SPANISH JOURNAL OF PALAEONTOLOGY

Working to the conservation and good use of the Devonian palaeontological heritage in Floresta, Boyacá (Colombia): a review of teaching case studies to engage students and the community

Gatsby-Emperatriz LÓPEZ-OTÁLVARO

Department of Geosciences and Environment. Faculty of Mines. National University of Colombia.
Geosciences Centre, University of Coimbra (Polo II), Rua Sílvio Lima, 3030-790 Coimbra, Portugal; gatsbyemperatriz@usal.es

López-Otálvaro, G.E. 2019. Working to the conservation and good use of the Devonian palaeontological heritage in Floresta, Boyacá (Colombia): a review of teaching case studies to engage students and the community. [Trabajando para la conservación y el uso adecuado del patrimonio paleontológico en Floresta, Boyacá (Colombia): una revisión de ejemplos de enseñanzas para involucrar estudiantes y a toda la comunidad]. *Spanish Journal of Palaeontology*, 34 (1), 153-162.

Manuscript received 14 March 2019
Manuscript accepted 27 May 2019

https://doi 10.7203/sjp.34.1.15299
 ISSN 2255-0550

ABSTRACT

The Floresta Massif, located in the Eastern Cordillera of Colombia, has a diverse and precious natural heritage. It is one of the areas that contains an exceptional palaeontological heritage of the Middle Devonian not only of Colombia, but also of South America. This heritage is represented by fossil specimens of marine fauna and terrestrial flora (correlated with North America and Europe) of the Floresta and Cuche Formations. Since 2004, actions made by several academic and research institutions, community and local government have introduced schoolchildren, teenagers and university students to art and science, and have promoted the conservation of palaeontological heritage as an essential, vibrant and relevant discipline. The high diversity of invertebrates, fishes and terrestrial plant fossils unearthed has promoted teaching and outreach projects, the creation of a small Museum of Palaeontology in the Floresta municipality, and the aim of developing a geotouristic ring road in the Floresta municipality and towns surrounding the Floresta massif. These initiatives are a lively example of conservation and good use of the palaeontological heritage of Floresta.

Keywords: Middle Devonian, Floresta, Boyacá, Colombia, fossils, artworks, education, palaeontological heritage.

RESUMEN

El Macizo de Floresta, ubicado en la Cordillera Oriental de Colombia, tiene un patrimonio natural diverso y valioso. Es uno de los lugares más destacados en patrimonio paleontológico excepcional del Devónico Medio, no solo de Colombia sino también de Suramérica. Este patrimonio está representado por especímenes fósiles de fauna marina y flora terrestre (correlacionable con Norte América y Europa) de las Formaciones Floresta y Cuche. Desde el 2004, las acciones realizadas por varias instituciones académicas y de investigación, la comunidad y el gobierno local han acercado a los niños, adolescentes y estudiantes universitarios al arte y la ciencia, y han promovido la conservación del patrimonio paleontológico como una disciplina esencial, vibrante y relevante. La gran diversidad de fósiles de invertebrados, peces y de plantas terrestres descubiertos ha promovido proyectos didácticos, la creación de un pequeño Museo de Paleontología en el municipio de Floresta, y el propósito de desarrollar una circunvalación geoturística en el mismo municipio y en las ciudades alrededor del Macizo de Floresta. Estas iniciativas son un vivo ejemplo de conservación y buen uso del patrimonio paleontológico de Floresta.

Palabras clave: Devónico Medio, Floresta, Boyacá, Colombia, fósiles, arte, educación, patrimonio paleontológico.

1. INTRODUCTION

The Devonian System of Colombia outcrops along some of the Precambrian massifs of the Eastern Cordillera, among which the Floresta Massif is found (Barrett, 1988). The Floresta Massif is located in the northeastern portion of the Eastern Cordillera of the Colombian Andes, in the Department of Boyacá (Botero, 1950; Cediel, 1976), 200 km northeast of Bogotá (Fig. 1). Lateral borders are defined by the Boyacá and Soapagá Faults (Fig. 2) constraining its tectono-sedimentary dynamics since the Paleozoic (Mojica & Villarroel, 1984). It is one of the places of greatest geological and palaeontological interest in Colombia and South America. The Massif constitutes one of the four Colombian metamorphic massifs of Precambrian/Paleozoic age, being cut off by pre-Devonian granitic intrusions (Mojica & Villarroel, 1984) and unconformably covered by a Devonian siliciclastic transgressive-regressive sedimentation cycle, as well as by Mesozoic and Cenozoic sediments (Cediel, 1969; Mojica & Villarroel, 1984; Moreno-Sánchez, 2004) (Fig. 2).

The Paleozoic sedimentary sequence in the Floresta Massif consists of Devonian El Tibet, Floresta and Cuche Formations, being Floresta and Cuche the most fossiliferous formations (Fig. 2). Marine invertebrates and fishes have been recovered in Floresta sediments (Caster, 1939; Royo y Gómez, 1941, 1942; Morales, 1965; Janvier & Villarroel, 1998; Morzadec *et al*., 2015), while terrestrial plants, marine invertebrates, and fishes have been reported for Cuche (Mojica & Villarroel, 1984; Janvier & Villarroel, 1998; Berry *et al*., 2000; Morzadec *et al*., 2015). The faunas and floras show strong affinities with other species in common in Pamplona (Colombia), Serranía del Perijá (Venezuela), New York (USA) and Europe (Berry *et al*., 2000; Morzadec *et al*., 2015), while restricted faunal exchanges (calmonids) were possible with the Malvinoaffric realm (Morzadec *et al*., 2015). The presence of such palaeontological content points to the proximity of Gondwana and Laurasia continents (Janvier & Villarroel, 1998; Berry *et al*., 2000; Pires de Carvalho, 2018) that later closed the Rheic ocean and formed Pangea (Janvier & Villarroel, 1998, 2000; Berry *et al*., 2000), giving constraints on paleogeographic

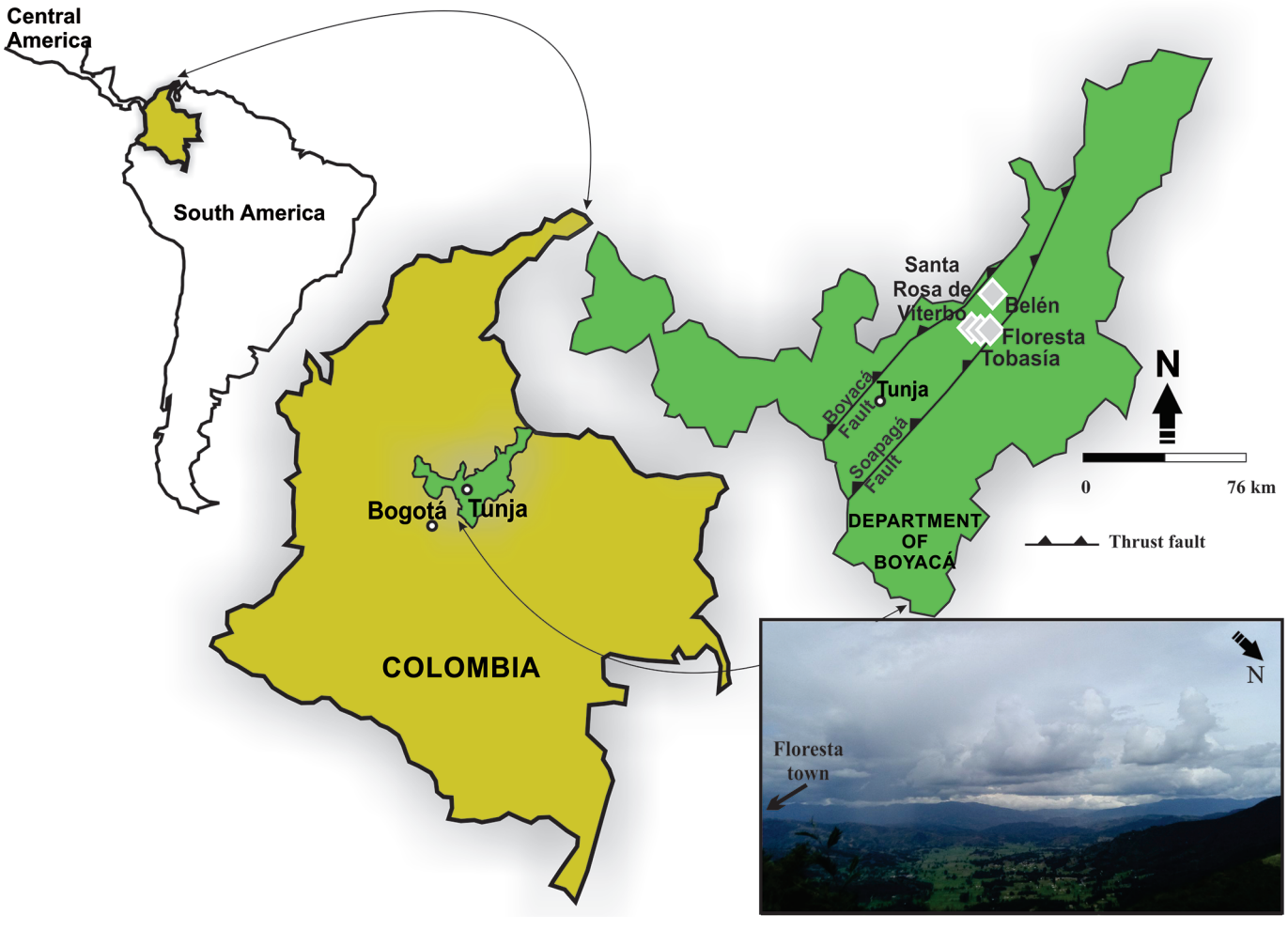

Figure 1. Location of the area of study. Image at the bottom right is a panoramic view of the Floresta area.

reconstructions of the Northern Andes. Therefore, exploring the geological record of the Floresta Massif is essential to understand the geologic evolution of Colombia.

Colombian laws preserve and protect the Geological and Palaeontological Heritage in the national territory being considered as part of the Cultural Heritage of the nation. Such a heritage is regulated by the law property of the nation and communal heritage. The current legislation ("*Decreto Ley 4131 de 2011*") empowers the Colombian Geological Service as a national authority to manage the required actions to protect this heritage. Among the actions carried out are the participation of the Colombian Geological Service in the World Heritage National Intersectoral Commission (with the purpose of strengthening UNESCO's activities in Colombia), and in the National Cooperation Agreement to Prevent and Counteract the Illicit Trafficking of Cultural Goods 2990-01-2017 (in which several national governmental, academic and research institutions are engaged) (Gómez Guerrero & Salgado Jáuregui, 2017).

Although reference sections now have legal protections with the collection of new material, the Palaeontological Heritage is not only confined to places where fossils remain in situ (Henriques & Pena dos Reis, 2015). Fossils removed during expeditions and stored in museums, geological surveys and academic and research institutions should be considered as part of communal geological heritage and should be selected for geoconservation (Gray, 2008; Henriques & Pena dos Reis, 2015). This is the case of type specimens providing the objective of reference sections (ICZN, 1999). Unfortunately, some type specimens of the Floresta Massif collected during some scientific expeditions are housed outside Colombia. Examples are the specimens described by Morzadec *et al*. (2015) and Pires de Carvalho (2018). They remain deposited in the Museum of Natural History of Nantes (France) and in the Cincinnati Museum Center Invertebrate Palentonology (CMCIP), Geier Collection and Research Facility, respectively.

Informal or free-choice learning environments can be of great help to contribute towards engaging people in learning about the evolution of past life and increase protective attitudes and behavior towards the fossil record (Henriques & Pena dos Reis, 2015). This work makes a compilation of published and unpublished educational interventions implemented by different institutions as early as 2004. Such interventions expected to engage students and the community of the Floresta municipality (located in the Floresta Massif) (Fig. 2) to perceive and protect the palaeontological and geological heritage of the Floresta Formation as the Middle Devonian type-locality of Colombia (Morales, 1965). Additionally, it reports a field trip around the ring road encompassing Puerto Arepas, Punta Larga, Tunguaquita, Cachavita, Cuche, and Tobasía rural sites, Santa Rosa de Viterbo, Floresta, Busbanzá and Corrales municipalities (Fig. 2) carried out in the frame of a Palaeontology class from the National University of Colombia (Campus of Medellín) during the semester 2018-1 (February-May 2018). This new case study is reported in this work since the Devonian of Floresta Massif represents a valuable didactic material and an important educational resource for teachers and professors to spread biological, palaeontological, geological, and geoheritage concepts. Overall, this work aims at exposing motivating case studies carried out by a diverse community interested in the conservation and good use of palaeontological and geological heritage of Floresta, which may be useful for inspiring similar initiatives to preserve the palaeontological heritage based on community involvement.

2. STRATIGRAPHY AND PREVIOUS RESEARCH

The Floresta Massif is a NNE-SSW elongated anticlinal located in the northeastern segment of the Colombian Andes (Janvier & Villarroel, 1998) (Fig. 2). It consists of a crystalline core unconformably overlined by the Devonian siliciclastic sequence of the El Tibet, Floresta and Cuche formations (Cediel, 1969; Mojica & Villarroel, 1984; Moreno-Sánchez, 2004) (Fig. 3). The onset of the sequence corresponds to the Devonian transgressive fluvial event represented by a lower segment of claystones and muddy sandstones that grade to pebbly conglomerates and sandstones of 30-500 m thick. Those sediments are known as the El Tibet Formation in the Massif (Mojica & Villarroel, 1984). On the evidence of spore assemblages, Gröser & Prössel (1994) assigned an Emsian accumulation age and a coastal domain for the El Tibet Formation.

The overlaying Floresta Formation (Olsson & Caster, 1939) conformably lies upon the El Tibet Formation (Figs 2-3). Sediments of the Floresta Formation reach 400-800 m thick (Moreno-Sánchez, 2004) and consist of two different stratigraphic levels (Morzadec *et al*., 2015). The lower level consists of alternating shales and silts with numerous levels of coquinas (Morzadec *et al*., 2015) characterised by a rich and diverse fauna of bryozoans, tabulate corals, brachiopods, crinoids, gastropods, trilobites and ostracods (Caster, 1939; Royo y Gómez, 1941, 1942; Morales, 1965; Morzadec *et al*., 2015), and fish remains of rhenanid and arthrodire type (Janvier & Villarroel, 1998). An in-depth study of inarticulate brachiopods identified one new genus and three new species in the lower segment of the Formation (Morzadec *et al*., 2015). Based upon brachiopods (lingulates) and trilobites, Morzadec *et al*. (2015) assigned a late Emsian age to this level. The upper level grades to small sandy lenses intercalated in silts below a concretion level bearing inarticulate brachiopods, trilobite remains and smaller forms consisting of brachiopods, crinoids and

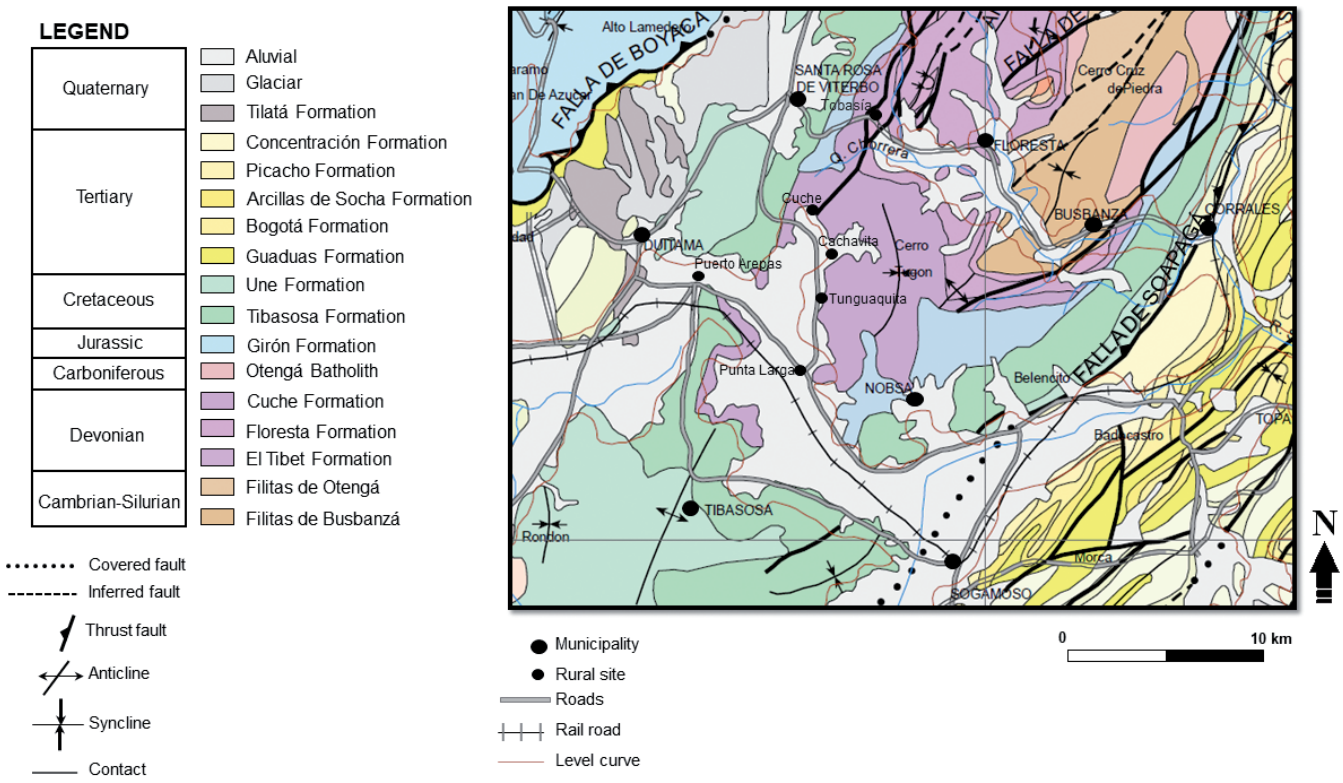

Figure 2. Geological map (Ulloa *et al*., 2003) of the southern segment of Floresta Massif. Municipalities and rural sites and the road ring followed during the fieldtrip of Palaeontology class of the Engineering Geology degree of the National University of Colombia, Campus of Medellín, during the semester 2018-1 are cited here.

tentaculitids. The trilobites collected from the upper level suggest a Givetian age (Morzadec *et al*., 2015). Relatively deep marine conditions to a deltaic front were suggested as depositional environment for the Floresta Formation (Moreno-Sánchez, 2004).

The top of the Paleozoic sequence is represented by the Cuche Formation (Botero, 1950) (Figs 2-3), and consists of 400-800 m thick of an alternating sequence including pinkish to greenish tidal to supratidal sandstones (Lower Member) and red, violet, and ochre sandstones and lagoonal siltstones (Upper Member) yielding vertebrate remains, mollusks and ostracodes, as well as abundant plant remains indicating a Late Devonian Frasnian to Famenian deposition within the transition from shallow marine conditions to nearshore terrestrial domain (Berry *et al*., 2000; Janvier & Villarroel, 2000; Burrow *et al*., 2003; Moreno-Sánchez, 2004).

The Devonian sequence is discordantly covered by mid-Mesozoic titled red beds and conglomerates of the Girón Formation (Upper Jurassic) or the conglomerate sandstones of the Tibasosa Formation (Hauterivian; Cediel, 1969; Javier & Villarroel, 1998) (Figs 2-3). This context shows an important hiatus in the lithological record of the Floresta Massif from the Carboniferous to the Middle Jurassic, which is associated with the tectono-sedimentary dynamics of Boyacá and Soapagá faults (Fig. 2) as early as the Paleozoic (Mojica & Villarroel, 1984).

3. THE CONSERVATION AND GOOD USE OF THE PALAEONTOLOGICAL HERITAGE OF FLORESTA: CASE STUDIES

The palaeontological heritage of Floresta has become an invaluable and relevant scientific good with a strong potential for the development of local geotourism. For that reason, it has gathered increasing attention from local government, academic and research institutions, tourism operators and the community. However, it is still highly vulnerable since projects of practical initiatives are interrupted after one or two years of execution. At least since 2004, several regional and local initiatives and actions regarding education on palaeontological heritage have been focused on the inhabitants of the village of Floresta. Their aim has been to develop several projects acting to raise public awareness on palaeontological conservation and good use. As a result of close cooperation with scientific institutions, local authorities and the population of the Floresta municipality coordinated strategies to encourage the promotion of knowledge, nature conservation and geotourism. Combining geological, palaeontological, geomorphological and cultural heritage, the Floresta

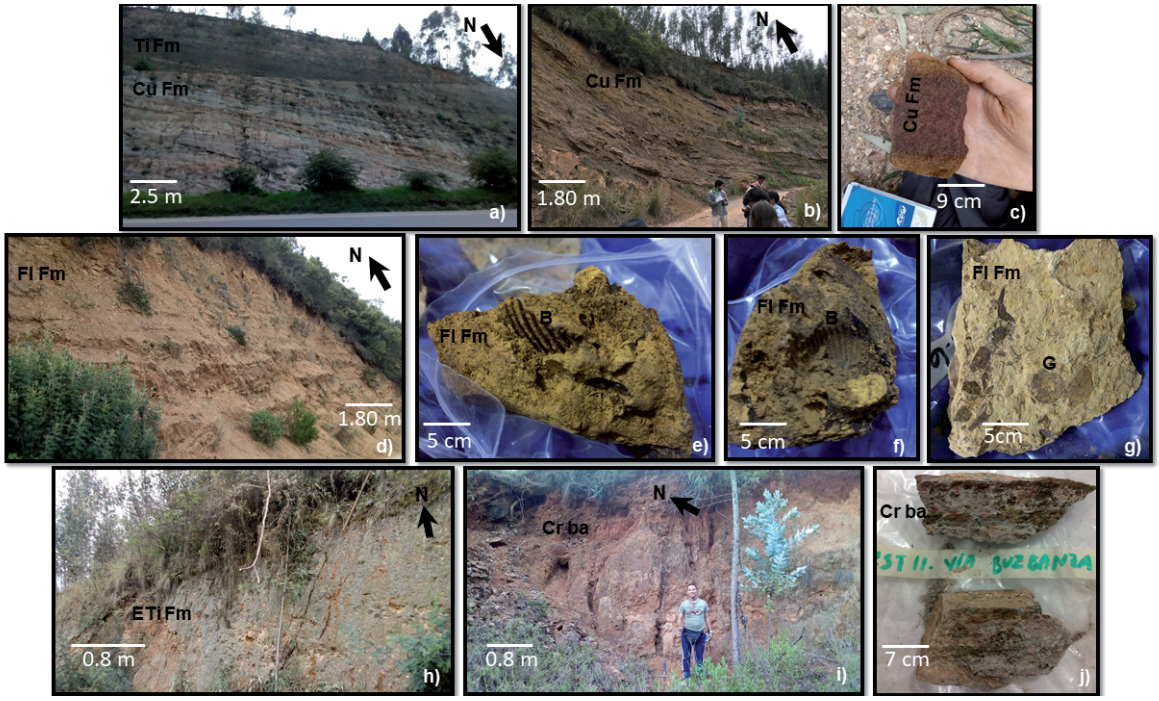

Figure 3. Photos taken during the fieldtrip of Palaeontology class of the Engineering Geology degree of the National University of Colombia, Campus of Medellín, during the semester 2018-1. **a)** Locality: Puerto Arepas (Highway Duitama-Sogamoso); look how folded and faulted red sandstones of Cuche Formation (Cu Fm) are covered by tilted conglomerate sandstones of Tibasosa Formation (Ti Fm). **b-c)** Cuche Formation (photo courtesy of Melisa Arango, a student of Palaeontology class 2018-1) and Ochre sandstone sample of Cuche Formation, road Cuche-Santa Rosa de Viterbo. **d-g)** Floresta Formation (Fl Fm) and fossil samples (**B**: brachiopod, **G**: gastropod), road Santa Rosa de Viterbo-Tobasía. **h)** El Tibet Formation (ETi Fm), road Santa Rosa de Viterbo-Tobasía. **i-j)** Schist of the crystalline basement (Cr ba), road Floresta-Busbanzá, scale: Camilo Vásquez, a student of Palaeontology class 2018-1.

municipality and surroundings offer multiple facilities to inspire regional and local sustainable development.

3.1. State projects

First, Ondas Project was originated in 2004 sponsored by Colciencias (Administrative Department of Science, Technology and Innovation of Colombia), the local government, the network of educational institutions of Floresta, and the Geological Society of Colombia during six months. The project sought to give palaeontological and geoheritage learning and insights to the "Trilobite" amateur group of palaeontologists, formed by forty-five enthusiastic children coming from rural and urban sites of the Floresta municipality (Giraud López, 2014).

Second, in 2006 the MUGAI Project, sponsored by the local government, the network of educational institutions of Floresta and the Geological Society of Colombia, gathered children from rural and urban sites from the Floresta municipality and also adults in order to spread palaeontological knowledge and gain an in-deep comprehension of natural heritage of their region (Giraud López, 2014).

Lastly, the Colombian Geologic Service through the National Museum of Geology José Royo y Gómez conducted the Project SGEO09-08 (from 2009 to 2011) aiming to share geoheritage knowledge through different palaeontological sites of Colombia. Floresta inhabitants attended workshops of fossil artworks and films that contributed to increase the knowledge of their palaeontological heritage (Giraud López, 2014).

3.2. Local administration initiatives

The proposal of the Mayor of Floresta made in 2005 and currently on hold, was entitled "Geological tourism by the Eco-Geo-Archaeo-Routes, participatory Palaeontological Museum and Ecological Tourism" to be developed on the road ring of Sogamoso - Corrales - Floresta, finishing at the Palaeontological Museum of the municipality. The objective was to form the community of visitors in the preservation of palaeontological sites avoiding destructive tourism, looting or damage due to inadequate treatments or illicit traffic of cultural goods. The project activities aimed at strengthening the facilities and collections from the Palaeontological Museum, acquiring teaching materials and

supporting the educational and scientific activities of the municipality, creating a workshop house for the elaboration of fossil replicas, and buying lands of palaeontological interest. The project required the participation of geologists who know the area so that they can train the community and geotourism guides of the region (Honorable Concejo Municipal de Floresta, 2005; Solano Álvarez & Sanabria Boada, 2005). Unfortunately, this proposal is still waiting for political agreement and funding.

3.3 Sustainable development and geotourism

The local community of "florestanos" participated in the creation of web pages to promote the local knowledge on geological, palaeontological and cultural heritage of the geotouristic ring road proposed by the Mayor of Floresta and the main activities that impact tourism in the region. These are: http://floresta.com.co/ecoturismo.html, and http://www.colombiaturismoweb.com/DEPARTAMENTOS/BOYACA/MUNICIPIOS/FLORESTA/FLORESTA.htm.

Moreover, a local artisan and woodworker based in Tobasía (5 km west of Floresta Municipality) (Fig. 2), Mr. Luis Becerra, had the initiative to promote the knowledge and curation of the palaeontological heritage by elaborating artistic renditions of Devonian trilobites in wood and resin. Mr. Becerra has participated in several scientific meetings in Colombia exposing his artworks and sharing his knowledge about the communal heritage of Floresta.

3.4. University extension projects

Universities have also participated intensively in the promotion of conservation of the geoheritage of Floresta by motivating students of Pedagogy and minors to acquire palaeontological experience in the classroom and in the field. Three instances are exposed below.

The first case concerns the creation of the Palaeobiology class under the direction of the Department of Biology of the Higher Teacher Education Faculty of the National Pedagogic University. This action facilitated the participation of students in pedagogical work and the promotion of knowledge on palaeontological heritage during their semester of extramural practices. The teaching activities were endorsed by the educational plan of the academic courses 2011, 2012 and 2013. The institutions involved included the urban High School Héctor Julio Rangel Quintero and the rural schools of the municipality. Two projects were derived from this proposal: "Fosiliz-arte: an experience in the municipality of Floresta (Boyacá) through the recognition of fossils and art as a learning strategy" (López Piñeros, 2012), and "Palaeontological youth: in search of the lost one. Recognising and valuing the palaeontological heritage of Floresta-Boyacá" (Castro & Gil, 2013).

On the one hand, López Piñeros (2012) proposed visiting the fossiliferous sites with the schoolchildren and teachers. Kids illustrated individually the specimens they found and made clay replicas of some of the fossil specimens that were later exposed in a Fossil Fair in the town's main park in 2012. Then, they wrote a storytelling individually with the palaeobiological and palaeoecological information of the invertebrate fossils they found in the fieldtrip (trilobites, brachiopods, corals, crinoids, bryozoans, bivalves). Subsequently, the students and teachers located the fossiliferous deposits in a handmade muck-up of the region. Moreover, during the Fair the students showcased the creations and knowledge developed during the Fosiliz-arte project to the general public. The project brought children and teachers closer to the understanding and appreciation of the palaeontological heritage. In addition, extracurricular activities were proposed to the Floresta government directives, namely continuous training of students and teachers on palaeontological heritage, and renovation of the Museum of Palaeontology premises.

On the other hand, the work of Castro & Gil (2013) mentioned above included teenagers between 13 and 16 years old from Floresta interested in the promotion of the palaeontological heritage of the municipality. The objective of this project was to awaken and strengthen the motivation of young people for palaeontology. A first phase consisted in surveying young people about their interests, knowledge and skills on the palaeontological heritage in order to expose the needs of the youth. Students visited various fossiliferous localities and prepared a new Fossil Fair developed in the High School Héctor Julio Rangel Quintero and in the town's main park during 2013. In this Fair, the students presented the following six creative works: a) "The Palaeontological Hangman", where the teenagers exposed the characteristics and importance of trilobites. They also sold replicas of trilobites made in chocolate; b) "Discover what is around you", which included a muck-up of the municipality with the location of the geological formations, the fossiliferous sites and the specimens found in the fieldtrip; c) "Win to the luck", a game in which, through illustrations and photos, the participants associated different fossil specimens to their extant representatives; d) "Palaeontological twister", a game that answered questions about the Paleozoic rocks and fossils of Floresta through replicas of fossils made in plasticine; e) "Beings of the past", a work promoting the importance of fossils, their palaeoenvironments and location in geological time, and protection through a puzzle; and f) "Domi-fossil", a game in which the students explained the historical and palaeontological heritage richness of Floresta and the Department of Boyacá in general, including emblematic sites such as the Boyacá Bridge (the place where the Battle of Boyacá was held,

resulting in the independence of Colombia in 1819) and replicas of amber and copal (fossilised tree resins) fossils (Castro & Gil, 2013). The Fossil Fair highlighted the active participation of students, the motivation of the school directives to strengthen this type of activities integrating the community and schoolchildren. The general public found the Fair as a chance to answer their questions about specimens found on the roads, gardens, patios, hills and rivers.

Unfortunately, both projects reported by López Piñeros (2012) and Castro & Gil (2013) culminated in 2013, which resulted in interrupting the training of children in palaeontology and palaeontological heritage as well as the integration of the community, and increased the vulnerability of the fossiliferous sites of Floresta.

Lastly, it is worth mentioning that Giraud López (2014) presented a Master Thesis in scientific illustration of Devonian fossils of Floresta Formation for pedagogical and scientific purposes. The author had been involved in palaeontological education since 2004, collaborating in the state and university projects introduced above and the University Institution of School of Arts and Letters of Colombia. Her Master Thesis is the first work to use the scientific illustration with palaeontological heritage of the Colombian Devonian for pedagogical purposes. Her contribution promotes the didactic and outreach potential of the Floresta Formation, raising awareness of both the geological and the palaeontological heritage of these sediments.

3.5. A fieldtrip to Floresta by the 2018 Palaeontology class of the Geological Engineering degree

Fieldtrips are important opportunities for promoting the improvement of knowledge about geology, thus contributing to the understanding of concepts and ideas covered in the classroom (Henriques *et al*., 2012; Dourado & Leite 2013; Lambert & Reiss 2015; de Celis *et al*., 2018). The scientifically relevant location of the Floresta Massif (Boyacá, Colombia) provides an exceptional framework for valuable educative and outreach activities. The 5-day fieldwork carried out by the Palaeontology class of 2018-1 semester (Fig. 3) from the Department of Geosciences and Environment of the Faculty of Mines, National University of Colombia in Medellín, was spearheaded by the author of this manuscript and provided a basis for an in-depth comprehension of the methodology and steps concerning the search, survey, excavation, preparation, curation and management of fossil invertebrates and sites. This was the first time a Palaeontology class from Medellín visited the Floresta Massif (among other sites that are not discussed here), probable because the city is 600 km away. The fieldwork aimed at stimulating the students of Palaeontology on the sustainable development of the Floresta municipality and surroundings through the knowledge, valorisation and protection of its geological and palaeontological heritage. Previous training consisted of a combination of earlier lectures of systematics, evolution, sedimentology, stratigraphy, palaeoenvironments and palaeogeography; laboratory work on palaeobiology; reports, scientific illustrations, abstracts and individual essay-writing, as well as a fieldwork around a ring road covering the southern segment of Floresta Massif, i.e., Puerto Arepas, Punta Larga, Tunguaquita, Cachavita, and Cuche rural sites, Santa Rosa de Viterbo, Tobasía, Floresta, Busbanzá and Corrales villages (Fig. 2). Students were engaged in a course material and work outside the University by presenting a daily brief discussion and a field report including palaeofaunistic classification, stratigraphy, structural elements of the outcrops, palaeoenvironments, palaeontological heritage legislation, and palaeontological tourism. The discussion also contained proposals for potential future directions of palaeontological education within this geographical context, such as increasing the fieldwork time since the activities were only designed for a single day.

4. CONCLUSIONS

The effective protection of the geological and palaeontological heritage requires the local community's involvement in all geoconservation actions, i.e., inventory, evaluation, conservation, economic assessment and monitoring procedures, and not only during the last stages of the process, when the caring of such heritage is expected from local communities.

The integration of science and art has been essential in all the initiatives aiming at raising the awareness among the population of Floresta regarding the geological and palaeontological heritage of the region. The students involved in educational activities were trained on geoconservation, and bridged the community and local authorities through masterful explanations, handmade illustrations, storytelling, the elaboration of fossils replicas, and artistic renditions in clay, plasticine, chocolate and wood, and ingenious didactic games. All this creativity has resulted in the emergence of a sense of belonging and in the increasing of motivation for the conservation of the Floresta palaeontological heritage.

Close cooperation with academic and research institutions with expertise in geology, biology and palaeontology is fundamental to support children, adult communities and local authorities. The National Pedagogical University, the University Institution of School of Arts and Letters, the Palaeontological Museum of Floresta, the National Geological Museum José Royo

y Gómez, and the Colombian Geological Service and the National University of Columbia (Campus of Medellín) have all provided a brilliant example of how to motivate the population of Floresta and university students in the promotion of knowledge and appreciation of its palaeontological heritage. The conservation and good use of this rich heritage needs to keep being encouraged through local and regional initiatives.

ACKNOWLEDGEMENTS

The author greatly appreciates the financial support given by the Department of Geosciences and Environment of the Faculty of Mines of the National University of Colombia, Campus of Medellín, in order to accomplish the fieldwork of the Palaeontology class during 2018-1 semester. GELO also deeply acknowledges the enthusiasm and assistance given by the community of the Floresta Massif, las Familias González Martínez and Suárez González, and the students during the field work in the semester 2018-1, as well as the constant guide and motivation provided by Dr. Maria Helena Henriques of the University of Coimbra (Portugal) to inspire and motivate these practical initiatives.

REFERENCES

Barrett, S.F. 1988. The Devonian System in Colombia. In: *Devonian of the World* (eds. McMillan, N.J., Embry, A.F. & Glass, D. J.). Canadian Society of Petroleum Geologists, Memoir nº 14, 705-717.

Berry, C.M., Morel, E., Mojica, J. & Villarroel, C. 2000. Devonian plants from Colombia, with discussion of their geological and palaeogeographical context. *Geological Magazine*, 137, 257-268.

Botero, G. 1950. Reconocimiento geológico del área comprendida por los municipios de Belén, Cerinza, Corrales, Floresta, Nobsa y Santa Rosa de Viterbo, Departamento de Boyacá. *Compilación de estudios geológicos Oficina Colombia*, 8, 245-311.

Burrow, C.J., Janvier, P. & Villarroel, C. 2003. Late Devonian acanthodians from Colombia. *Journal of South American Earth Sciences*, 16, 155–161; doi:10.1016/S0895-9811(03)00026-9.

Caster, K.E. 1939. A Devonian fauna from Colombia. *Bulletins of American Paleontology*, 24, 101-318.

Castro, C. & Gil, M. 2013. *Juventud paleontológica: en busca de lo perdido. Reconociendo y valorando el patrimonio paleontológico de Floresta-Boyacá*. Trabajo de grado para optar al título de Licenciados en Biología. Unpublished Senior Project. Universidad Pedagógica Nacional. Bogotá. Colombia.

Cediel, F. 1969. Geología del Macizo de Floresta. *I Congreso Colombiano de Geologia*. Bogotá, 17-29.

Cediel, F. 1976. *Geología del Macizo Floresta. Nota Explicativa del Mapa Geológico.* INGEOMINAS. Bogotá.

de Celis, A., Sanguino, F. & Díaz-Cáceres, J.A. 2018. The Didactic Potential of the Toarcian-Aalenian Transition at the Section of Fuente del Molino (Guadalajara, Spain). *Geoheritage*, 10, 443-449.

Dourado, L. & Leite, L. 2013. Field activities, science education and problem-solving. *Procedia – Social and Behavioral Sciences*, 106, 1232-1241.

Giraud López, M.J. 2014. *El mar en la localidad tipo del Devónico Medio del Municipio de Floresta, Boyacá, Colombia*. Ms. Thesis. Unpublished. Corporación y Escuela de Artes y Letras. Institución Universitaria. Bogotá, 175 p.

Gómez Guerrero, M.E. & Salgado Jáuregui, E. 2017. *Guía para Reconocer Objetos del Patrimonio Geológico y Paleontológico*. Museo Geológico Nacional José Royo y Gómez. Servicio Geológico Colombiano, 43p.

Gray, M. 2008. Geodiversity: the origin and evolution of a paradigm. In: *The History of Geoconservation* (eds. Burek, C.V & Prosser, C.D.). Geological Society, Special Publications, 300, 31-36.

Grösser, J.R. & Prössl, K.F. 1994. Palynologische Untersuchungen der Devonbasis in Floresta Massiv, Ostkordillere, Kolumbien, S.A. *Geissener Geologische Schriften*, 51, 105-121.

Henriques, M.H. & Pena dos Reis, R. 2015. Framing the Palaeontological Heritage within the Geological Heritage: An Integrative Vision. *Geoheritage*, 7, 249-259; doi: 10.1007/s12371-014-0141-9.

Henriques, M.H., Tomaz, C. & Sá, A. 2012. The Arouca Geopark (Portugal) as an educational resource: A case study. *Episodes*, 35, 481-488.

Honorable Concejo Municipal de Floresta. 2005. *Esquema de Ordenamiento Territorial Municipio de Floresta. Proyecto de Acuerdo*. Unpublished report, 492 p.

ICZN. 1999. *International Code of Zoological Nomenclature. 4th Ed. International Commission on Zoological Nomenclature*. The International Trust for Zoological Nomenclature, London. http://iczn.org/iczn/index.jsp.

Janvier, P. & Villarroel, C. 1998. Los peces Devónicos del Macizo de Floresta (Boyacá, Colombia). Consideraciones taxonómicas, bioestratigráficas, biogeográficas y ambientales. *Geología Colombiana*, 23, 3-18.

Janvier, P. & Villarroel, C. 2000. Devonian vertebrates from Colombia. *Palaeontology*, 43, 729-763; doi: 10.1111/1475-4983.00147.

Lambert, D. & Reiss, M.J. 2015. The place of fieldwork in science qualifications. *School Science Review*, 97, 89 -95.

López Piñeros, P.L. 2012. Fosiliz-arte: una experiencia en el municipio de Floresta (Boyacá) a través del reconocimiento de los fósiles y el arte como estrategia de aprendizaje. *Revista Bio-grafía*, 5, 89-97.

Mojica, J. & Villarroel, C. 1984. Contribución al conocimiento de las unidades paleozoicas del área de Floresta (Cordillera Oriental Colombiana; Departamento de Boyacá) y en

especial al de la Formación Cuche. *Geología Colombiana*, 13, 55-79.

Morales, P.A. 1965. A contribution to the knowledge of the Devonian faunas of Colombia. *Boletín de Geología*, 19, 51-111.

Moreno-Sánchez, M. 2004. *Devonian plants from Colombia: geologic framework and paleogeographic implications*. Ph.D. Thesis, Faculté des Sciences. Université de Liège. 183 p. Unpublished.

Morzadec, P., Mergl, M., Villarroel, C., Janvier, P. & Racheboeuf, P.R. 2015. Trilobites and inarticulated brachiopods from the Devonian Floresta Formation of Colombia: a review. *Bulletin of Geosciences*, 90, 331-358.

Olsson, A.A. & Caster, K.E. 1939. Part I: General Considerations. *Bulletins of American Paleontology*, 24, 9-11.

Pires de Carvalho, M. da G. 2018. Occurrence of *Dipleura dekayi* Green, 1832 (Trilobita; Homalonotidae) in the Devonian of Colombia. *American Museum Novitates*, 3902, 1-8; doi: 10.1206/3902.1.

Royo y Gómez, J. 1941. *Fósiles Devónicos de Floresta (Departamento de Boyacá)*. Museo Geológico Nacional. Ministerio de Minas y Petróleos. Sección 3 Geología. Bogotá, 95-41.

Royo y Gómez, J. 1942. *Fósiles Devónicos de Floresta (Departamento de Boyacá)*. Compilación de los Estudios Geológicos Oficiales en Colombia. Instituto Geológico Nacional. Bogotá, 5, 388-95.

Solano Álvarez, P.M. & Sanabria Boada, J.P. 2005. *Esquema de Ordenamiento Territorial, Municipio de Floresta, Boyacá. Corporación Autónoma Regional Corpoboyacá*. Alcaldía Municipal de Floresta. Unpublished report, 121 p.

Ulloa, C., Rodríguez, E. & Rodríguez, G. 2003. *Geología de la Plancha 172-Paz del Río. INGEOMINAS. Memoria Explicativa. Santafè de Bogotá*. 109 p.