

Geoconservation of underground ecosystems in Santander (Colombia) from geotourism and geoeducation strategies

Abstract

Colombia is characterized by presenting numerous resources in underground ecosystems, which are sensitive sites with special features within karstic landscapes. Santander is located in the central northern part of Colombia and contains not extensive explored extensive network of underground systems associated with highly fossiliferous carbonate rocks of the Cretaceous Rosablanca Formation, which is characterized by a very rich geodiversity exokarst and endokarst geofoms and biodiversity. Unfortunately, there is no environmental awareness in the community or action plans oriented to conservation and use of these underground systems.

Keywords: karst, Santander, natural heritage, ecosystems, geoconservation.

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Introduction

Colombia contains numerous resources in underground ecosystems, which are sensitive sites with special features within landscapes referred as karstic environments.¹ Geospeleology is the branch of the earth sciences that is dedicated to the study of underground cavities. This science is very recent in Colombia and dates back to the early 18th century, when Humboldt visited the Iconozo Bridge, the Grotto of Alfonza and the Cave of Los Ladrones, department of Tolima.² However, Vélez was the first in exploring the caves of Moniquirá, (Boyacá). Since then, underground cavities have been object of interest by different authors.³⁻⁸ It must be developed for the benefit of the communities that own them to boost the industry based on tourism, water, scientific and educational aspects. Thanks to the caves, the scientists can know the climate of the past to understand climate change, learn about evolution because the most important archaeological and paleontological finds have been made in the caverns, and generate education and environmental awareness. There are several studies on cave heritage and management.^{9,10} Geotourism is a relatively new concept in the tourism industry, which has emerged as a rapidly growing form of tourism.¹¹ Several authors,¹²⁻¹⁷ have defined geotourism. According to Servati and Qasemi,¹⁸ geotourism, as a subcategory of tourism, which is considered one of the new methods in providing tourism attraction (is a relatively new concept in tourism industry which has considerable growth in recent decade. Underground systems are significant elements of geoheritage and, therefore, they should be included catalogue of geosites.¹⁹ There are different studies on cave heritage and management.^{9,10,20-22} The karst system of Santander has approximately seventy (70) underground cavities associated with the Cretaceous Rosablanca Formation, which consists highly fossiliferous marine mudstones and limestones.²³ Underground systems represent unique natural laboratories and incredible landscapes from which, visitors can gain exceptional knowledge about the karstic dynamics. National Geographic has adopted the term “Geoeducation” to describe education about our world, providing students with a global understanding of how to work at local, regional and global levels. However, the concept of Geoeducation is not known in Colombia, because it has not been

given importance to geosciences. Geoeducation plays an important role in integrating local communities to improve their quality of life, providing social equity. Geoconservation has steadily become an established concept^{24,25} which refers to the conservation and sustainable management of geological/geomorphological heritage sites of special interest for education and research. According to Stephens et al.,²⁶ a geoconservation plan implemented for caves, can be based on excellent features of caves, which are important for education, research and eco/geo-tourism. The aim of this paper is to promote the geotourism and geoeducation practices around underground systems in Santander for geoconservation purposes.

Geological setting

The Cretaceous Rosablanca Formation, according to its current structural characteristics, morphology, relief and climate, and morphodynamic processes, constitutes an active karstic system.²⁷ It overlaps concordantly Los Santos Formation and is in transitional contact with the overlying Paja and Ruitoque formations.²³ Different studies²⁸⁻³⁰ have been carried out on this geological unit, particularly in relation to its stratigraphy and sedimentation environment. It consists of dolomitic limestones and evaporitic limestones with few intercalations of rocks of terrigenous origin in the lower part,³¹ biomicrites, marls and shales in the middle part²⁹ and sandstones and biosparitic rudstones with large bivalves in the upper part.²⁸ Santander shows one of the largest developments of karstic environments in Colombia. Figure 1 illustrates the location of the main occurrences of karst in Santander and the main exokarst and endokarst features.

Results

The valuation of underground systems has been performed according to the guidelines of the Instituto Geológico y Minero de España (IGME), which has been adopted by the Colombian Geological Service (CGS) for the characterization of the nation's geological heritage, valuing the elements that conform it according to the evaluation parameters. The evaluation of underground systems in Santander was carried out applying the valuation guidelines adopted by the CGS, according to their particular scientific, didactic

and tourism interest for the development of projects and initiatives.³² A characterization of underground cavities led to speleometric maps and speleotematic catalogs was made. The periods of the karst cycles have been characterized taking into account the classification of Llopis-Llado.³³ The study of speleothems, tectonic indicators and karst associated to the underground cavities will serve to deepen the interpretations of the origin and evolution of the karstic regions in Santander, highlighting its geological importance, in order to generate educational and touristic activities that have the consequence of conservation of it, a virtual ethical signal linked to a QR code emphasizing the active geological processes that can be seen in it and its importance, along with an annex of the map of the caves as an aid to tourists to have an idea of how they should behave, which is a viable alternative due to the tourist occurrence of each cave and lack of control at the entrance, as well as a permanent tour guide of the activities of geotourism that could be developed there with a good planning and implementation in an ideal scenario that would have

as repercussions improvements and contributions to the economic and social development of the region. Underground georoutes have been performed, taking into account the use of personal protective equipment, the guidelines for the correct exploration of the karst system, the principles of geology, the speleothems and their formation, the karst geofoms, the basic hydrogeology and the importance of the natural and cultural heritage in order to develop geotourism and geoeducation activities, sensitizing the participants to perform good practices during the development of these activities in order to contribute to the geoconservation of the underground ecosystems and, therefore, to the sustainable development of the region. Therefore, the results can include the mineralogical characterization of speleothems that would contribute to the development of an architectural analysis for the reconstruction of paleoclimates, the didactic and informative material so that the visitors get a richer visit in terms of scientific education, the development of geoeducation and geotourism training activities.

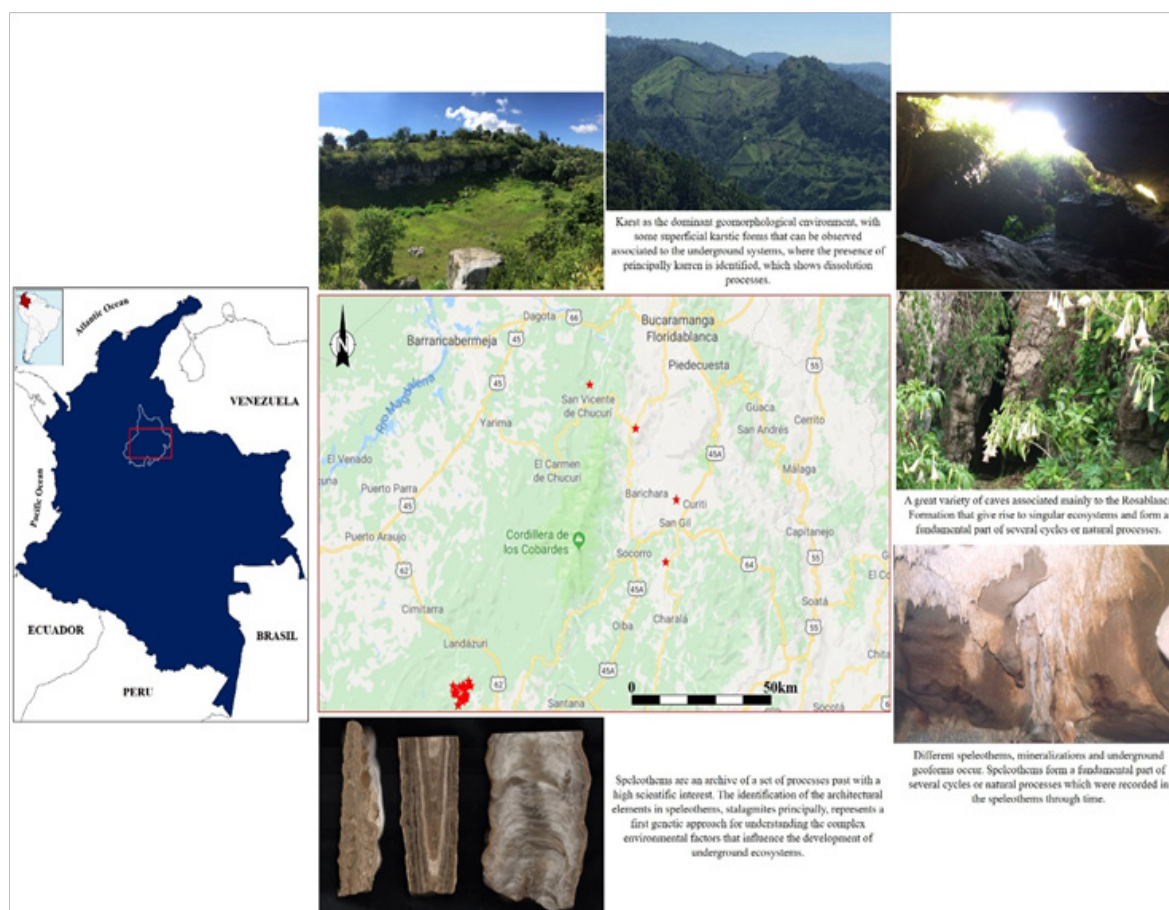


Figure 1 Geographical location of the main occurrences of karst in Santander and exokarst and endokarst features.

Geoconservation of underground ecosystems

In Colombia, there are numerous underground ecosystems, which, however, are not regulated or monitored by government guidelines or assisted by corporations and environmental entities, despite the wealth of fauna they contain and the tourism and sports possibilities they offer.³⁴ Deterioration of caves and speleothems directly due to tourist activities and vandalism has been observed,³⁵ which consequently

induce a great harm to the equilibrium of the ecosystem. Activities such as mining, disposal of garbage, bonfires, dumping of sewage, indiscriminate tourism, destruction of speleothems and pictograms, graffiti on walls and ceilings, looting of archaeological material and little legislation for their protection have severely affected the underground ecosystems,³⁴ which, according to Anh-Duc & García-Guinea³⁶ are highly dynamic and understanding of their environment

requires immediate methodological attention. Therefore, it is very important to keep in mind that for purposes of geoconservation it is necessary to raise awareness among those who are going to

participate in the activities of geotourism and geoeducation that comply with norms of good practices to avoid the deterioration of these subterranean ecosystems (Figure 2).



Figure 2 Geoconservation of underground systems.

Conclusions

Numerous underground systems in Santander municipalities, such as Zapatoca, Los Santos, Rionegro and El Peñón, can be considered as representative speleosites due to their exceptional values, standing out for their spatial development, richness and diversity of speleothems, underground streams and lakes and paleontological or archaeological remains. It is hoped to obtain strategic alliances with different entities that allow to expand these works to new municipalities and cavities of the department, taking into account the great Karstic potential that the entire department has. Karst sciences and geospeleology have enormous potential and must be known to scientists because of their great importance and ability to understand phenomena such as climate change and contribute to the sustainable development of regions.

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Conflicts of interest

The authors declare that there are no conflicts of interest.

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