El Castillo Mountain prehistoric caves (Cantabria, North of Spain). Structural geology, karstic development and prehistoric art manifestations. World Heritage, UNESCO 2008

A. FOYO; M.A. SANCHEZ, C. TOMILLO & E. IRIARTE
Applied Geology Research Group. Ground and Material Sciences Department
Civil Engineering School
University of Cantabria
Avda. de los Castros s/n, Santander, Cantabria
SPAIN

Abstract: - One of the main factors in the development and evolution of a karstic system are the structural characteristic of the rock masses. The karstic system of the El Castillo Mountain has been developed along of planes of different kinds of discontinuities, like thrust faults originated during the Hercinian orogeny and a dense net of fractures generated during the Alpine orogeny. Here we show the description of the structural geology and the possible relationship between the geological discontinuities of the rock mass and the prehistoric painting sites.

Key-Words: Structural geology, prehistoric caves, prehistoric painting sites

1 Introduction
The karstic system of the El Castillo Mountain is developed next to Puente Viesgo village Community of Cantabria, North of Spain (Fig.1a). It is constituted by multiple small holes and seven main cavities: El Castillo (The Castle), El Oso (The Bear), El Lago (The Lake), Las Chimeneas (The Chimneys), La Flecha (The Arrow), La Pasiega and Las Monedas (The Coins). All of them they are located inside the El Castillo Mountain, a conical and calcareous promontory 355 m heights over sea level (Fig. 1b).

From many years ago, the narrow relationship between the geological structure of the rock masses and the karstic development has been described by many authors [5, 6, 7, 8, 9], and the caves are even more sensitive in their evolution with the geological structure than the superficial waters and their valleys [10]. On the other hand, in the El Castillo Mountain caves, alike the narrow relations with the tectonic history of the rock mass, there is a curious coincidence between the structural discontinuities and the geological support of the prehistoric pictures, as well as with the vein of ochre, which is the prime matter to elaborate the colouring materials for painting.

In the El Castillo Mountain, El Castillo main cave it has been one of the most research cavities, because the stratigraphy of their prehistoric deposit includes lithic industry [2], and animal and human rest, Neanderthal and of Homo sapiens fossils [1], from the upper Acheulean prehistoric period until the Age of Bronze [1], which represents a continuous registration of about of 200,000 years of the human
Figure 1. a) Situation Map. b) General view of El Castillo Mountain history. Also, together with The Chimneys, The Pasiégia and The Coins caves, they contain some magnificent samples of prehistoric art manifestations of the Solutrean and Magdalenian prehistoric periods [3].

2 Geological characteristics of the El Castillo Mountain

2.1 Stratigraphy and Petrology
El Castillo Mountain is made of a sequence of Carboniferous limestones, Namurian to Westfalian geological age [11], and it is part of the Cabuérniga Tectonic Shield, that corresponds with the stratigraphical and structural continuation of the Cantabrian Units formed during the Hercynic orogenetic events.

In general, they are massive and fractured limestones that can be defined as biomicrites, mudstone-packstone, that contain idiomorphic quartz occasionally [11]. The weathering surfaces are of gray to white colour and in a fresh sample it presents a marked dark gray colour.

2.2 Structural characteristics
From the structural point of view the El Castillo Mountain is part of a large geological structure denominated as the Cabuérniga Tectonic Shield, and the formation of Carboniferous limestones, inside of the caves are developed, it is integrated in the shield with an orientation W-E (Fig. 2). During the late phases of the Hercynian orogenic event [11], and as a result of the efforts of the North to South compressive deformation, it has taken place the displacement toward the south of the carboniferous formations by means of long thrust fault structure, like geological napes, over the materials of age Mesozoic age, which are represented in all their chronological extension: Triassic sands and shales, Jurassic limestones and Cretaceous marls.

As consequence of the hercynian orogenic events, the development of different thrust fault structures with a general orientation NE-SW, produce the displacement of the limestones toward the South, and they cause the overlapping of carboniferous materials over it self (Fig. 3). The presence of long napes is common in the Asturian and Cantabrian regions and they are the structural patterns during the late hercynian orogenetic events[11]. Around the El Castillo Mountain, three of these structures have been identified, being specially important the denominated as the Little Nape of the El Castillo cave [12], and as other multiple micro napes, conserve the orientation of the general structure (Fig. 3).

Finally, together with these main two types of structures, there is a dense net of fractures defined as smaller order structures (Fig. 3). In general, these fractures correspond with two families of N-S and NW-SE orientation, and always with a vertical-subvertical development. It is considered that they have been originated during the late Alpine events, or even more recent age, corresponding at the distension phases of the orogenic cycles. All the fractures crossing and displace the napes and micro napes hercynian structures and consequently, they must be the last manifestation of tectonic deformation around the El Castillo Mountain.

2.3. Relationship between the Hercynic and Alpine structures and the development of the karstic system.

The development of the karstic system of the El Castillo Mountains they have a narrow relation with the orientation of the mayor and dominant smaller order discontinuities that affect at the limestone formation. As consequence of the massive character of the limestones, in absence of stratification planes,
The main tectonic structure corresponds with the front of the Cabuerniga Shield. However, the evolutions of the karstic conduits have had taken place preferably in favour of the secondary structures like the thrust faults of different kinds, napes and micro napes with a structural direction NE-SW, originated during the Hercynian events. An example specially important is the Nape of the El Castillo cave (Fig. 3), which define the entrance of the cave and it configures the great rocky refuge that it was the living zine of the oldest palaeolithic inhabitants. Alike, this structural element it has controlled the development of the first great room and the initial galleries [12].

Together with the Hercynic napes and little napes, the discontinuities of small order r like Alpine fractures they constitute the second structural element that it has controlled the development of the cavities and karstic conduits, specially when the karstic gallery presents a marked longitudinal development (Fig. 3), i.e. in the West sector of the El Castillo cave, and the West sector of the El Oso cave, main gallery of the Las Monedas cave and North East sector of the El Field.

3 Relationship between the geologic and structural characteristics of the cavities and the prehistoric art manifestations.

The relationship between development and evolution karstic system and the geological and structural characteristic of the limestone formations are more or less well known. However, in the El Castillo Mountain caves, it must be added a peculiar relation between the karstic development controlled by the geologic structure and the prehistoric art manifestations. That relation consists on two elements: a) the karstic system include two important deposits of ochre mineral, that they are neccessary to the production of coloring materia, and b) a curious relationship exists between the panels or walls were the prehistoric mans painting and the structural control in the development of the galleries.

The deposits of an ochre mineral are located in the Cueva del Oso and in the Cueva de Las Chimeneas. The minerals appear along discontinuity
NE-SW, which is to say, the Hercinic nape surfaces (Fig. 3).

Furthermore, the cavities with prehistoric art representations are El Castillo, Las Chimeneas, La Pasiega and Las Monedas. We are confirmed that, in these cavities, painting walls, panels of paintings, it has a curious coincide with surfaces that correspond directly with the discontinuity planes, Hercynic nape surfaces such as in the El Castillo or in La Pasiega caves (Fig. 3), as well as typical fracture discontinuities like in Las Monedas cave. The reason could be that these discontinuity planes have been generated many surfaces with a little, rough and lightly porous surfaces. The later development and karstic evolution, it has caused an intense laundry of the residual clays, became as appropriate surfaces to be the final support of the art manifestations (Fig. 4).

Figure 4. Prehistoric pictures made along a micro nape in the final gallery of El Castillo cave

4 Summary and conclusions

The karstic systems of the El Castillo Mountain contain seven big cavities. Four of them have an important prehistoric art manifestation and, in the case of the El Castillo cave, the rest of occupation and human fossils from the Neanderthal epoch. From the geologic point of view these cavities allow to propose the existence of a narrow relation between the structural properties of the limestone rock masses and the location of the art pictures. The epikarst has been developed in favour of discontinuities type napes, generated during the compressive stages of the Hercynic orogeny, and different kinds of fractures formed during the Alpine orogeny.

Acknowledgements

The Applied Geology Research Group of the University of Cantabria, would like grateful to the Culture Department of the Regional Government of Cantabria.

References:
Geológico de España a escala 1:50.000 (2º Serie). IGME, Madrid.
