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Chicamocha Canyon Geopark project: A novel strategy for the socio-economic development of Santander (Colombia) through geoeducation, geotourism and geoconservation

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ABSTRACT

The proposed Chicamocha Canyon Geopark project is starting its way for nomination as a UNESCO Global Geopark under the recognition of the Global Geoparks Network. This paper aims to present the justifications of establishing this geopark. It also assesses the potential role of a geopark figure in Santander as an urgent measure to promote the geoconservation of the Chicamocha Canyon territory. The success of this project will not only improve the living conditions of local communities, but also will be a reference model in terms of geological conservation at national and international level. The Chicamocha Canyon, where is proposed to develop this project, has a great potential for the development of the tourism industry due to climatic conditions of the region, besides possessing a rich cultural and natural heritage that needs to be enhanced and protected. Undoubtedly, this initiative should satisfy all the requirements to be a UNESCO Global Geopark, which include a delimited area that defines a territory, the occurrence of geological features of international importance with scientific, educational and aesthetic value, the presence of other types of heritage such as archaeological sites, as well as a proper access infrastructure that favors the socio-economic development of the region. In order to guarantee the successful consolidation of the proposed geopark within the defined territory, this initiative must count the strong support of the local communities and must involve stakeholders such as government authorities, academic and research institutions, and local businesses.

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1. Introduction

According to UNESCO (2011), a geopark represents a "unified area with geological heritage of international significance and where that heritage is being used to promote the sustainable development of the local communities who live there". It is a well-defined area that contains one or more geoheritage sites selected on the basis of scientific importance, rarity, scenic quality, or relation to geological history, events and processes (e.g., Eder & Patzak, 2004; UNESCO, 2014). Geoparks have been created worldwide for tourist-oriented promotion of geological knowledge via demonstration of unique and/or peculiar geological features in connection with nature and culture; they also serve for educational and scientific purposes (e.g., Farsani, Coelho, Costa, & Amrikazemi, 2014; UNESCO, 2016). The conservation of geologically significant sites, education of the public and socio-economically sustainable development of the local communities are among the key issues geoparks address (e.g., Dong, Song, Chen, Zhao, & Yu, 2014; Erikstad, 2013; Jones, 2008; Semeniuk & Brocx, 2019; Wang et al., 2014; Zouros & McKeever, 2009). Geoparks can provide appropriate management strategies, by empowering the local communities with knowledge of their own geological heritage and enhancing the connection between this heritage and other natural and cultural elements of the territory (e.g., UNESCO, 2014).

Geoparks can also bring economic benefits to the local communities through the practice of responsible tourist and educative activities around the geosites (e.g., Koh, Oh, Youn, & Kim, 2014; McKeever & Zouros, 2011). One of the main international initiatives that have encouraged this concept is the Global Geopark Network (GGN) guided by the UNESCO and established in 2004 at the first international conference on geoparks held in Beijing China (e.g., Dowling, 2013; Štrba, Kršák, Molokáč, & Adamković, 2016; UNESCO, 2016). The GGN list includes to 2020, 161 geoparks distributed in 44 Member States, from which several geoparks cross political boundaries. Fig. 1 illustrates the localization of the Latin America and Caribbean Geoparks Network. The UNESCO Global Geoparks are represented in Latin America by seven successful initiatives: Araripe in Brazil, Grutas del Palacio in Uruguay, Kütralkura in Chile, Imbabura in Ecuador, Colca y Volcanes de Andagua in Perú, and Mixteca Alta and Comarca Minera in Mexico. Latin America has the challenge of increasing its number of global geoparks, with an explicit commitment to increase awareness of geodiversity and promote best practices in protection, education and sustainable tourism (UNESCO, 2019).

A great effort has been made to promote these initiatives, particularly through the creation of the regional Latin America and Caribbean Geoparks Network in 2017. Currently, several countries such as Argentina, Brazil, Chile, Colombia, Costa Rica, Ecuador, Peru, Nicaragua and Venezuela are proposing different geopark projects by means of strategies where the academic sector (mainly geoscientific schools), the community itself, the public and private sectors, organizations of the civil society and the different government levels meet. The Chicamocha Canyon region offers a world-class geology as a globally unique potential geopark and, although the importance of this region is known from different points of view, to date, this aspect is something that deserves to be highlighted for its recognition. In this sense, the Chicamocha Canyon Geopark (CCG) project is proposed as an initiative of a multidisciplinary team and local and national allied partners that recognize that it represents an opportunity to give visibility of Colombian national values, through a strong commitment of social progress and conservation of our natural and cultural legacy. In this article, we present some information on the proposed geopark, including an overview of the project, its natural and cultural heritage attributes, geotourism and geoeducation activities, local economy and sustainable development.

Fig. 1. World map, showing the distribution of the Latin America and Caribbean Geoparks.

2. Materials and methods

A literature review of national and international scientific articles, papers of proceedings, theses, thematic and topographic maps, satellite images, shadow maps and terrain models, books and web sites, was performed on the Chicamocha Canyon region. Primary data were provided by the co-authors, which included fieldwork notes and observations, photo-documentation, exchange of ideas and experiences of the research team on the acquired knowledge and group discussions.

Each site was mapped in the fieldwork, using 1:25000 topographic maps of the Agustín Codazzi Geographical Institute. Satellite images from Google Earth (2020) were used to identify the main litostratigraphic units and regional structures, whereas the main geological basis was the Geological Map of the Department of Santander, developed by the Geological Survey of Colombia (GSC) (Royero & Clavijo, 2001; Royero & Vargas, 1999). Regional analysis and mapping of geological faults was performed by interpreting shadow maps with terrain models downloaded from NASA - Alaska Satellite Facility (NASA, 2015). For the gathering of information during the fieldwork, the Garmin® International Global Positioning System (GPS) technology was used to obtain the coordinates of the points of interest in the Chicamocha Canyon region and on some occasions the routes or tracks carried out in some days were taken for later analysis. Finally, the geosites were compiled into a database implemented with Microsoft Excel software. The information was extracted from a computer equipment and the Garmin base camp software allowed interaction with the information collected in the fieldwork, its visualization and later its export to the appropriate format to be used in SIG programs such as ArcGIS.

Fieldwork allowed the identification and characterization of sites that could be included in the list of potential geosites and the recognition of new potential geosites. Each geosite was qualitatively evaluated using the criteria proposed by Brilha (2016): (1) representativeness, (2) integrity, (3) rarity and (4) scientific knowledge, the last of them based on the existence of already published scientific data on the geosite. The list of geosites in the study area was subsequently prepared. Each geographic site was characterized using the following data: (1) Geosite name, (2) Typological category, (3) Heritage category, (4) Heritage subcategory, (5) Value criteria, (6) Location and (7) Main characteristics. After a list of geosites was done, it was also necessary to take into account the potential scientific and educational value of each site mainly based on its didactic character, that means, how students from different educational levels can easily understand it. However, it is also very important to consider its

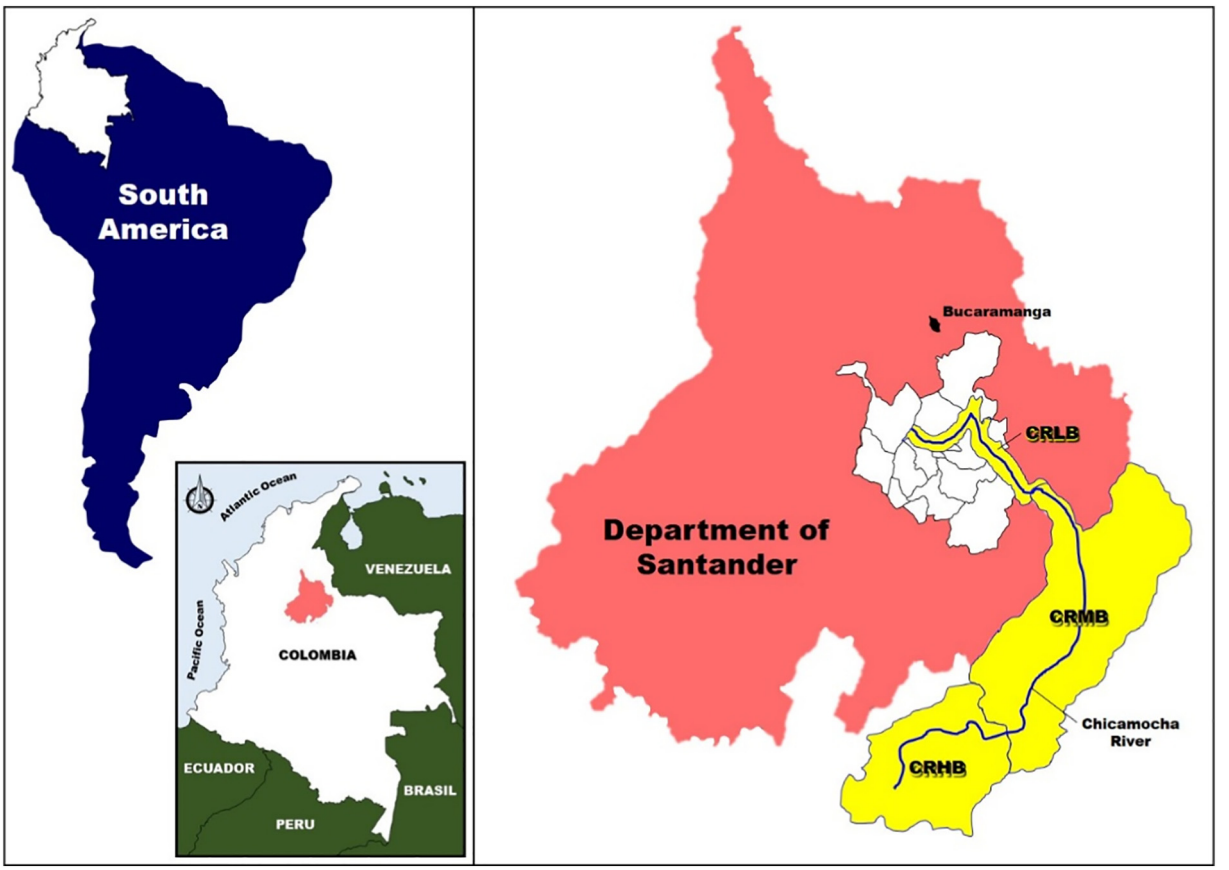

Fig. 2. Left, geographic location of Colombia in South America and Department of Santander in Colombia. Right, map of the Department of Santander showing the perimeter of the CCG project (white color) and the Chicamocha River basins. CRLB, Chicamocha river low basin; CRMB, Chicamocha river middle basin; CRHB, Chicamocha river high basin.

accessibility and safety. According to Brilha (2016), the inventory of geological and geodiversity sites is the first and crucial step in any geoconservation strategy. On the other hand, the field work also allowed the identification of the different elements of the landscape and the visualization of interpretive paths through which the geosites could be connected.

Access to global biodiversity data was carried out through the Global Biodiversity Information Facility (GBIF), a global infrastructure of over a billion biological specimen records published freely by institutions across the world (GBIF, 2019).

3. CCG project

The CCG project is located in the northeastern region of Colombia (South America), being crossed by the Chicamocha river whose hydrographic basin forms the Chicamocha Canyon, which is located just 54 km S-SE of Bucaramanga (Santander) (Fig. 2). Access to this territory takes place along the national road that leads from Bucaramanga to Bogotá. The Chicamocha Canyon begins in the foothills of the Sierra Nevada del Cocuy and ends near Lebrija. The area for the CCG project is about 2866,63 km^2 corresponding to the administrative limits of the Piedecuesta, Los Santos, Cepitá, Jordán, Aratoca, Curití, San Gil, Mogotes, Pinchote, Barichara, Villanueva, Cabrera, Galan y Zapatoca municipalities. The climatic conditions of the arid enclave of the Chicamocha Canyon are directly related to the local topography, which surrounds the Chicamocha river and acts as a barrier to the rains and humid currents that come from the Orinoquía and the Magdalena river valley (Serrano et al., 2009). It has an

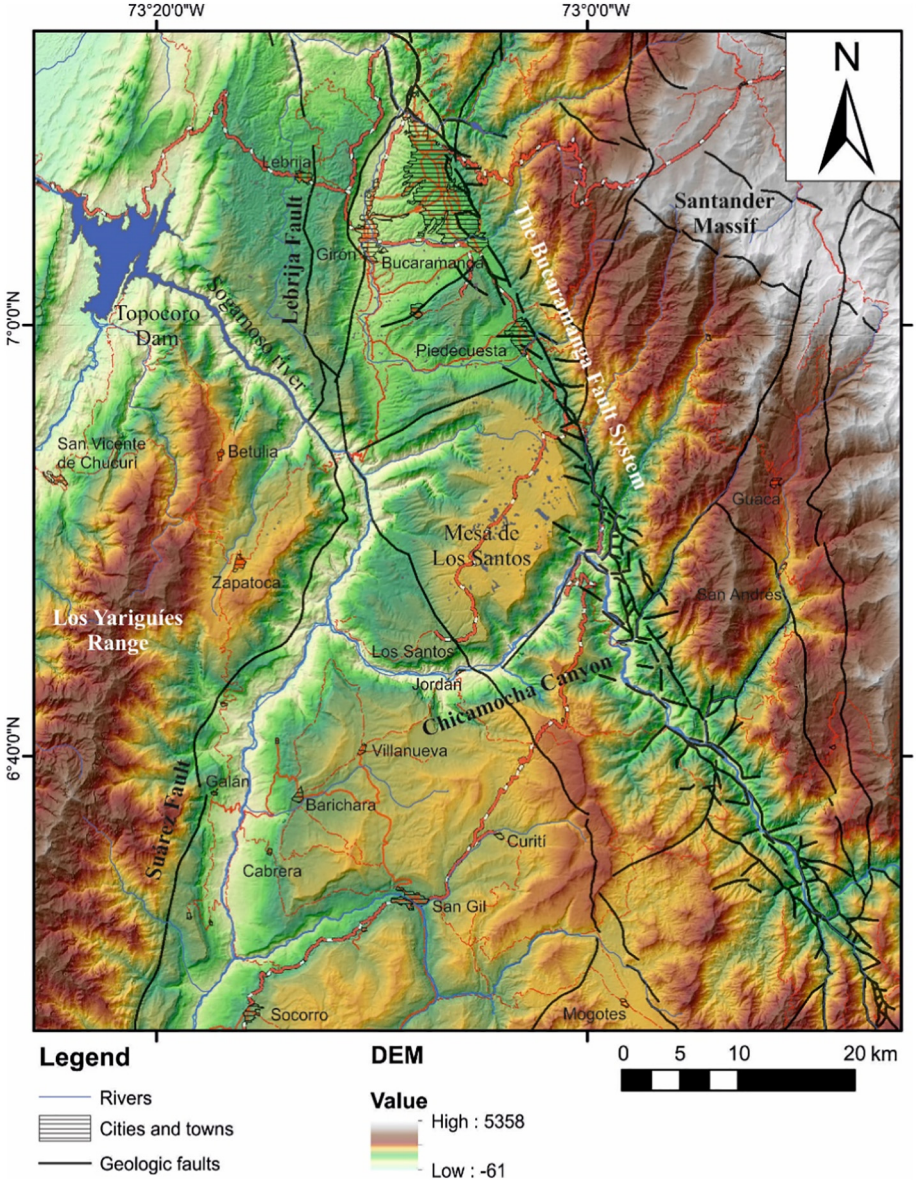

Fig. 3. Digital terrain model and shadow map of NASA (2015), showing the NW-trending Bucaramanga Fault.

average annual temperature of 25–28 °C and an average annual precipitation of 731 mm (e.g., Albesiano & Rangel, 2006; Albesiano, Rangel, & Cadena, 2003; Díaz-Pérez, Puerto-Hurtado, & Fernández-Alonso, 2011; Valencia-Duarte, Trujillo, & Vargas, 2012).

The CCG project encompasses from E to W the Santander Massif, the Mesas and Cuestas region (Lebrija, Ruitoque, Zapatoca, Los Santos y Barichara), the Los Yariguíes Range and the low basin of the Chicamocha River (Fig. 3). The Mesas and Cuestas region is limited by the NW-trending Bucaramanga Fault and the NE-trending Suárez NS-trending Lebrija faults. The Chicamocha River initially shows a NW direction, following the Bucaramanga Fault, changes its course (SW direction) abruptly in the Pescadero township, and approximately 2 km before Jordán it changes again its course (EW direction) until joining the Suárez River to form the Sogamoso River.

The CCG project is based on a strategy for socio-economic and sustainable development through geoeducation, geotourism and geoconservation. The candidacy of this geopark must be based on strong support from the community, involving authorities, educational institutions and research. Geoparks are destined to seek an integrative approach in which social participation is fundamental. Therefore, this initiative focuses on a bottom-up strategy, following UNESCO guidelines and, therefore, does not correspond to guidelines imposed at the governmental level or to academic proposals. In this way, the CCG project would come from the interest of the local stakeholders themselves, who must assume the responsibility of managing and disseminating their natural and cultural heritage. This should be linked to the enhancement of the geological heritage, which should be carried out by geoscientists as a way of managing the territory with an emphasis on the articulation of agents that foster local development actions, stimulating the development of educational, tourism and conservation, good institutional practices that integrate efforts within the territory and public policy guiding mechanism. Therefore, this initiative aims not only to declare the Chicamocha Canyon to UNESCO as a new Global Geopark, but also to be included in the GGN, which is supported by UNESCO and promotes among its members the joint work and the exchange of ideas on good practices, raising quality standards. However, it is important to bear in mind that the declaration of a geopark is based on three principles (Carcavilla-Urquí & García-Cortés, 2014): (1) existence of a geological heritage that serves as a protagonist and driving axis; (2) initiation of geoconservation and outreach initiatives; (3) socio-economic and cultural development at the local level (Fig. 4).

There are numerous reasons that justify the need to start a way for nomination of the Chicamocha Canyon as a UNESCO Global Geopark. The potential that the Chicamocha Canyon presents for a future application is based on the attributes that reflect the natural and cultural heritage of this region. Despite the fact that different studies focused on contributing to the generation and transfer of knowledge from different perspectives have been carried out there, some of which have made attempts to highlight their heritage values, however, none of these works have revealed the importance of this region as a territory that could aspire to postulation as a geopark. This work brings together the experiences of a team of professionals, who have held several fieldworks during the last two decades in the Chicamocha Canyon region to document their physical and biological features, as well as their cultural characteristics.

Determining these reasons has been approached in a didactic and explanatory way in order to highlight its most important geological phenomena that have contributed to model the landscape of the Chicamocha Canyon, and the sites of geoheritage interest. Along georoutes, it is possible to visit potential geosites, which preserve important evidence about the oldest history of this

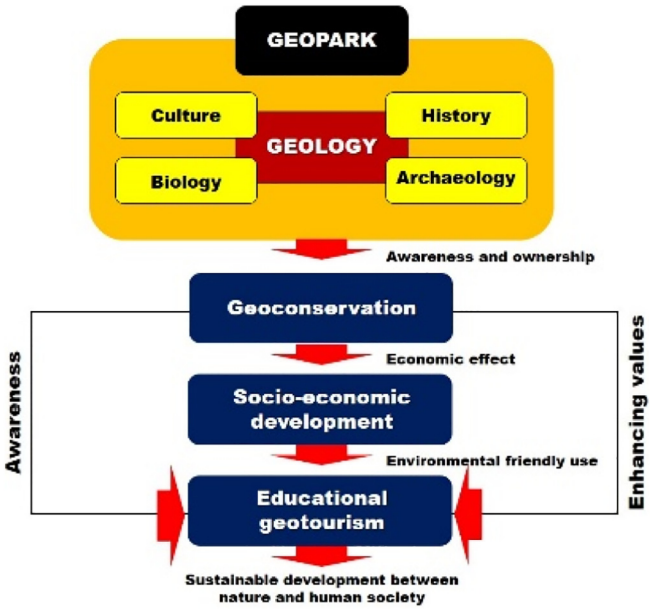

Fig. 4. Schematic diagram showing the functions and requirements of geoparks. (Adapted and modified after Woo, 2014).

region, and to admire fascinating geological scenarios. The geological landscape reveals valuable information to decipher the scientific, didactic and cultural interest of this territory. In the past, there have been some initiatives aimed at obtaining UNESCO's global recognition of this territory, but its failure was that they have not had a real interdisciplinary team to integrate geological, biological, archaeological, historical and cultural, among others, to relate not only the characteristics but also the evolution of the territory. On the other hand, the geological significance and geotourism potential of this territory are not fully understood and explored. Geotourism provides real economic benefits to the local communities (Ruban, 2017), and, when local communities understand the benefits of geotourism, they take responsibility for managing the destination (Mabvuto-Ngwira & Conway, 2011). The aspiration of the candidature of the CCG project should be linked to the enhancement of the geological heritage, which must be carried out by researchers in geosciences, in order to ensure the management of the territory by articulating agents that foster local development actions, stimulate the development of geoeducation, geotourism and geoconservation programs, as well as good institutional practices that integrate efforts within the territory, and serve as a guiding mechanism for public policy.

4. Natural and cultural heritage attributes of the CCG project

The CCG project integrates the values of natural and cultural heritage that characterize the personality of its territory being very important the participation of the local communities in the development of the project. The participation of local communities in the decision-making process is a fundamental prerequisite to generate support, cooperation and a broad sense of responsibility towards the protection and conservation of the region's natural and cultural heritage (Amorfini, Bartelletti, & Ottria, 2011). According to Nikolova and Sinnyovsky (2019), geoparks are areas of interest for scientific researches and education but also aim to provide the necessary conditions for development of natural and cultural tourism. Beyond cultural heritage that has been particularly studied, this logic will also affect other types of heritage less documented (Van Geert, 2019). Humans recognize that some landscapes are more diverse than others, regardless of natural resources, and the concept of diversity is clear and intuitive and terms such as geodiversity and biodiversity have been assigned to the study of this concept with a focus on various aspects of the natural system (Ibáñez, Brevik, & Cerdà, 2019).

4.1. Geodiversity of the CCG project

The term “geodiversity” is a relatively recent concept, but one that is widely used and disseminated, with a marked tendency to consider it as a synonym of “geological diversity”, a meaning that today is very restrictive (e.g., Serrano & Ruiz-Flaño, 2007a, 2007b). Geodiversity is a vital idea for the efficient management of geological heritage (Gray, 2008), and therefore requires a very adequate definition. According to Carcavilla-Urquí, López-Martínez, and Durán (2007), geodiversity represents the geological diversity of a territory, understood as the variety of geological features present in a place, identified after considering their frequency, distribution and geological evolution. The Chicamocha river has contributed to the modeling of the current landscape of the Chicamocha Canyon region with a peculiar relief consisting of plateaus separated by deep and abrupt valleys cut in sedimentary and crystalline rocks (Guzmán, 2016).

The regional geology and landscape of the Chicamocha Canyon, which is extremely rich in geodiversity, are the result of a sequence of events that occurred from the Precambrian to the present. The oldest rocks are represented by the crystalline basement of the Santander Massif traditionally divided into the following geological units, in ascending order of tectono-stratigraphic level: Bucaramanga Gneiss, Silgará Formation and Orthogneiss, which were cut by several igneous bodies of Paleozoic–Jurassic age (e.g., Boinet, Bourgois, Bellon, & Toussaint, 1985; Dörr, Grösser, Rodríguez, & Kramm, 1995; Goldsmith, Marvin, & Mehnert, 1971; Ordóñez, 2003) and smaller Cretaceous intrusive bodies, which form part of the Santander Plutonic Complex and are interpreted as calc-alkaline crustal bodies emplaced after peak-metamorphism. These basement rocks are unconformably overlain by unmetamorphosed rocks of the Middle Devonian Floresta Formation. Carboniferous and Permian clastic to calcareous sediments unconformably overlay this unit. According to Kammer (1993), the Paleozoic sequences are restricted in their occurrence due to pre-Cretaceous erosional events. Post-Paleozoic sediments, which overlay the Upper Paleozoic marine sediments, include the red beds of the Bocas and Jordán formations. The latter consists of fine-grained feldspar muddy sandstones and sandy mudstones with interlayered volcanic rocks and intrusive clasts (Suarez & Díaz, 2016) and is discordantly overlain by the red bed sequence of the Jurassic Girón Formation. Cretaceous sedimentary rocks occur around the Santander Massif and are preserved as erosional relicts. Neotectonic activity of the Bucaramanga fault is evident from tectonic geomorphology and paleoseismologic studies (e.g., Diederix, Hernández, Torres, Osorio, & Botero, 2009; Diederix, Torres, Hernández, & Botero, 2008; Galvis, Velandia, & Villamizar, 2014; Velandia, 2017; Velandia & Bermúdez, 2018).

The CCG project consists of several potential geosites (Fig. 5). It has been tried that their distribution be homogeneous throughout the territory, and that all the municipalities involved have at least one geosite within their boundaries, maximum involvement of the community and local administrations in place. To organize such a vast and diverse territory, it has been decided to make a division into sectors with a certain internal homogeneity, separated from each other by the channels of the main river courses. In the region, some works have been carried out focused on knowing the geological heritage through georoutes and their potential for developing geotourism and geoeducation activities (e.g., Atuesta-Ortiz, 2018; Caballero & Reyes, 2015; Castellanos & Ríos, 2008; Gélvez, Barajas, Zafra, Herrera, & Ríos, 2018; Gélvez, Rodríguez, Barajas, Zafra, & Tarazona, 2018; Gélvez, Rodríguez, Tarazona, & Castellanos, 2018; Mantilla & Villabona, 2013; Ríos et al., 2019; Ríos, Manco, & Castellanos, 2018; Suarez & Díaz, 2016; Yepes & Daza, 2017; Zafra, 2019; Zafra, Gélvez, Barajas, Ríos, & Castellanos, 2019; Zafra, Ríos, Archila, Barajas-Rangel, &

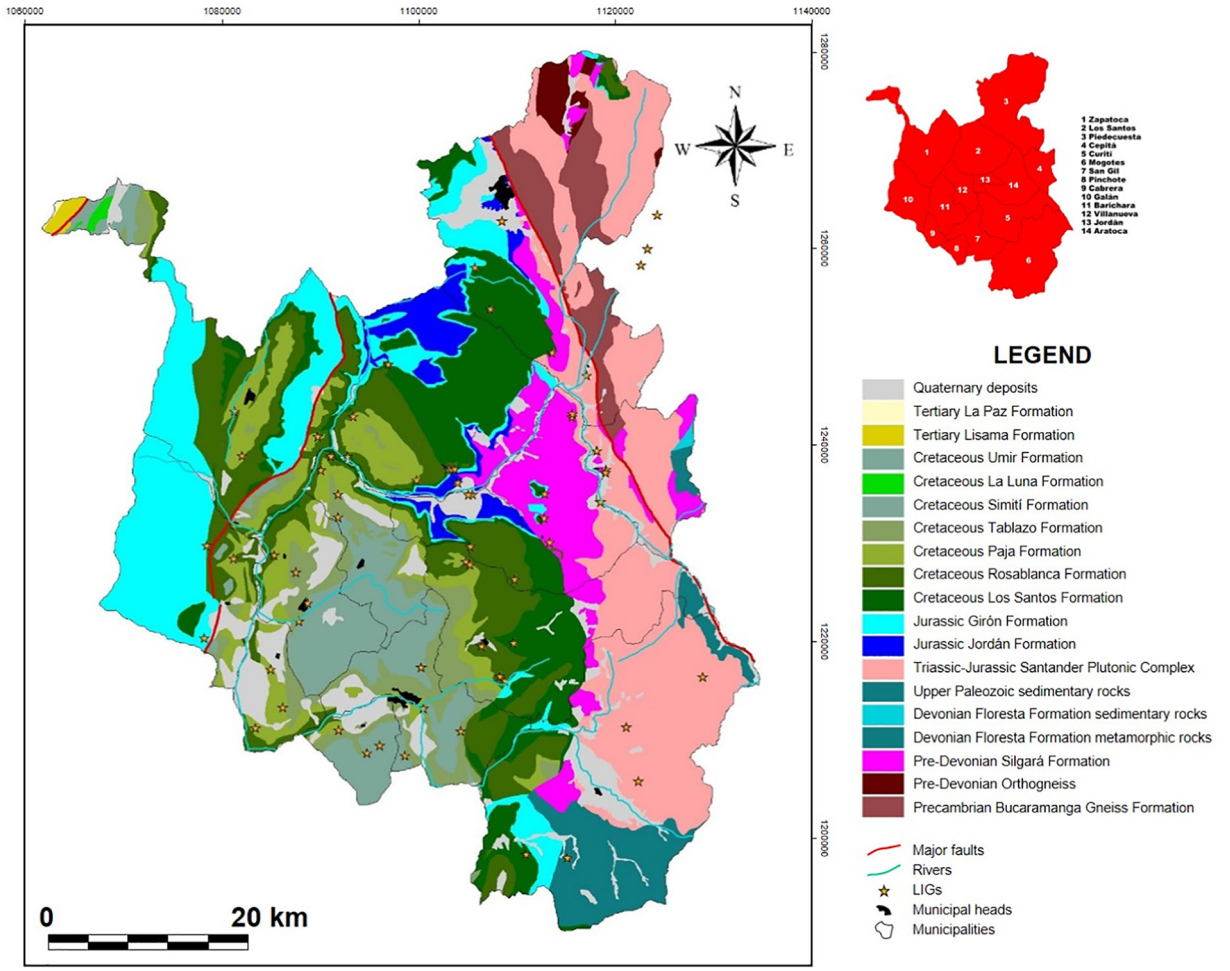

Fig. 5. Map of potential geosites (yellow stars) within the territory proposed for the CCG project.

González, 2018; Zafra, Rodríguez, Gélvez, Guzmán, & Ríos, 2018). Results by those research efforts contain an updated and extensively illustrated the state of knowledge of the geological attractions of this region and constitute a significant contribution to the literature of regional geology. The geosites included in the CCG project are clear examples of places that enhance the natural and cultural heritage of the territory, and the uniqueness and beauty of these places provides significant potential as geotourism resources.

The CCG project encompasses special places that exemplify geological topics such as the early evolution of the Earth's crust, some relevant mineral manifestations associated with igneous and metamorphic processes, representative sedimentary and fossilization processes, as well as recent river dynamics that has contributed greatly to landscape modeling, etc. (Fig. 6). An excellent view of Piedecuesta in which the Bucaramanga Fault that separates the oldest rocks (Bucaramanga Gneiss) of the Massif of Santander from the sedimentary sequence of the Jurassic-Cretaceous of the Mesa de Los Santos is observed in Fig. 6a. The Chicamocha Canyon is the result of various natural factors such as the tectonic activity and the action of weathering agents, which have led to fracturing and the formation of slope deposits (Fig. 6b). In particular, the Chicamocha river and its tributaries have shaped the relief through deep valleys carved by the action of the deposit material as it is removed and transported. Undoubtedly, the size, topography and geological complexity of this region make it a place of exceptional geomorphological beauty. Fig. 6c shows the contract geomorphology between the Chicamocha Canyon; and the region of the Mesa de Los Santos. The majesty of the landscapes of the Chicamocha Canyon (Fig. 6d–g) can be compared to that of the Colorado Canyon in United States of America. The Chicamocha Canyon was carved out by the Chicamocha River and is the result of incision onto the original plateau, with the formation of large cliffs on both sides. From the Pescadero bridge, it is possible to observe how the Chicamocha river changes its course from SE-NW to approximate E-W (Fig. 6h). Fig. 6i illustrates the typical mountainous and arid landscape of Pescadero. Fig. 6j shows the Mogotes Fan whose flat morphology contrasts with the abrupt topography developed by the Mogotes Batholith. The Mesa de Barichara is characterized by a gentle to very gentle slope (generally less than 25°), which becomes a little steeper in the vicinity of the different drains (Fig. 6k). The older rocks of the Santander Massif (migmatitic gneisses) are illustrated in Fig. 6l. The response to deformation in metamorphic rocks of the Silgará Formation is evident in recumbent isocline fold in

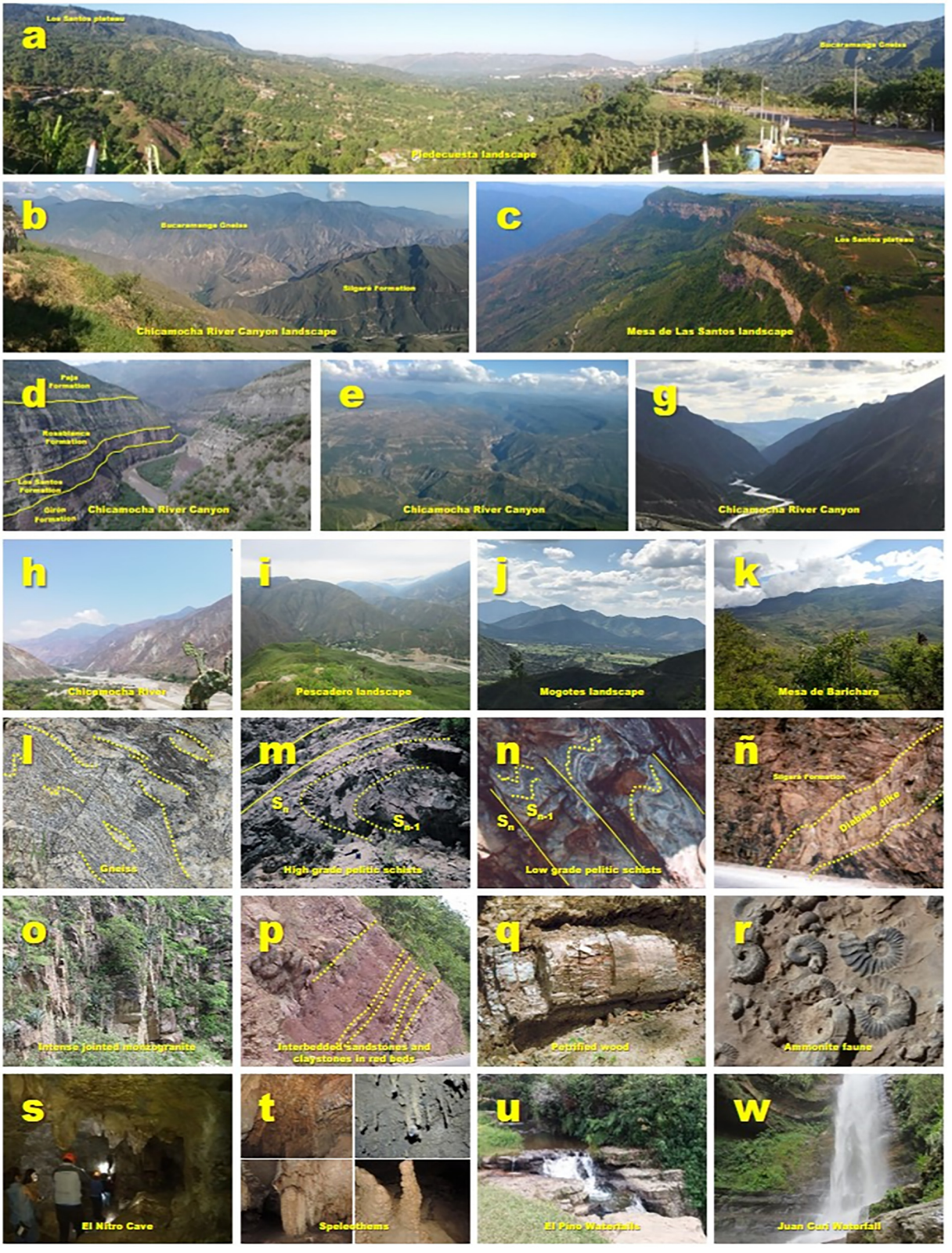

Fig. 6. Geodiversity of the CCG project.

quartzite packages (Fig. 6m) and crenulation cleavage in pelitic schists (Fig. 6n). A diabase dyke cutting pelitic schists of this geological unit is observed in Fig. 6ñ. The Pescadero Monzogranite outcrops show strongly jointed rocks (Fig. 6o) with high fracture density associated with tectonic processes of the Bucaramanga Fault. A typical outcrops of the red beds of the Girón Formation is shown in Fig. 6p. Around the Mesa de San Pedro, remains of a petrified trunk in the red beds of this geological unit (Fig. 6q). In sedimentary rocks of the Paja Formation fossiliferous concretions are observed in which the presence of ammonites (Fig. 6r). That preserve evidence of marine life of the geological past of the region during the Lower Cretaceous is ruled out. The karst geomorphology is a common feature of the Rosablanca Formation limestones, with the El Nitro Cave (Fig. 6s) as an excellent example of underground cavities revealing an exokarst with several types of lapiaces on the surface and speleothems (endokarst, Fig. 6t), such as columns, stalactites, stalagmites, etc. Natural wells of crystalline waters connected to each other by impressive waterfalls (Fig. 6u–w) of notable characteristics, some of them wrapped legends, stories and scares.

The territory of the proposed Geopark has been affected by tectonic movements, whose manifestations are expressed in the numerous faults and zones of high seismicity (not of greater danger) in the Mesa de Los Santos. According to the seismographs of the National Seismological Network of Colombia of the Colombian Geological Service (CGS) installed in the Chicamocha Canyon, an average of 5 daily earthquakes are recorded in the Mesa de Los Santos region that make this unique region the second seismic nest in the world (e.g., Sepúlveda-Jaimes & Cabrera-Zambrano, 2018), whose ranking is: (1) Hindu Kush (Afghanistan); (2) Mesa de Los Santos (Colombia); (3) Carpathian Mountains (Romania). According to the CGS, more than 60% of the thousands of earthquakes that have been registered in Colombia originated in the seismic nest of the Mesa de Los Santos with a unique concentration of seismic activity at depths greater than 120 km (e.g., Perico-Martínez & Perico-Granados, 2014; Vargas, 2004). Most of the earthquakes that occur there are of intermediate depth and are generally not associated with destructive earthquakes and with magnitudes below 6.5° on the Richter scale (Herrera, 2013). The Mesa de Los Santos is a region with seismic activity unique in the world.

The large variety and complexity of several potential geosities of stratigraphic, geomorphological, mineralogical, petrological or tectonic interest, together with the quality of landscapes and exposure of the outcrops, makes the Chicamocha Canyon a territory with great scientific and educational potential (e.g., Caballero et al., 2013, Caballero et al., 2013; Caballero, Parra, & Mora, 2010; Castellanos & Ríos, 2008; Galvis et al., 2014; García & Añez, 2017; Mantilla, Ordoñez, Cepeda, & Ríos, 2001; Ordóñez, 2003; Ríos, 2001, 2005; Ríos & García, 2001; Ríos, García, & Takasu, 2003; Ríos, Gélvez, & Márquez, 2003; Ríos & Takasu, 1999; Struth, 2016; Velandia, 2017).

4.2. Biodiversity of the CCG project

Biodiversity is the variation of life forms that exist not only among plant species, animals, microorganisms and other forms of life on the planet, and includes the genetic diversity of populations, species, communities, ecosystems and landscapes (e.g., Gastón & Spicer, 2004; Rawat & Agarwal, 2015). The Convention on Biological Diversity (CBD) by United Nations (1992) was ratified by Colombia with the incorporation of Law 165, 1994 into national legislation. It defines biological diversity as the variability of living organisms from any source, including terrestrial and marine ecosystems and other aquatic ecosystems, and complexes ecological aspects of which they are part, which includes species-specific diversity and ecosystems. Biodiversity all around the world is rapidly declining as a result of deforestation and habitat fragmentation, with potentially important effects on the functioning of ecosystems (e.g., Cardinale et al., 2012). Biodiversity is important because it constitutes the support of a wide variety of environmental services, which have depended on human societies (Andrade, 2011). Colombia's biodiversity has one of the highest indexes worldwide, although vast aspects of this biodiversity are still poorly inventoried (Ospina-Larrea, Borja-Acosta, Buitrago-Cardona, Torres, & Acevedo-Charry, 2020).

The Chicamocha Canyon is characterized by the predominance of slopes greater than 15%, superficial soils and mulberry and deciduous vegetation coverings with one or two thin strata of foliage, with low rainfall and moisture retention capacity (Albesiano et al., 2003). Such geological history has been shaped the flora and fauna in the northern Eastern Oriental of the Colombian Andes (e.g., Avendaño & Donegan, 2015). For instance, the species occurred in this region has evolved with extreme climatic factors that determine arid environments and includes tropical dry forests, thorny thickets, subxerophytic forest, and Sub Andean forest fringes (Fig. 7a–d). For example, *Stenocereus griseus* (Fig. 9a) is the most characteristic species of Cactaceae for its coverage and abundance in the cardonales of the Chicamocha Canyon (Rangel & Franco, 1985). In the surroundings of this region, arboreal, shrubby and herbaceous vegetation (Fig. 7e–h) is characteristic, as they are the most representative forms in the floristic level (Fig. 7i–o) and of importance in the contribution to the ground cover. It can be grouped into the following hierarchical types according to the size category and/or form of growth in which it is found (tree, shrub or herbaceous). In the Chicamocha Canyon, subxerophytic coverings of scrub and forest on their slopes prevail, tall forests in riparian zones of the micro-basins (e.g., Albesiano et al., 2003; Valencia-Duarte et al., 2012), surrounded in low and middle zones, by areas with tobacco crops (*Nicotiana tabacum*, Solanaceae), and in high parts by coffee crops (*Coffea arabica*, Rubiaceae), cacao (*Theobroma cacao*, Malvaceae) and banana (*Musa paradisiaca*, Musaceae) (Valencia-Duarte et al., 2012).

The GBIF reveals the occurrence of 700 records from Piedecuesta, Los Santos, Cepitá, Jordán, Aratoca, Curití, San Gil, Mogotes, Pinchote, Barichara, Villanueva, Cabrera, Galan y Zapatoca (GBIF, 2019), which include plants such as Liliopsida (monocots), Magnoliopsida (dicots), Polypodiopsida (ferns), and Psilotopsida (whisk ferns), and animals such as Actinopterygii (fishes), Amphibia (frogs and salamanders), Aves (birds), Insecta, Mammalia (mammals) and Reptilia (snakes, lizards and tortoises). The particular environments in the Chicamocha Canyon and surrounding areas generate a high biodiversity and a considerable number of endemic and sensitive species vulnerable to changes of anthropic origin. For example, plants as *Cavanillesia chicamochae* and


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Zamia encephalartoides or animals as the lizard *Stenocercus santander*, *Saucerottia castaneiventris* (Fig. 7p), *Ortalis columbiana* (Fig. 7q), *Thryophilus nicefori* (Fig. 7r), and *Myiarchus apicalis* (Fig. 7s). Ecotourism related with such endemic biodiversity in the CCG project could (and should) support local entrepreneurs there. There are other species observed in this region. The introduced and presently feral *Capra aegagrus hircusque* (Fig. 7t) is a species of artiodactyl mammal of the Caprinae subfamily, which was introduced for livestock farming and has adapted very well to the xerophytic environment and constitutes a gastronomic attraction. However, excessive goat grazing, especially in very steep places, has played a decisive role in the distribution and physiognomic aspect of the vegetation. Non-consumption by goats has led to a proliferation of species such as *Cnidoscolus tubulosus*, *Cordia curassavica*, *Jatropha gossypiifolia*, *Lantana canescens*, *Lippia origanoides*, *Opuntia depauperata*, *Prosopis juliflora*, *Senna pallida* and *Stenocereus griseus*, which have toxic tannins and structures defensives like thorns and stingers that protects from the action of goats (Albesiano et al., 2003).

Although our search found only bat species reported in GBIF, more generalist and wide distributed mammals also inhabit the Chicamocha Canyon, such as rabbits (*Sylvilagus* sp.), paca (*Cuniculus paca*), armadillos (*Dasypus novemcinctus*; Fig. 7u), ant-bears (*Myrmecophaga tridactyla*; Fig. 7v) and marsupials such as possum (*Didelphis marsupialis*; Fig. 7w), also called th southern oreared possum or gambá (Brito et al., 2008), which can be observed with some luck and patience. The *Macroperipatus geagy* (Fig. 7x) is the inhabitant species of coffee plantations of the Mesa of Los Santos, which was first onychophore the of the Peripatidae family reported by Jerez-Jaimes and Bernal-Pérez (2009) in the department of Santander (Colombia). A hairy caterpillar (butterfly larva), belonging to the order of the Lepidocters of the family Saturniidae, is shown in Fig. 7y. It is commonly known as hairy cat or burner, whip or burner worm. It is characterized by having a soft, worm-shaped body, divided into rings and with many legs, and feeds on leaves. This species is considered harmful because it has a voracious appetite, attacks trees, fruit, ornamental and forest plants. Fig. 7z illustrates a frog (*Hypsiboas crepitans*), also known as the banana frog, which is a species of the amphibious genus of the Hylidae family, whose natural habitats include dry tropical or subtropical forests, dry and wet savannas, rivers, intermittent streams of water, freshwater lakes, freshwater marshes, springs, river deltas, arable land, pastures, plantations, rural gardens, urban areas, previously heavily degraded forested areas, water storage areas such as ponds and aquaculture deposits, irrigation lands and flooded agricultural areas. The Amphibia: Caudata (*Bolitoglossa* spp.) (Fig. 7a′) was registered in coffee plantations of the Mesa de Los Santos by Jerez-Jaimes and Bernal-Pérez (2009). For the dry tropical forest of Mesa of Los Santos, 127 species of lepidoptera (butterflies, Fig. 7b′) have been recorded, where the highest values of diversity and richness of species occurred between 680 and 900 m (Casas-Pinilla, Mahecha, Dumar, & Ríos-Málaver, 2017). The *Atta laevigata* ant (Fig. 7c′), commonly known as Santanderean culona ant, which lives in the departments of Santander (Colombia) and whose predilection has passed from the aborigines to the current inhabitants, making this product known not only in this region, but throughout the country and even internationally, as exotic food with aphrodisiac properties that is consumed fried, roasted and raw (Mosquera, 1990). Fig. 7d′ illustrates a *Columba livia*, a species of carrier pigeon introduced of North American belonging to the order of the columbiforms, of the Columbidae family. The carrier pigeons are typical of Africa and Eurasia and are one of the few groups of birds found throughout the world, except in snowy areas, due to that have migrated constantly until reaching numerous populations. One of its greatest peculiarities is that over the years, they stopped being wild animals to adapt to all kinds of environments, which has forced them to change some of their behaviors. These birds were introduced by the Spanish. Fig. 7e′ shows a crow known as *Quiscalus lugubris*, commonly known as quiscalo, it is a native bird that migrated to these areas from the eastern plains and is a danger to birds, although there are several species in Colombia.

These still understudied biodiversity plays an important role providing ecosystem services such as supporting (pollination and seed dispersal), provisioning (food, ornamental), regulation (pest control, carbon sequestration), and cultural (recreational experiences, science and education).

4.3. Cultural heritage attributes of the CCG project

One of the regions of Colombia with the greatest historical wealth is the department of Santander. Cultural expressions in Santander are varied and have a differentiated development in the different municipalities (Fig. 8a). In particular, within the CCG project, there are municipalities that present that wealth, highlighting Barichara, known as “the most beautiful town in Colombia”, which still retains its colonial architecture and it seems that time does not pass there. In 1978, it received the title of National Monument. In general, the Santander's municipalities are generally characterized by their calm and silence, cobbled streets, colonial-style houses and churches, and local products. With a tendency to Catholicism, this territory reveals the religious architecture in its churches (Fig. 8b) as a reflection of colonial engineering. The Catholic faith is manifested in the identity of the people of Santander and the cultural heritage through the architectural beauty of the monuments and related traditions. These municipalities also have sites of great tourist attraction such as historical monuments (Fig. 8c–d). Fig. 8e shows a monument tribute to the reconstruction of the San Jose de la Robada town, which was destroyed by an earthquake in 1869 being rebuilt in 1881 by inhabitants of the neighboring municipalities and the municipal cabildo decided to change its name by Galán town in memory

Fig. 7. Biodiveristy of the CCG project: (a) spiny scrubs; (b) threatened ceiba barrigona (*Cavanillesia chicamochae*) from tropical dry forest; (c) sub-Andean forest species; (d) xeforifitic grasslands; (e)–(h) arboreal, shrubby and herbaceous vegetation; (i)–(o) floristic varieties; (p) Chestnut-bellied Hummingbird (*Saucerottia castaneiventris*, Photo: F. Cediel @nacumero); (q) Colombian Chachalaca (*Ortalis columbiana*, Photo: F. Cediel @nacumero); (r) Niceforo's Wren (*Thryophilus nicefori*, Photo: F. Cediel @nacumero); (s) Apical Flycatcher (*Myiarchus apicalis*, Photo: F. Cediel @nacumero); (t) goat (*Capra aegagrus hircusque*); (u) armadillo (*Dasypus novemcinctus*); (v) ant-bear (*Myrmecophaga tridactyla*); (w) possum (*Didelphis marsupialis*); (x) *Macroperipatus geagy*; (y) butterfly larva; (z) frog (*Hypsiboas crepitans*); (a′) Amphibia: Caudata (*Bolitoglossa* spp.); (b′) *butterflies*; (c′) *Atta laevigata*; (d′) *Columba livia.* (e′) *Quiscalus lugubris.*

Fig. 8. Territory of culture of the CCG project.

of José Antonio Galán. An earthquake is the best example to demonstrate how geoeducation can contribute to minimizing consequences on people. However, historical museums and collections (Fig. 8f) preserve also very interesting evidences of the ancestral culture. In the Chicamocha Canyon region, archaeologists have found numerous important findings (agriculture, hunting and fishing, domestic activities, decoration, rupest art, etc.) of the pre-Hispanic Guane culture, an extinct society that inhabited there before the arrival of the Spanish (e.g., Echeverry, 2017; Morales & Cadavid, 1984; Moreno-González, 2012a, 2012b, 2013a, 2013b).

Human's relationship with the geological landscape of the Chicamocha Canyon manifests itself in time by taking this geographical feature as an abyss to cross or an obstacle to overcome. From the data collected by archaeologists, it is possible to make some observations about possible cultural practices embodied in myths and legends which material and spiritual expression elucidate several aspects about human activity (Moreno-González, 2012a).

Undoubtedly, there are customs and traditions that represent the legacy of our ancestors and continue to this day, among which techniques such as the stepped wall and gastronomic samples stand out. Echeverry (2017) conducted a virtual inventory and recording of rupest art (petroglyphs and pictographs) found in caves and fractures in rocks of the Los Santos Formation on the top of the Mesa de Los Santos region (Fig. 8g). Several artifacts of the Guane culture have been found in this region (Fig. 8h). The Lengerke route is a network of highways connecting different towns of Santander along the Chicamocha Canyon. The route was built in the mid-XIX century by Geo Von Lengerke, taking advantage of the previous existence of indigenous trails and remained in force until the first half of the XX century, when the appearance of modern roads caused them to become obsolete. However, the original roads are still used today, although less frequently, by the inhabitants of the region. There is no doubt that the life of the local communities is closely related to its geographical conditions and the towns that make up the Chicamocha Canyon give proof of this. In Santander, numerous fairs and festivals are held that reflect its culture, which include the Cordiality Fairs in Zapatoca, Return Fairs and Festivals in Villanueva and Curití, Tiple and the Requinto Festival in San Gil, Festival of the Stone Carving in Barichara, Agricultural Fair, String Music Festival and "Guane de Oro" Music Contest in San Gil, National Festival of Trios in Pinchote and in Piedecuesta one of the most famous religious festivals in Santander is celebrated during Holy Week. The musical expressions found in Santander are the guabina, whirlwind, bambuco or aisle as genres of folklore (Fig. 8i). The Santanderean accent is also an identity part that despite its confluence with other accents still maintains certain peculiarities and structures. However, the Santander accent is not uniform as a whole, presenting differences in intonation and pronunciation.

The CCG project aims to promote geotourism and geoeducation activities for geoconservation purposes, contributing to the socio-economic and sustainable development of the region. Natural and cultural heritage starts from a vision where the approach to heritage is resized, understanding it as an integral heritage, which is an expression of an intense and permanent relationship of

Table 1
Main natural and cultural heritage of the Chicamocha Canyon and surrounding areas.

Geosite	Typological category	Heritage category	Heritage subcategory	Value criteria	Location	Main characteristics
Chicamocha National Park	View point	Geomorphology	Canyon, Plateaus	Aesthetic, Scientific, Touristic	Aratoca	360 degree viewpoint from which it is possible to observe in the stunning landscape of the Chicamocha Canyon, a natural wonder of Colombia
Chicamocha National Park	View point	Geomorphology	Canyon, Plateaus	Aesthetic, Scientific, Touristic	Aratoca	Panoramic view of the Mesa de Los Santos and Mesa de Villanueva, which show a Cretaceous sedimentary sequence overlying the a red bed Jurassic sedimentary sequence
Landscape panoramic view	View point	Geomorphology	Canyon, Plateaus	Aesthetic, Scientific, Touristic	Aratoca	Panoramic view of the Mesa de Los Santos and Mesa de Villanueva, which shows a Cretaceous sedimentary sequence overlying a red bed Jurassic sedimentary sequence
Garnet-bearing metamorphic rocks of the Silgará Formation	Point	Metamorphic Petrology	Metamorphic rocks	Scientific	Aratoca	Metamorphic sequence of the Silgará Formation
El Picacho Hill	View point	Geomorphology	River	Aesthetic, Scientific, Touristic	Aratoca	Panoramic view of the Chicamocha River and Jordán
El Tambor natural well	Point	Natural well	Natural swimming pool	Ecological, Educative	Aratoca	El Tambor natural well located in the sector of La Laja on the road that leads to the municipality of San Gil
Aratoca Fault	View point	Geotectonic	Fault	Scientific	Aratoca	The Aratoca Fault is a high-angle reverse structure that puts metamorphic rocks of the Silgará Formation in contact with the sedimentary rocks of the Jordán and Girón formations
Landscape panoramic view	View point	Stratigraphy	Sedimentary rocks	Scientific	Aratoca	Panoramic view of the Mesa de San Pedro, which show a Cretaceous sedimentary sequence overlying a red bed Jurassic sedimentary sequence
Discordance of the Mesa de San Pedro	Point	Stratigraphy	Sedimentary rocks	Scientific	Aratoca	Discordant contact between the Girón (with fragments of fossilized wood) and Los Santos formations
Indio Bridge	Point	Archaeology	Historical built	Cultural, Ecological, Educative	Aratoca	Ecological place formed by gigantic crisscrossing rocks immersed in the humid forest
Landscape panoramic view	View point	Geomorphology	Canyon, Plateaus	Aesthetic, Scientific, Touristic	Aratoca	Panoramic view of the Mesa de San Pedro and Mesa de Villanueva, which shows a Cretaceous sedimentary sequence overlying a red bed Jurassic sedimentary sequence
Royal road	Area	Archaeology	Historical road	Cultural, Historical, Educative	Barichara	Historical royal road leading from Barichara to Guane
National Monument	Area	Architectonic, Anthropology	Hispanic architecture	Cultural, Historical, Educative	Barichara	Declared a National Monument in 1978 for being an architectural testimony of the conquest, Barichara is considered the most beautiful town in Colombia, thanks to the artisans who built their houses and churches, standing out places such as Casa natal de Aquileo Parra, Puente Grande, Cathedral of the Immaculate Conception, Emilia Pradilla González House of Culture Museum, Cemetery, and craft workshops
Landscape panoramic view	View point	Geomorphology	River, Canyon	Aesthetic, Scientific, Touristic	Barichara	Panoramic view of the Suárez River Canyon and the Los Yariguíes Range Natural National Park
La Chorrera Natural Park	Area	Natural and Cultural Heritage		Ecological, Educative	Barichara	A natural park with a variety of green bushes and gardens, a river of abundant water that leads to a beautiful natural well
Guane Archaeological and Paleontological Museum	Point	Paleontology	Fossils	Scientific	Barichara	It comprises an important collection of fossils largely marine, more than 60 million years old, including urchins, turritellas, ammonites, fishes, plants; there are also bowls, pitchers, pots, vessels, jars, cups, jaguars, elements of worship and work of the Guane culture and a sepulchre from the colonial period
Paleontology of the ammonite faune	Point	Museography, Paleontology, Archaeology	Fossils, Rocks, Minerals, Ancient pottery,	Cultural, Historical, Scientific, Educative	Barichara	Paleontological deposit of Cretaceous marine fossils over 60 million years old, among them sea urchins, turritellas and ammonites

Table 1 *(continued)*

Geosite	Typological category	Heritage category	Heritage subcategory	Value criteria	Location	Main characteristics
Landscape panoramic view	View point	Geomorphology	Mummy Canyon, Plateaus	Aesthetic, Scientific, Touristic, Educative	Barichara	Confluence of the Suarez and Chicamocha rivers to form the Sogamoso river, geomorphology and hydrology (boundaries between Zapatoca, Villanueva and Los Santos)
Soils - culona ants	Area	Stratigraphy, Biodiversity	Sediments, Sedimentary rocks	Cultural, Ecological	Barichara	Presence of culona ants associated with the clays of the Simití Formation
Cemetery	Point	Architectonic	Historical, Religious, Political, Social collections	Cultural, Historical	Barichara	Carved stone sculptures and tombstones with artistic designs and allusive trades and characters from the region
Los Aljibes Park	Area	Geomorphology, Stratigraphy	Hydrogeology, Sedimentology	Ecological, Scientific, Educative	Barichara	Reservoirs and water tanks associated with aquifers and water infiltration processes
Clays and ceramics	Area	Stratigraphy	Sediments, Art, Heritage	Cultural, Historical, Scientific, Educative	Barichara	Use of clays for the elaboration of vessels and construction materials in an artisanal way
Royal roads	Area	Archaeology	Historical road	Cultural, Historical, Educative	Barichara	Horseshoe path of the colonial era, including indigenous times, using different types of rock
Stone carving workshops	Point	Architectonic	Sedimentary rocks, Art, Architecture	Aesthetic, Scientific	Barichara	Use of sand for construction, finishing, streets and architectural elements
Cathedral church	Point	Architectonic	Historical, Religious, Social collections	Cultural, Historical	Barichara	Built in stone and local techniques that take advantage of the different types of surrounding lithology
Pictograms	Point	Archaeology	Pictographs	Cultural, Historical, Scientific, Educative	Barichara	Indigenous pictograms on rock associated with caves and ancient indigenous settlements
Paramera stream	Area	Mineralogy, Stratigraphy, Geomorphology, Geotectonic	Rocks, Minerals	Ecological, Scientific, Educative	Barichara	Outcrop of rock, contact between the Tablazo and Simití formations
El Mico waterfalls-- Barichara stream - Barichara Fault	Area	Geomorphology, Stratigraphy	Waterfall, Fault	Aesthetic, Scientific	Barichara	Watercourse of the Barichara stream, controlled by the Barichara Fault including a waterfall of more than 100 m
La Paramera natural well and waterfall	Point	Geomorphology	Natural swimming pool, Waterfall	Aesthetic, Ecological, Scientific, Touristic	Cabrera	Imposing waterfall that falls on sedimentary rocks that exceeds 100 m high, where it is possible to enjoy of a natural swimming pool
Cultural Heritage	Area	Architectonic, Anthropology	Hispanic architecture	Cultural, Historical, Educative	Cabrera	Colonial architecture and stoned streets that represent a testimony of history, highlighting the Church of the Immaculate Conception built in the XVII century, reflecting the stone and carving and showing paintings of more than 200 years
Royal road	Area	Archaeology	Historical roads	Cultural, Historical, Educative	Cabrera	Historical royal road leading from Cabrera to Barichara and Guane
Fossil valley	Point	Paleontology	Fossils	Scientific	Cabrera	The Cretaceous Paja Formation contains a marine fauna of ammonites in concretions
Municipal Museum	Point	Museography, Archaeology	Historical, Religious, Political, Social collections	Cultural, Historical, Scientific, Educative	Cabrera	It comprises an important collection of ancient pottery and antiques
Dejection cone	Area	Geomorphology	Dejection cone	Scientific	Cepitá	Fluvial geoform, which corresponds to a more "conical" form with high slopes and dominated by mass movements with little or no water content
Landscape panoramic view	Area	Geomorphology	Erosion processes	Aesthetic, Scientific, Touristic	Cepitá	Landscape sculpted by erosion (e.g., gully erosion due to removal of soil along drainage lines by surface water runoff)
Cultural Heritage	Area	Architectonic, Anthropology	Hispanic architecture	Cultural, Historical, Educative	Cepitá	Stoned streets, houses in stepped walls, walls in bareque, wooden doors and windows and roof in mud tiles preserve the essence of the Santander

(continued on next page)

Table 1 *(continued)*

Geosite	Typological category	Heritage category	Heritage subcategory	Value criteria	Location	Main characteristics
						towns that give testimony of the colonial air that remains intact in this region
Antique house	Point	Museography	Antiques collections	Cultural, Historical, Educative	Cepitá	It comprises an important collection of antiques
Biodiversity in the Chicamocha Canyon	Area	Biodiversity	Endemic faune and flora	Ecological, Educative	Cepitá	Endemic faune and flora typical of semi-arid zones
Pescaderito natural wells and waterfalls	Point	Geomorphology	Natural swimming pool, Waterfalls	Aesthetic, Ecological, Touristic, Educative	Curití	Natural wells of crystalline waters connected to each other by small waterfalls
La Vaca Cave	Area	Geomorphology and Speleology	Karst	Ecological, Economic, Touristic, Educative	Curití	Underground ecosystem that serve as a stage for practicing caving or speleology. It is cataloged as one of the most extreme caves of Santander since it has the best scenarios and incomparable beauty, where lovers of adventure will be in permanent contact with water, enjoying the different trawls, slides of mud, calcareous formations and biodiversity
Exploitation of limestones	Point	Sedimentary Petrology	Rocks	Economic, Educative	Curití	Exploitation of limestones
Sedimentary rocks of the Paja Formation	Point	Sedimentology, Sedimentary, Petrology and Paleontology	Sedimentary structures, Fossils	Scientific	Curití	Sedimentary structures of the Cretaceous La Paja Formation (lower Barremian based on fauna of ammonites); siltstones with limestone concretions and thin gypsum sheets to the base, and very fissile siltstones with limestone concretions interlayered with layers of argillaceous sandstone and calcareous siltstones to the top
El Santuario Natural Park	Area	Natural and Cultural Heritage		Ecological, Educative	Curití	El Santuario Natural Park is a natural enclave of nature was declared a Natural Park, which promotes the preservation of its flora and fauna and other natural resources; vegetation completely exotic and typical of the jungle, allowing endemic animals such as picures, pharaohs, tinajos, armadillos, iguanas, reptiles and a great variety of snakes coexist in absolute freedom
Limestone mines	Point	Sedimentary Petrology	Rocks	Economic, Educative	Curití	Exploitation of limestones from the Cretaceous Rosablanca Formation
El Yeso Cave	Area	Geomorphology and Speleology	Karst	Ecological, Economic, Educative	Curití	Underground ecosystem that serve as a stage for practicing caving or speleology. It shows very interesting speleothems with stalactites that exceed 90 cm in length. In some narrow places, stalactites and stalagmites join to form columns that measure more than 1 m and exceed 50 cm in thickness
Landscape panoramic view	View point	Geomorphology	River, Rocks, Geoforms	Aesthetic, Scientific, Touristic	Galán	Arid territory bathed by the Suárez River
Los Yariguíes Range Natural National Park	Area	Geomorphology, Biodiversity	River, Canyon, Faune and flora	Aesthetic, Scientific, Touristic	Galán	Los Yariguíes Range Natural National Park, which has a jungle reserve, showing ecosystems that vary from Andean forests, through tropical rainforests and moors that are one of the most important water reserves in Colombia
Royal road	Area	Archaeology	Historical road	Cultural, Historical, Educative	Galán	Horseshoe and Lengerke roads, historical legacy of the beginnings of commerce in our country
Main Park	Area	Architectonic	Monument	Cultural, Historical, Educative	Galán	Monument tribute to the reconstruction of the San Jose de la Robada town destroyed by an earthquake in 1783
Festivals	Area	Cultural Heritage	Art	Cultural, Touristic	Galán	Galán dresses up, decorates and expresses his entire culture through fairs and parties with numerous equestrian shows, horseback riding, bullfighting parties and orchestras invited for the integration of cultures, do not miss the best experience at parties in Galán, Santander
Cathedral church	Point	Architectonic	Historical,	Cultural,	Galán	Carved stone temple in honor of San José, with

Table 1 *(continued)*

Geosite	Typological category	Heritage category	Heritage subcategory	Value criteria	Location	Main characteristics
			Religious, Social collections	Historical		spectacular wooden altarpiece with luxury appliqués and reliefs, enough windows near the deck and two side corridors that provide air and lighting with grape vines that give a fresh touch to the enclosure, and images of saints are located on the sides
Neotectonics	Point	Geotectonic	Tectonics	Scientific	Jordán	Study of the motions and deformations of Earth's crust (geological and geomorphological processes) that are current or recent in geologic time
Sedimentology and Stratigraphy	View point	Sedimentology and Stratigraphy	Sediments and sedimentary rocks	Scientific	Jordán	Processes of formation, transport and deposition of sediments can be considered and then applied to develop conceptual models for the full range of sedimentary environments
National Monument	Point	Architectonic	Hanging bridge	Cultural, Historical, Educative	Jordán	It is considered one of the oldest and most emblematic hanging viaducts for being the first toll road in Colombia
Royal road	Area	Archaeology	Historical road	Cultural, Historical, Educative	Jordán	Historical royal road leading from Jordan to Los Santos
Sedimentation process	View point	Sedimentology	Sediments and sedimentary rocks	Scientific	Jordán	Environments of deposition of sedimentary rocks
Seismic nest (Mesa de Los Santos)	Point	Geotectonic	Seismicity	Scientific	Los Santos	Los Santos Seismic nest is considered the second site around the word with high seismicity after the Hindu Kush region in Afghanistan and before the Carpathian mountains in Romania
Neotectonics (Mesa de Los Santos)	Point	Geotectonic	Tectonics	Scientific	Los Santos	Study of the motions and deformations of Earth's crust (geological and geomorphological processes) that are current or recent in geologic time
Ammonite faune (Mesa de Los Santos)	Point	Paleontology	Fossils	Scientific	Los Santos	Fossils of ammonites more than 60 million years (lower Barremian), which are extracted in the limit between the Rosablanca and Paja formations
Gypsum mines (Mesa de Los Santos)	Point	Mineralogy, Geomorphology, Stratigraphy	Minerals, Canyon, Plateaus, Sedimentary rocks	Economic, Aesthetic, Scientific, Touristic, Educative	Los Santos	More spectacular panoramic view of the Chicamocha Canyon, where the Chicamocha River opens a deep gorge with vertical steep rock offering an unforgettable view
Salto del Mico waterfall (Mesa de Los Santos)	Point	Geomorphology	Waterfall	Aesthetic, Ecological, Touristic, Educative	Los Santos	Imposing waterfall of 50 m that is a great natural attractions; this beautiful place in Colombia is one of the favorite destinations visited by those who practice adventure and nature tourism
Barite mines (Mesa de Los Santos)	Point	Mineralogy	Minerals	Economic, Educative	Los Santos	Veins of barite cutting limestones of the Rosablanca Formation
Bucaramanga-Santa Marta Fault (Mesa de Los Santos)	View point	Geotectonic	Fault	Scientific	Los Santos	The Bucaramanga-Santa Marta Fault is a major oblique sinistral strike-slip fault (wrench fault) in the northern Colombia
Los Teres Archaeological site (Mesa de Los Santos)	Area	Archaeology	Ancient pottery	Cultural, Historical, Scientific, Educative	Los Santos	Archaeological site that reveals the existence of two pre-Hispanic communities that inhabited the same territory in different periods of time and were independent in their origins, their historical development and their socio-cultural evolution
La Fuente (Mesa de Los Santos)	Area	Archaeology	Pictographs	Cultural, Historical, Scientific, Educative	Los Santos	Pictographs made by the Guanes Indians who inhabited this region
Los Cacaos High	View point	Geomorphology	Valley, Snowy mount	Aesthetic, Scientific, Touristic	Mogotes	It is located at an altitude of 2600 masl where it is possible to observe the immensity of the Santa Bárbara de Mogotes Valley and the Nevado del Cocuy
Hoyo de Los Pájaros	Point	Geomorphology and Speleology	Karst	Ecological, Economic, Touristic, Educative	Mogotes	Karst landscape with cave geomorphology; Underground ecosystem that serve as a stage for practicing caving or speleology
El Pino natural well and waterfalls	Point	Geomorphology	Natural swimming pool,	Aesthetic, Ecological, Touristic,	Mogotes	Natural well categorized as one of the most visited tourist sites in the municipality of Mogotes, swimming and contemplating the majestic

(continued on next page)

Table 1 *(continued)*

Geosite	Typological category	Heritage category	Heritage subcategory	Value criteria	Location	Main characteristics
			Waterfalls	Educative		landscapes and its nature makes it unique and incomparable
El Resumidero Cave	Area	Geomorphology	Karst	Ecological, Economic, Touristic, Educative	Mogotes	Karst landscape with cave geomorphology; Underground ecosystem although non appropriate for practicing caving or speleology
Rica y del Sapo Cave	Area	Geomorphology, Speleology and Archaeology	Karst, Pictographs	Cultural, Historical, Scientific, Educative	Mogotes	Karst landscape with cave geomorphology; Underground ecosystem although non appropriate for practicing caving or speleology
Cultural Heritage	Point	Architectonic, Anthropology	Hispanic architecture	Cultural, Historical, Educative	Mogotes	Pictographs made by the Guanes Indians who inhabited this region
Landscape panoramic view	View point	Geoscience	Canyon, Plateaus	Aesthetic, Scientific, Touristic	Piedecuesta	Geological evolution of the Santander Massif
Pescadero Granite	Point	Igneous Petrology	Igneous rocks	Scientific	Piedecuesta	Pescadero Granite along the Manco River Canyon showing mafic microgranular enclaves
Pescadero Granite	Point	Geomorphology	Igneous rocks	Scientific	Piedecuesta	On the bridge over the Chicamocha River, in Pescadero, it is possible to a relief in which an impressive geomorphology of abrupt slopes can be observed in rocks with intense block jointing
Chicamocha River	Area	Geomorphology, Sedimentology	Fluvial dynamics	Scientific	Piedecuesta	On the bridge over the Chicamocha River, in Pescadero, it is possible to admire the fluvial dynamics of this important tributary and the paleocapture of its channel which changes abruptly from direction; Edge erosion, Lateral migration of the channel, Morphological changes in the levels of terraces, Production of fine sediments
El Mico waterfalls	Point	Geomorphology	Waterfall	Aesthetic, Ecological, Touristic, Educative	Pinchote	El Mico waterfalls
Folding of sedimentary rocks	Point	Geotectonic	Fold	Scientific	Pinchote	Folding of sedimentary rocks
Cretaceous sedimentary rocks	Point	Stratigraphy, Structural Geology	Geometry of strata, Flexures, Folds	Scientific	San Gil	Cretaceous sedimentary sequence and broad tabular areas of flexures or folds of large radius
National Monument	Point	Architectonic, Anthropology	Historical center	Cultural, Historical, Educative	San Gil	San Gil has a historical center that has been declared an asset of cultural interest at the national level
Juan Curí natural well and waterfalls	Point	Geomorphology	Natural swimming pool, Waterfalls	Aesthetic, Ecological, Scientific, Touristic, Educative	San Gil	Imposing waterfall in the middle of a virgin forest, which is found travelling a mountain trail to cross several smaller waterfalls, until reach a large waterfall that exceeds 200 m high, where it is possible to enjoy of a 2 m deep natural swimming pool
Pozo Azul natural well and waterfalls	Point	Geomorphology	Natural swimming pool, Waterfalls	Aesthetic, Ecological, Touristic, Educative	San Gil	Natural well categorized as one of the most visited tourist sites in the municipality of San Gil, swimming and contemplating the majestic landscapes and its nature makes it unique and incomparable
Landscape panoramic view	View point	Geomorphology	Geoforms	Aesthetic, Scientific, Touristic	Villanueva	Plateaus and slopes of denudational structural environment
Las Pinturas Cave	Area	Geomorphology and Speleology	Karst	Ecological, Economic, Touristic, Educative	Villanueva	Underground ecosystem that serve as a stage for practicing caving or speleology
El Nitro Cave	Point	Geomorphology and Speleology	Karst	Ecological, Economic, Touristic, Educative	Villanueva	Underground ecosystem that serve as a stage for practicing caving or speleology
Soil - culona ants	Area	Biology, Sedimentology	Sediments, Sedimentary rocks	Cultural, Ecological	Villanueva	Endemic species of this area, which is rooted in the social and gastronomic culture
Pictograms	Point	Archaeology	Pictographs	Cultural, Historical,	Villanueva	Indigenous pictograms on rock associated with caves and ancient indigenous settlements

Table 1 *(continued)*

Geosite	Typological category	Heritage category	Heritage subcategory	Value criteria	Location	Main characteristics
Howler monkeys lookout	View point	Geomorphology, Biodiversity	Geoforms, Endemic faune and flora	Scientific, Educative Aesthetic, Scientific, Touristic	Villanueva	Excellent view to observe geomorphological aspects and endemic faune and flora
Stone carving workshops	Point	Architectonic	Sedimentary rocks, Art, Architecture	Aesthetic, Scientific	Villanueva	Use of sand for construction, finishing, streets and architectural elements
Admiral Columbus mine	Point	Mineralogy, Geomorphology, Stratigraphy	Minerals, Rivers, Geoforms	Economic, Aesthetic, Scientific, Touristic, Educative	Villanueva	More spectacular panoramic view of the Chicamocha Canyon, where the Chicamocha River opens a deep gorge with vertical steep rock offering an unforgettable view; limestone exploitation of the Rosablanca Formation
Paleontological deposits	Area	Paleontology	Fossils	Scientific	Villanueva	Mineralized fossils of aquatic animals and amphibians that inhabited their municipality
Las Juntas	Area	Geomorphology, Geotectonic	Rivers	Aesthetic, Ecological, Touristic, Educative	Villanueva	Site, where the Suarez and Chicamocha rivers make up the Sogamoso River; from here, it is possible to observe the gypsum mines, the ferry that crosses the river with the gypsum extracted from the municipality of Zapatoca transporting it for further processing, and one of the largest sheepfolds (goat farm) in the municipality
El Nitro Cave	Area	Geomorphology and Speleology	Karst	Ecological, Economic, Touristic, Educative	Zapatoca	Karst landscape with cave geomorphology; Underground ecosystem that serve as a stage for practicing caving or speleology
Las Alsacias Cave	Area	Geomorphology and Speleology	Karst	Ecological, Economic, Touristic, Educative	Zapatoca	Karst landscape with cave geomorphology; Underground ecosystem that serve as a stage for practicing caving or speleology
Landscape panoramic view	View point	Geomorphology	Canyon, Plateaus	Aesthetic, Scientific, Touristic	Zapatoca	Panoramic view of the Mesa de Los Santos and Mesa de Villanueva, which show a Cretaceous sedimentary sequence overlying the a red bed Jurassic sedimentary sequence
Paleontology of the Cretaceous marine environment	Point	Paleontology	Fossils	Scientific	Zapatoca	The Cretaceous Rosablanca Formation contains a marine fauna of invertebrates, including bivalves, gastropods, echinoderms, cephalopods, polychaetes and crustaceans; scarce vertebrate fossils, such as fish vertebrae and turtle shells also occur

human beings and their environment. However, it is important to publicize this legacy, which is constituted by elements of nature, which are maintained in their original context, intervened in some way by human beings, in order to transmit it to future generations. The safeguarding of heritage is not only about protection and preservation, but about using it to preserve heritage sites, adapt infrastructure for tourism development, landscape restoration through nature and culture, and contribute to development sustainable. Table 1 summarizes the main attributes of the natural and cultural heritage that forms part of the Chicamocha Canyon and surrounding areas.

5. Geotourism in the CCG project

Geotourism is a relatively new concept, which has gained rapid development over the past decades (Wang, Wu, Li, & Chen, 2019) as a rapidly growing global activity (e.g., Hose, 2000, 2011; Allan, 2014; Dowling & Newsome, 2010; Hose & Vasiljevic, 2012; Dowling, 2013; Ruban, 2015; Wang et al., 2019). The CCG project provides an excellent resource for the development of geotourism (e.g., Caballero & Reyes, 2015; Castellanos & Ríos, 2008; Gélvez, Rodríguez, Tarazona, & Castellanos, 2018; Mantilla & Villabona, 2013; Ríos et al., 2018; Yepes & Daza, 2017), which can be promoted as a strategy for sustainable tourism development and promotion of the Chicamocha Canyon. The relevant scientific, educational and aesthetic values of the geological heritage can convert this region into a tourist resource important enough to become one of the main attractions of this territory (Fig. 9). The CCG project should utilize and promote territorial identity in tourism efforts, based on its natural and cultural resources as suggested by Wang et al. (2019), which can be of great importance for the development of local communities, also expanding the tourism offer in the region. According to UNESCO (2014), geoparks should have three targets: conservation, education and development of the local economy through geotourism. On the other hand, among the main goals of geoparks are preserving unique geoheritage and introduce it as a new tourism attraction by making use of existing natural resources and popularizing geological science (e.g., Ng, 2007; Wang, Tian, & Wang, 2015).

Fig. 9. Geotourism activities of the CCG project.

Santander has evolved positively in relation to the development of tourism and could become the first choice for domestic and foreign tourists looking for adventure and nature tourism in Colombia. However, it is necessary to promote a tourism opportunity such as the Chicamocha Canyon to encourage tourists to experience, learn and enjoy the natural and cultural heritage, allowing the visitor to become aware of the opportunity and to stimulate attitudes favorable to its conservation. It is not enough just that there is a potential for geotourism development in this region, it is necessary to design strategies aimed at generating geotrails for geotours, tourist guides, tourist maps or websites where the natural and cultural heritage be described and promoted as suggested by Pazari and Dollma (2019), which, however, is outside the scope of this paper. There are numerous factors that have influenced the development of a tourism industry in our territory, including an image of conflict in the country at international level, scarce infrastructure in road networks, signaling, electrical lighting, transport network, basic and complementary services, informality of tourism, public policy decisions that closed the economy, quality in the supply and low competitiveness of the tourism product, lack of knowledge of tourism markets, bilingualism, connectivity between regions, environmental sustainability and selective and low tourism, among others.

With the effort and support of the Universidad Industrial de Santander, Colombian Geological Survey, local, regional and national government, public and private entities of the national and international order and the UNESCO advice, the CCG project could be performed to develop the necessary infrastructure and facilities. However, it will require a significant investment of money, including the establishment of an interpretation center, operation of tourist corridors, policies to formalize tourism, education, training and research, products and services, connectivity, conditioning of trails and viewpoints, implementation of informative and interpretive signs, building a geological museum at a paleontological site, promotion and marketing and institutional strengthening. On the other hand, it is necessary to create an interpretation center in geosciences to coordinate the activities that

are developed in the proposed geopark as well as establishing a permanent exhibition with explanatory panels, backlit displays, models, interactive panels that offer the visitor an overview of the natural and cultural values of the territory.

The conservation of geological heritage and inclusion of the local communities in the sustainable use of the geological heritage will also need to be facilitated. The direct and indirect benefits of the CCG project would include obtaining the UNESCO seal in the national and international scope, potential to increase the number of tourists after obtaining recognition by UNESCO as a Global Geopark, improvement of the quality of life of the local communities, increased employment opportunities for traditionally excluded sectors, development of various economic, business, cultural and tourist activities, and businesses and geoconservation.

6. Geoeducation in the CCG project

National Geographic has adopted the term *geo-education* to describe the in-school and out-of-school learning experiences where students learn about how the world functions, which is essential to maintaining our economic competitiveness, protecting our national security, sustaining our natural resources, and preserving the quality of life in local communities. Geoeducation is a form of education focused on geosciences (e.g., Cayla et al., 2010; Bollati et al., 2012), which has become a research field in its own, given the socioeconomic development it is likely to create. The geosciences in the CCG project have been focused on the fields of exploration and exploitation of oil and gas, development of geological maps at local and regional scales, exploration, exploitation and profit taking of mineral deposits and water resources, research in their different areas of action with the generation and transfer of basic and applied knowledge and social projection. However, the geosciences are currently not popular nor easily accessible by the general public. Lack of education is thought to be one of the greatest threats to geoheritage (Wang et al., 2019). The need to solve such a problem involves raising public awareness of the value of geoheritage through geoeducation (e.g., Gray, 2008; Loon, 2008).

The CCG project would promote developing a strong geoeducation process (Fig. 10). The Research Group in Basic and Applied Geology of the Industrial University of Santander with the support of the Research Seedbed in Geological Heritage has been promoting the realization of geoeducation activities, which include didactic workshops on various topics related to geosciences developments in events such as Earth Science Week, U18 and the UIS Neighbors and Friends Program, and in educational institutions of the metropolitan area of Bucaramanga. This working group has contributed to the identification and characterization of potential geosites (e.g., Caballero & Reyes, 2015; Castellanos & Ríos, 2008; Gélvez, Barajas, Zafra, et al., 2018; Gélvez, Rodríguez, Barajas, et al., 2018; Yepes & Daza, 2017; Zafra, 2019), which reflect their great academic and scientific interest (e.g., Gélvez, Rodríguez, Tarazona, & Castellanos, 2018; Ríos et al., 2018, 2019; Zafra, 2019; Zafra et al., 2019; Zafra, Rodríguez,

Fig. 10. Geoeducation activities of the CCG project.

et al., 2018). However, there are geosites more suitable for geoeducation than others, because of their didactic potential, which can be used through several georoutes by students from primary, secondary and high school and universities, introducing them to the geoheritage of this region by its interpretation, communication and conservation (Arrad, Errami, Ennih, Ouajhain, & Bouaouda, 2020).

Educational programs and conservation of the geological heritage, taking care of the links with the rest of the patrimonial values, both natural and cultural, which should be articulated with tourism and recreational activities, promoting citizen empowerment and responsible public use. It will also act as an outdoor classroom opened for every resident to understand the geological history and processes of their own land, and a better understanding of geology and landforms enhances awareness and protection which eventually leads to geological conservation and better protection of our planet earth (Ng, 2007). The knowledge gap on geoheritage can be filled through geoeducation activities that will encourage the different stakeholders of the region towards the establishment of a legal framework to protect and promote the area's geoheritage (Arrad et al., 2020).

A Chicamocha Visitor's Center could be conveniently created in the Chicamocha National Park, which is located on the Bucaramanga-Bogota national road. It includes the Chicamocha National Park cableway, one of the longest in the world (6.3 km long), which connects the stations of the Chicamocha National Park and Mesa de Los Santos, being used by tourists to observe the Chicamocha Canyon; the monument to the Santandereanidad created by the sculptor Luis Guillermo Vallejo, which was built in the form of tobacco leaf as a symbol in the common struggle to recreate artistically the revolution of the comuneros in 36 sculptures and is one of the most representative attractions; the Santanderean small town, with the architecture of the Santanderean towns, gives a regionalist touch and according to the conditions of the park; the 360° viewpoint, located in the upper part of the park, allowing the appreciation of the majesty of the Chicamocha Canyon from all angles with an unparalleled view. However, a geological museum would be required for recreation uses. This center would provide geopark information and be a service center to cater for visitors in transportation arrangements, guiding services, hiking and camping information. It also would act as an assembling place for participants of ecotours and geotours to develop activities such as cycling mountaineering, camping, balloon, walking, speleology, rafting, fishing, riding, mountaineering, paragliding, etc. A shuttle bus service could transfer people between the Chicamocha Visitor's Center and several destinations. Additionally, cafes, restaurants and pubs could form part of the rest area of the Chicamocha Visitor's Center.

7. Local products as an expression of the natural and cultural heritage

Local products should be a reflection of the natural and cultural heritage of the territory, some of which could be developed thinking that they can be used in decorative or utilitarian ornaments, commemorative objects made from stone, wood, ceramic or vegetal fiber, paintings, furniture, toys, jewelry, clothing, etc. The agricultural industry throughout history has been closely linked to the department of Santander, which is the first national producer of tobacco, cocoa, Tahiti lemon and cassava, and one of the main poultry producers (eggs and chicken meat) and of cattle, also standing out for its coffee, palm and fruit crops (watermelon, pineapple, lulo, tangerine or orange). On the other hand, the development of crafts in ceramics, wood, stone, wool, etc. stands out. The gastronomy (mute, goat, pepitoria, chicha, oreada meat, corn arepas, tamales, sandwiches and culona ants) of this region is one of the most desired by tourists who visit it, being an irreplaceable resource that could be combined with activities such as planting, caring, harvesting and gathering with local communities, which generates new experiences and

Fig. 11. Local products: (a) crafts; (b) lulo, ahuyama, maracuyá and grape crops; (c) poultry, pig, paneling and cocoa industry; (d) typical foods; (e) manufacture of ceramic products; (f) manufacture of products in fique.

attractions for tourists. However, it is essential that there are incentives to support and improve the local production through the development of products and brands.

The cultural and historical values of the region are of great importance as they constitute an animated museum of myths and legends, stories, folklore, festivals, etc., which contribute to enrich tourism products. It is essential to value local products as tourist resources, as well as their dissemination in order to know the production processes of products such as cheeses, sweets, chicha, honeybees, handicrafts, typical foods, etc. (Fig. 11). On the other hand, local products can be related to geopark activities and symbols of geological heritage as geoproducts, which are based on geological elements of geoparks not only introduce the local products as cultural components to tourists but also increase the public knowledge on geology (Farsani, Coelho, Costa, & Carvalho, 2012).

A geoproduct is a new term that is considered as a geological attraction (Complova, 2010) that can reveal several natural and cultural heritage aspects. Geoproducts can include geo-souvenirs (fossil replicas of the region, stratigraphy and faulting cakes, geology in art, etc.), local foods and beberages, georoute guides, geomaps, brochures, post cards, geo-interpretative panels, interpretive and educational centers, museums, restaurants, farms, trails and guided tours, local festival exhibitions and conferences. They will provide supports, tools and activities to communicate geoscientific knowledge and environmental and cultural concepts to the public (UNESCO, 2010).

The crafts of Santander play an important role in the development of the region because they are the image of the culture and working capacity that characterizes its inhabitants. The extensive craft tradition includes textiles, jewelry, food, leather, wood, ceramics, among others, which should be rescued. However, stone, ceramic and fique crafts are the most recognized in the national market. Stone carving is the best known of Santander's crafts, giving rise to several products such as culona ants, church facades, ashtrays or fountains. The malleability of the fique allows the manufacture of different elements, such as sacks and bags, shoes and wallets, rugs, lamps or baskets. Local producers within the territory would have multiple benefits and could promote their products by integrating them to the natural and cultural heritage of the region. On the other hand, this would encourage the creation of new sources of work by stimulating the growth of small businesses and training local communities as guides or other service providers.

8. Sustainable development

Since its introduction in the late 1970s, the concept of sustainable development has suggested the possibility of a synthesis between economic development and preservation of the environment (Bergh & Jeroen, 1996). According to the World Commission on Environment and Development, sustainable development can be defined as development that meets the needs of the present without compromising the ability of future generations to meet their own (WCED, 1987). Heads of State, government leaders, high-level representatives of the United Nations and civil society entities met in 2015, during the 70th Session of the United Nations General Assembly celebrated in New York and approved the 2030 Agenda for Sustainable Development, which was developed with the active participation of UNESCO. The Sustainable Development Goals promote a better and more sustainable future for all, addressing the global challenges we face, including those related to poverty, inequality, climate, environmental degradation, prosperity and peace and justice, and the 2030 Agenda for Sustainable Development urges countries to begin efforts to achieve these objectives (UNESCO, 2017). The actions of the human being have been linked to the use of natural resources, generating waste that affected environmental quality. It is unavoidable to identify those conditions that have results commonly recognized as desirable in a region that aspires to progress towards sustainable development. According to WCED (1987), the critical objectives in a development and environmental policy that fulfill the concept of sustainable development are: reviving economic growth, qualitatively changing growth, satisfying elementary needs for work, food, water, energy and health, ensure a sustainable population level, conserve and strengthen the natural resource base, reorient technology and risk management, unite economic and environmental aspects in decision making. According to Law 1715 of 2014 of the Republic of Colombia, sustainable development is what leads to economic growth, to the elevation of the quality of life and social welfare, without depleting the basis of renewable natural resources on which it is based, or deteriorate the environment or the right of future generations to use it to meet their own needs, at least under the same conditions as the current ones (UPME, 2014).

PNUD (2018) carries out the first baseline of the Sustainable Development Goals in Colombia, combining the knowledge of local public sector actors and the academy, as a strategy to transform alliances and the determination of a territory. It seeks to strengthen local institutional capacities aimed at the identification, monitoring and evaluation of indicators of sustainable development goals, allowing territorial entities to establish concrete actions to reduce and close gaps and to identify the access and availability of the information of the indicators proposed in the agenda, which will allow local governments to establish challenges and present challenges for their monitoring and follow-up.

The human impact on geoheritage values of the CCG project is significant due to the lack of transfer of geoscientific knowledge. The uncontrolled tourist visits developed by irresponsible promoters has impacted negatively the natural and cultural heritage of the Chicamocha Canyon region. For example, the progressive destruction of the pictograms made by the Guane culture in sandstones of the Mesa de Los Santos, the abandonment of the royal roads, originally used by the Guanes and Yariguíes indigenous communities and later by the trader Geo Von Lengüerke, the extraction and looting of fossils in the paleontological sites of the Zapatoca and Guane, the threat of karstic systems due to mining, disposal of garbage, bonfires, dumping of sewage, indiscriminate tourism, destruction of speleothems and pictograms, graffiti on walls and ceilings or looting of archaeological material, and the disposal of industrial wastes.

In Colombia, there are no policies that regulate the use, valuation and conservation of the natural and cultural heritage. Therefore, the development of protocols related to ethical considerations and protection of the natural and cultural heritage is essential in order to avoid ongoing negative impacts. Natural hazards are phenomena with a large spatial dimension and impact every part of the world in various ways depending on geomorphology and demographics of different locations and which might have a negative effect on people or the environment (e.g., Nirupama, Adhikari, & Sheybani, 2014; Ferrero & Magagna, 2015).

Education is very important for sustainable development as it contributes to the integral fulfillment of sustainable development goals. However, educational institutions through quality education have a responsibility to also contribute to the achievement of these objectives. On the other hand, educational institutions play a fundamental role in the transfer of knowledge to new generations about the multiple global social, economic and environmental challenges that the world currently faces. Education both rigorous and effective, can increase people's awareness and sensitivity to the need for protection of the geological heritage and for adopting geoethical attitudes. Fig. 12 illustrates some of the activities that can contribute to the sustainable development goals.

9. Conclusions

The imposing, majestic and fascinating Chicamocha Canyon in Colombia represents a natural attraction, which formed part of the list of 261 participants who submitted nominations to aspire to the 7 natural wonders of the world (Quintero, 2009). It is characterized by the occurrence of several potential geosites of global importance which provide a great opportunity for future

Fig. 12. Activities that contributes to the sustainable development goals.

generations interested in geological and paleontological heritage to continue fieldwork and excavations for further discoveries. However, these geosites, of geoheritage importance, are located in open areas in and/or around areas where they can be still in a good state of preservation or continue to degrade under the many natural hazards impacting them through weathering, erosion, climate changes, etc. Therefore, it is imperative to develop management plans to protect and valorize these geosites.

The recognition of UNESCO as a geopark for this region will augment these activities and contribute to promote sustainable tourism. Therefore, establishing the CCG project would help in developing a detailed inventory of the sites of geoheritage significance, building a management plan for their promotion and protection, promoting local manufactured products and improving the infrastructure of this region by increasing the living standard of local populations through geotourism. However, the project needs the involvement of many stakeholders, such as local communities and authorities, Colombian Geological Survey, Santander Government, municipalities, Ministry of Education, Ministry of Tourism, Ministry of Culture, museums of sciences, professionals of archaeology, biology, geology, history and culture and social work from the Universidad Industrial de Santander, academics from other public and private institutions of higher education, public and private schools, hotels, restaurants, guides, tourism professionals and managers of private companies, etc.

The CCG project would contribute to the exploitation of the national geodiversity resource via research, education, and tourism activities including geotourism. It would provide several benefits, such as raising the profile of the territory and be a high-quality tourist destination by using the communication and promotion tools of the GGN, promoting the development of geoeducation, geotourism and geoconservation activities, strengthening the quality and distribution of tourism products and local products through the management of the "UNESCO Global Geopark" quality seal. The geodiversity of the Chicamocha Canyon has not been fully developed due to its incomplete representation of the geological heritage types. It is necessary to develop a policy focused on efficient development of the geodiversity resource in the form of a geopark, which should be developed on the national level.

The National Commission of the UNESCO should be involved in the evaluation of the geopark proposal. Further investigations should focus on the protocol instruments regulating geopark establishment in Colombia. Additionally, the opinion of the policy-makers likely to be involved in the proposal to establish a geopark in the Chicamocha Canyon has to be considered and analyzed before further progress can be developed. Responsibility for the management and coordination of the proposed geopark lies with the CCG project Coordinating Committee, made up of representatives of the institutional, socio-economic and scientific agents involved in the project, through a cooperation agreement, including National Government (Ministries of Commerce, Industry and Tourism, Environment and Sustainable Development, and Culture); Local governments (Municipalities); private sector, Industry and Commerce, Tourism operators, ONGs, etc. and the public and private universities and education authorities and the Geological Survey of Colombia. The Coordinating Committee should be the coordinator and the manager of the legal entity denominate CCG project.

10. Future research in the CCG project

Globally, geoparks have proven to be highly successful thanks to the importance they place on their natural and cultural heritage and the socioeconomic development of local communities. Regarding future research, although there is information here about natural (geodiversity and biodiversity) and cultural diversity, an extended baseline is yet mandatory for this region, based on studies that should be made of geosites, making a quantitative valuation, to define and specify their potential for geotourism, geoeducation or geoconservation purposes. The use of citizen science initiatives and inter-administrative collaboration with research groups, centers and institutes could be good strategies to explore areas without information, complement the inventory of different groups and present a baseline. Such information will help decision makers and local communities to study, manage and conserve the natural and cultural heritage of the CCG project. Future research should focus on the need to create strategies focused on the socio-economic and environmental sustainability of the territory, the awareness of the general public on the importance of natural and cultural heritage are highlighted. Through educational programs, the transfer of knowledge about the region's geology and landscape and its impact on society and civilization, and the promotion of the conservation of natural (geodiversity and biodiversity) and cultural diversity.

CRediT authorship contribution statement

C.A. Ríos: Investigation, Conceptualization, Methodology, Writing - original draft. **R. Amorocho:** Investigation, Conceptualization, Methodology, Writing - original draft. **C.A. Villarreal:** Investigation, Conceptualization, Methodology, Writing - original draft. **W. Mantilla:** Investigation, Conceptualization, Methodology, Writing - original draft. **F.A. Velandia:** Investigation, Conceptualization, Methodology, Writing - original draft. **O.M. Castellanos:** Investigation, Conceptualization, Methodology, Writing - original draft. **S.I. Muñoz:** Investigation, Conceptualization, Methodology, Writing - original draft. **D.A. Atuesta:** Investigation, Conceptualization, Methodology, Writing - original draft. **J.H. Jerez:** Investigation, Conceptualization, Methodology, Writing - original draft. **O. Acevedo:** Investigation, Conceptualization, Methodology, Writing - original draft. **M. Vargas:** Investigation, Conceptualization, Methodology, Writing - original draft. **V.M. Caballero:** Investigation, Conceptualization, Methodology, Writing - original draft. **C.A. Goso:** Investigation, Conceptualization, Methodology, Writing - original draft. **A. Briggs:** Investigation, Conceptualization, Methodology, Writing - original draft.

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Declaration of competing interest

None.

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