodology used for the assessment of the inventory of mining sites of interest, was the Methodological guide for integration of the Mining Heritage in the Environmental Impact Assessment of Alberruche *et al.* (2012), also published by IGME. This methodological guide establishes the criteria that allow knowing the assets that make up mining heritage, and that deserve to be preserved, for

inclusion in environmental assessment projects, and thus contribute to improving the enhancement and protection of this mining heritage.

Inventory of geo-mining heritage and museums in the municipality of Los Patios

The following subsections display an inventory of sites and elements considered of interest, related to the topics addressed in this study.

Patio's Estoraques

These erosional features developed on unconsolidated fine-grained sediments of the Guayabo Formation are the result of the weathering and the accelerated erosion to which they have been exposed. These pedestals are attractive because of the natural beauty that makes them unique and can be of great interest, even to people without specific education in Earth science (Fig. 2).



Fig. 2.- Overview of the Estoraques, Los Vados sidewalk. Source: <http://lapaleontologiaencolombia.blogspot.com>

El Suspiro mine

The area of the mine is 1000 Ha (Fig. 3A). The rock that is extracted at El Suspiro mine is used for the manufacture of cement and the holder of the mining concession is CEMEX (Fig. 3B-C). According to the stratigraphic column of the Maracaibo basin and the local column, limestone and other minerals of economic interest are present in the Cogollo and Luna formations. The area has a high geological complexity, where the deformation is represented by folds (anticlines and synclines), faults, intraformational clays, and intense jointing. When folding is too strong the layers may be completely vertical (Fig. 4).

Agua Linda Museum

The Agua Linda Museum was created by the initiative of Saddy Molina, on January 23, 1975. This octogenarian empirical paleontologist sought to preserve the paleontological heritage of the region. In recent decades, pieces of terrestrial



Fig. 3.- A) El Suspiro mine dump. B) Diamante cement factory at El Suspiro mine, year 1998. B) CEMEX cement Factory at El Suspiro mine, year 2014.



Fig. 4.- El Suspiro mine where vertical strata are observed due to strong folding.

fossil bones from mastodons and megatherium were extracted, as well as marine fossils such as Jurassic ammonites, fish from the order of the Jurassic Ganoids, mollusks, and fossil footprints (Fig. 5). These elements were found around the Agua Linda path, mainly at El Suspiro mine area. Other findings of the area include a great variety of marine fossils from the Cretaceous when the area was an inland sea (great variety of ammonites), as well as fish remains, fragments of unidentified ribs, and the finding of a marine reptile is also reported. There are also Megafauna findings, among which are bony plates of indeterminate Gliptodon, as well as possible remains

of toxodons, artiodactyls, and the aforementioned remains of mastodons commented in the post “Mastodons in Colombia III Part” (Paleontología en Colombia, 2011) where the finding of defenses is mentioned, molars, ribs and vertebrae; although perhaps the most relevant finding corresponds to the *Eremotherium* (*Pseudoeremotherium*) *cucutense*.

Los Vados Museum

At Los Vados Museum, paleontological elements fulfill their social meaning by offering their visitors observation, exploration, and contributing to scientific knowledge about the past. At Los Vados Museum, two components are part of the Vados Experimental Ecopark project: anthropological and paleontological. In the paleontological collection, there are fossil remains from the Cretaceous and the Pleistocene, highlighting some bones of the giant Megatherium (Fig. 6), traces of ammonites and cephalopods. At Cúcuta, a finding was reported by La salle brothers of an *Eremotherium*, which was described by Jaime Porta Casanellas in 1961; this scientist *considered* that what was found in the surroundings of Cúcuta is a new species and he called it *Eremotherium cucutense*. The importance of the museum’s fossils lies in showing that several million years ago, this territory was covered by an ocean that was

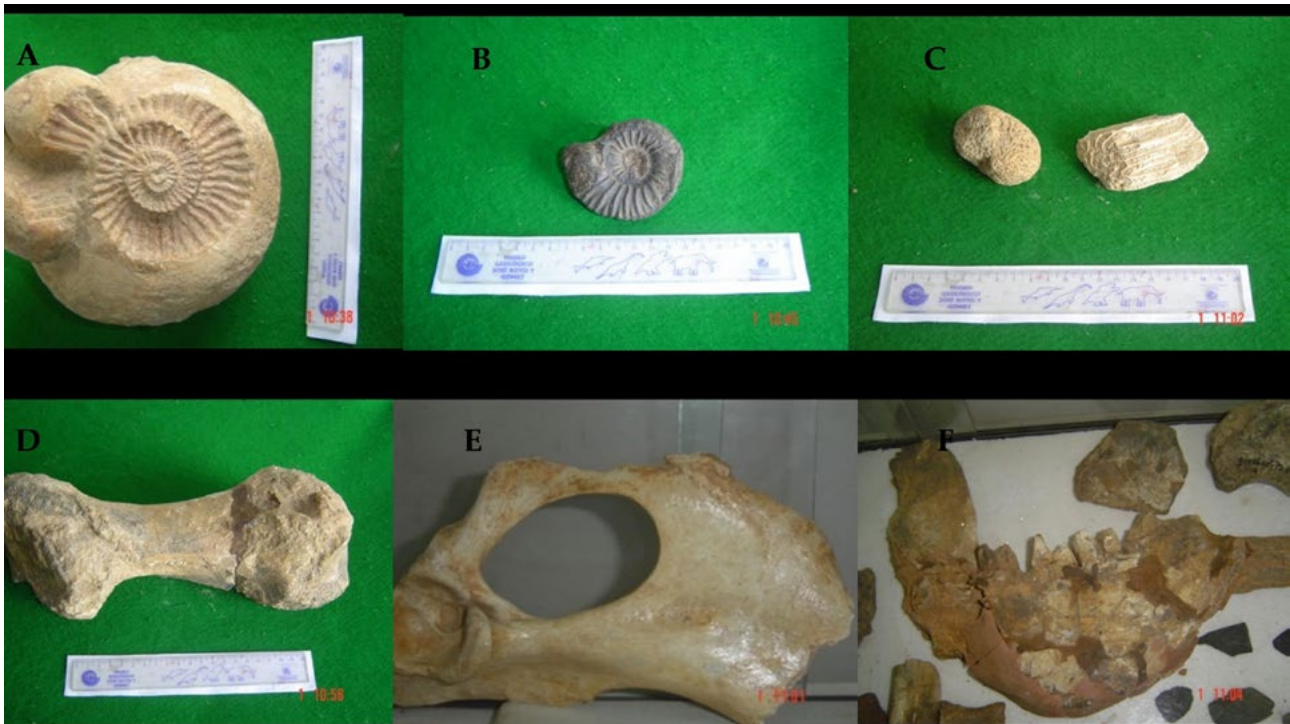


Fig. 5.- Fossils in the Agua Linda Museum: A) ammonite external mold, B) ammonite, C) marine sponge and coral, D) mastodonte humerus, E) equus iliac bone, and F) megatherium jaw.



Fig. 6.- Megatherium bone at Los Vados Museum.
Source <https://museolosvados.blogspot.com/>

home to a very special marine fauna, but it was gradually displaced as the mountain ranges rose, protecting terrestrial species, like the mastodons, primitive elephant, Eremotherium, giant sloth-like specimens, Glyptodonts (giant armadillos) and the Toxodonts (hippo species). These species roamed various sites in the Cúcuta metropolitan area and part of Colombia. Later on, the environmental changes and possibly the intensive hunting by human, affected the extinction of these species.

Universidad Francisco de Paula Santander (UFPS) Museum

This museum exhibits the equipment used during the development of the UFPS mining engineering program. These items became museum pieces due to their age (50 years old). In the museum there are samples of rocks and minerals acquired by the UFPS and were donated by students and professors from the Mining Engineering program. Most of the donated samples have been collected during field practices and specific work from students and professionals. There is also old equipment, in good condition, which was used to detect gases such as safety or benzine lamps, gravimetric dust detectors, bellows pumps, electrical detectors, methanometers and other equipment (Fig. 7).

Abandoned structures

In 1924, Mr. Francisco Antonio Entrena discovered a limestone deposit on the way to Agua Linda. After a few years, the San José of Cúcuta factory was founded. In the area of the mine, where the raw material was calcined, there are a furnace remains in good condition despite the abandonment (Fig. 8A) and some abandoned kilns used by the ceramic industry (Fig. 8B).

Valuation results of geosites and mining heritage

Open-pit mining, paleontological findings, geological structures, and some relics, are elements that may serve to establish a Geological and Mining Park at El Suspiro mine.



Fig. 7.- General view of the Universidad Francisco de Paula Santander Museum.

This involves education for protection, conservation, and sustainable development. This site displays some advantages such as its scientific and aesthetic value, which make it attractive to be visited, and enables the development of the mine closure and abandonment project. Geology and mining are social and economic alternatives for the development of the community at the municipality of Los Patios. For a geological and mining theme park project, museums are highly relevant places. With the three museums currently available and the one that could be implemented in the mine area, they would provide the site with infrastructure for geo-tourism. In Tables 1 and 2 are shown the results of the valuation of the geological places interest (following the methodology described by Vegas *et al.*, 2012), and of the elements that could be considered mining heritage (following the methodology described by Alberruche *et al.*, 2012). In accordance with the proposed simplified valuation methodology, the geosites have a very high value (4); and for elements of mining heritage the value is high. Therefore, these elements must be used appropriately so as not to endanger the geological and mining heritage of the study area. Once the sites of interest have been evaluated, a disclosure must be made both for their knowledge and for their protection. The use can be managed based upon several aspects: as a tourist resource (routes, museums, mining geological parks), as a didactic resource and as a scientific resource. It is necessary both at the regional and national level, the formation of associations and entities that have as objective the study, the valuation and the disclosure of these patrimonies, for a better use and conservation thereof. Cultural heritage alone does not act on the reality of a municipality. However, all kinds of cultural entrepreneurship, whether on the archaeological or the geological and paleontological heritages, generates educational, scientific and cultural dynamics that have a direct impact on social life and on the development of a community. The archaeological and paleontological heritage of Los Patios is, above all, an opportunity to generate this type of cultural, educational, scientific and eventually tourist dynamics, which

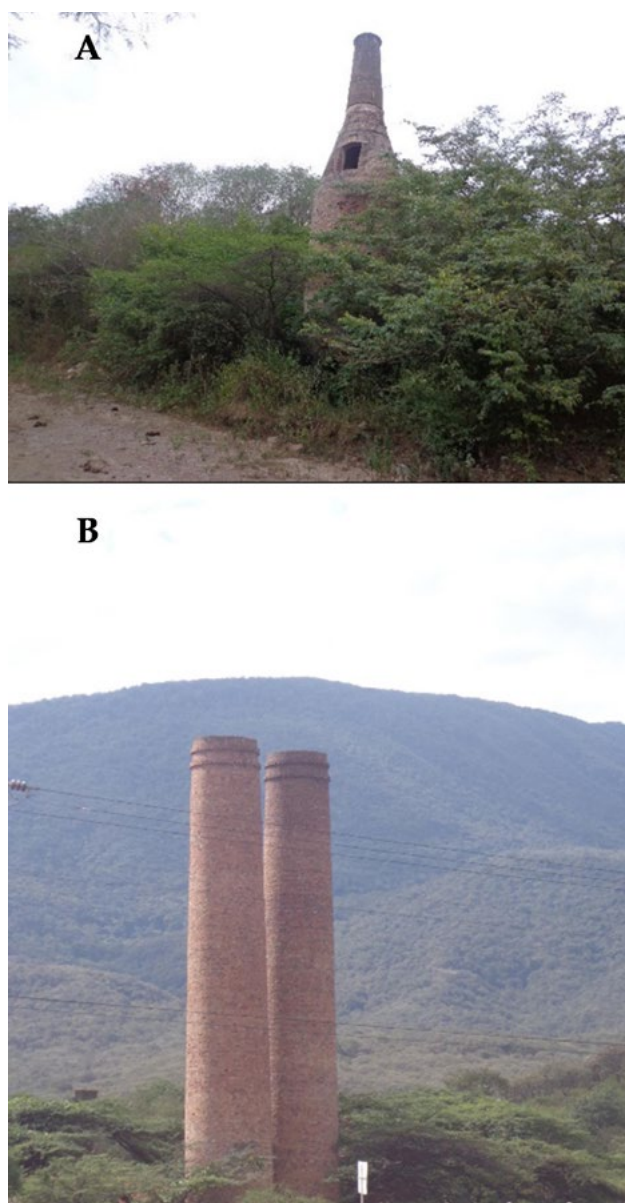


Fig. 8.- A) Ancient cement kiln. B) Fireplaces oven hive at Vados tile factory, abandoned since 1998.

Parameters Museum	Weight	Estoraques	Suspiro Mine	Agua Linda Museum	Los Vados Museum	UFPS Museum
Representativeness	15	30	60	60	60	60
Type locality character	5	5	10	10	10	10
State of conservation	20	80	80	80	80	80
Observation conditions	25	100	50	100	100	100
Rarity	5	5	10	10	10	10
Educational content	5	5	10	20	20	5
Accessibility	10	40	10	20	20	40
Spectacularity and beauty	10	10	40	40	40	40
Outreach content	5	10	10	20	20	10
Total Global value	100	285	280	360	360	355
Geological heritage interest		4	4	4	4	4

Table 1. Geosites and museums valuation results.

Parameters	Weight	Ancient cement kilns	Fireplaces oven
Representativeness	20	80	20
Technological, architectural, historical and socioeconomic	20	40	20
State of conservation	20	80	80
Singularity	20	40	20
Relationship with other heritage elements	5	10	20
Educational content	2.5	2.5	5
Outreach content	2.5	5	5
Accessibility	10	10	40
Total Global value	100	267.5	210
Mining heritage interest		3	3

Table 2. Mining heritage and abandoned structures valuation results.

can give a profile and a particular identity to the municipality in the region as well as to contribute in developing the community. According to these results, we can infer that the sites of geological interest, and the elements of the mining heritage are of high interest and may be considered in the implementation of museums and mining parks (Fig. 9).

Conclusions

The places of geological interest, and the elements that can be considered as mining heritage, in many cases are appropriate for the development, characterization and dissemination of the geological and mining heritage. In these scenarios, the explanation of the geological history and the processes that shaped some of these spaces, facilitates the enrichment of tourist, scientific and educational activities.

At the municipality of Los Patios, there are several places (museums, mines), landscapes and geological structures, relics (furnaces, buildings) and other elements, which could be classified as geological or mining heritage. Some of these elements are threatened by the lack of strategic planning in local and regional development. According to that, these must be recovered and protected before they are used as geological or mining heritage, since they are of high interest and could be



Fig. 9.- Museum and theme park model.

taken into account in the implementation of museums and mining parks.

For the evaluation, recovery, and protection of geological or mining heritage, different entities, government, private sector, academia, and community must be integrated, through projects such as inventory, outreach, conservation, restoration, and commissioning of museums and theme parks, according to international models and experiences.

The concept of a theme park, whose central axis would be El Suspiro mine, is potentially viable. Such issues must be considered in the mine closure plan, which must be agreed between CEMEX, the Norte de Santander government, Los Patios mayor's office, and Agua Linda community.

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