THE BOULDER EROSION GRANITE CAVE SYSTEM OF "ALBARELLOS", AVION - OURENSE (GALICIA, SPAIN)

El Sistema de Cuevas de Erosión de Albarellos, Avión – Ourense (Galicia, España)

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Abstract: Albarellos is a new boulder erosion granite cave system characterized by their subterranean gigant and well developed erosion forms: Potholes with more than 5 m of diameter, and 11,5 m of depth; erosion tunnels and coalescent potholes modelling the subterranean channel. Cave is being surveyed and studied. This paper is only a preliminary report focused on the subterranean forms.

Palabras clave: Granito, cueva, erosión, canal, marmitas
Key words: Granite, cave, erosion, channel, potholes

1. INTRODUCCIÓN

The Albarellos system is located at Beresmo, township of Avión (Ourense) (coordinates UTM: X:562686; Y:4694251; Z:295). It is a boulder cave system through which the Avia River is channelized underground in the sector between 160 m and 295 m of length approximately. In the area corresponding to the Albarellos system, the water level has a great seasonal oscillation; during flood stages of the river, the water almost totally floods the voids between blocks, but during baseflow the water level decreases up to 15 m below the terrain surface.
In most of its high and low watercourses, the underground river flows alternatively between large blocks fell down to the bottom of the river bed, between blocks fallen from the walls of the same canyon, and along a channel incised in the substratum up to a maximum of 2 m.
In the middle watercourse, the river flows along an underground canyon of continuous walls or removed blocks, which reaches 6 m and 8 m high depending on the areas.
The sinkhole of the river is a vertical pit where the water moves between moved blocks and also incises in the rocky substratum *in situ*, and from this point the thickness of the blocks fallen from the surrounding slopes increases, reaching each time a greater depth until a maximum of 15 m. The water construction below the underground system of the Albarellos reservoir causes the emergence of the Avia River be underwater during the periods of maximum filling of such reservoir, and only during baselow, i.e. water decrease of the reservoir tail, the water flows underground up to 295 m of maximum length of the system and located at a height of -33.2 m with respect to the one of the river sinkhole. So far, 430 m long of passages and galleries have been mapped, located at different levels above the present watercourse. The river incision is obviously produced in the rocky substratum *in situ.* Therefore, the pothole has its elongation axis in vertical position. However, it is frequently observed that in some moved blocks that collapsed towards the present valley axis there is a pothole whose elongation axis is not preserved. Based on these two facts, we infer that the fluvial erosion firstly excavated the valley on the vertical, and during the incision process the fluvial erosion formed potholes in what was the bottom of the river watercourse at every moment. Once the valley was formed, the blocks collapsed (where the river previously excavated the pothole) infilling the bottom of the channel where water circulates. Therefore, the potholes formed in moved blocks do not preserve their original position.

1.1. Geological framework

Though the cave is totally developed in granite rocks, it is located at the contact between igneous rocks and metamorphic terrains. The metamorphic materials appear on detritic deposits as boulders of different sizes. The igneous rocks are intrusive granodiorites (pre-synkinematic phase 3, early granodiorite), with net contacts with the adjacent metamorphic series. This granodiorite is characterized by its feldspar megacrystals and general orientation of the biotites N160ºE. The metamorphic complex is formed by pleated white quartzites, amphibolites, and grey micaceous schists and green albitic schists with garnets, all from the Lower Ordovician (IGME 1981).

1.2. Hidrological and climatic framework

The Avia River starts in Fonteavia at 880 m high in the Serra do Suído (township of Avión). The total river length is 37 km, with a basin surface of 673 km2 and a mean flow of 18.5 m3/sec (maximum flow in February: 49 m3/sec; minimum flow in September: 2 m3/second (VV.AA 2003)). The underground system of Albarellos is located upstream from the Albarellos reservoir. The maximum height of the reservoir is 265 m.a.s.l. (Del Hoyo 1979). In August 2013, the authors of this work verified the cave existence below 250 m.a.s.l..

This watercourse evolves to leeward from the Serra da Faladoira (700 m) – Serra de Faro of Avión (1,100 m) ridge in the crossing of a zone of pluviometric gradient III (93-100 mm/100 m high) to a zone of gradient VI (75-78 mm/100 m) (Martínez et al. 1999). The annual total maximum pluviometries of all Galicia are located on the slopes to windward due to the canalising of the flows coming from the SW by the Rías Bajas. The Amiudal (Avión) site shows a1 2-month accumulated pluviometry (2012-2013) of 1,763 l/m2, with a maximum of 333.2 l/m2. The closest site to windward (Fornelos de Montes) shows an accumulated pluviometry of 3,574.4 l/m2 and a maximum of 658.4 l/m2.

2. MORPHOLOGIC DESCRIPTION

The orientation of the Avia River in the section of the underground system of Albarellos is N130ºE-N160ºE. It is located roughly at the contact between the metamorphic complex and the granodiorite. All the area is affected by an alteration process with regolith covers still visible on the sides of the paths or the upper part of the valley of the Avia River, more evident on the granitic part than on the metamorphic one. The fact that really influences on the formation of the underground course of the river is the structure in the interference between two granite domes with very well developed sheeting, of variable dipping between subhorizontal and subvertical that affect the whole section. Possibly, the vertical incision could have been enhanced by the generalized uplifting of Galicia during the Paleogene (Vidal Romaní et al. 2014) and that gave place to other similar underground systems (e.g., A Trapa, Pontevedra). The generalized vertical incision originated several processes from whose conjunction the formation of the underground system of Albarellos appeared. We summarized it as follows: 1º- formation of a valley of mostly vertical walls due to the incision of the Avia River in the the rocky substratum *in situ* where the largest potholes were developed (10 m high and 5 m of diameter) and 2º- fall of granite blocks, preferably from SSW slope of the valley. The construction of the reservoir modifies the base level of the Avia seasonally causing a modification of the emergence point that could have been lower initially, but now it is located at the contact of the tail of the reservoir originating the formation of a sandy delta at the river-reservoir confluence, which is only visible when the water of the reservoir is low.

Fig.1. Sumidero estacional entre marmitas dislocadas.
Fig.1. Seasonal sinkhole in between dislocated potholes.

Though the general outline of the system is practically lineal, the network incision and the channel evolution are clearly marked by subvertical fractures parallel to the outline of the system, and by the sheet structure of metric thickness and with variable dippings between 30 and 45, sometimes subvertical. Thus, the longitudinal profile of the watercourse is stepped, with small steps between undulating walls, with a non sinuous form on plan view, and potholes which are appearing on the vertical produced as the incision progresses. The potholes of greater dimensions are always those developed over the rocky substratum *in situ*. Given the fact that the incision of the rocky watercourse is not uniform along the channel but in the points where whirlpools were formed, it is possible to see the appearance of pothole on the vertical in different sections of the watercourse.

All the large potholes are associated with lateral smaller ones, hanged in some cases, or networked by coalescence or by tunnels that interlink them giving place to forms of complicated geometry (potholes type F (Nemec et al. 1982)) and of large dimensions. The narrowest sections slightly go over the meter of width. They are characterized by parallel walls and a rocky bottom without sediment, indicating the high velocity (relative).

There are few granite caves similar to Albarellos, with an erosion canyon, F forms (Nemec et al. 1982) and well-developed. We may cite *Millerton Lake Cave System* (California, U.S.A.; Blue Canyon tonalite; 956 m long, -41 m of difference in height) and *Hurricane Cave* (Colorado, U.S.A.; 1180 m long; 168.6 m of difference in height)

2.1. Sinkhole

It is formed by two quasi-superimposed sections. The upper one is clearly a neopassage generated by the slide of a structure of castle-rock type in the direction of the main channel. This displacement preserved part of the original channel as paleolevel under the active Avia River, and originated the pit that forms the present sinkhole. The bottom of the main channel at the sinkhole section is located at 8 m deep. The width of the channel in this part of the cave is between 1.1 m and 6.4 m wide.

Fig.2. Sumidero (pozo). Cota del canal -8 m.
Fig. 2. Main sinkhole (pit). Channel is at -8 m of depth.

2.2. Middle watercourse (the "Gran Cañón")

The initial section of the "Gran Cañón" is a collapse area which clearly marks the structural step in the underground watercourse between -8 and -14 m deep. Large potholes of type D/E (Nemec et al. 1982) are preserved in their original position, and hanging potholes, even with lateral tunnels were observed, from -10 m up to the surface height. Also, potholes in isolated blocks were located at heights up to + 4 m. The mapping allows us to indentify up to 3 levels (paleolevels) located outside the main canyon. There are different types of potholes, types C-D (Nemec et al. 1982) and submetric and metric sizes (both in diameter and depth) and types A and B (Nemec et al. 1982) developed over moved blocks.

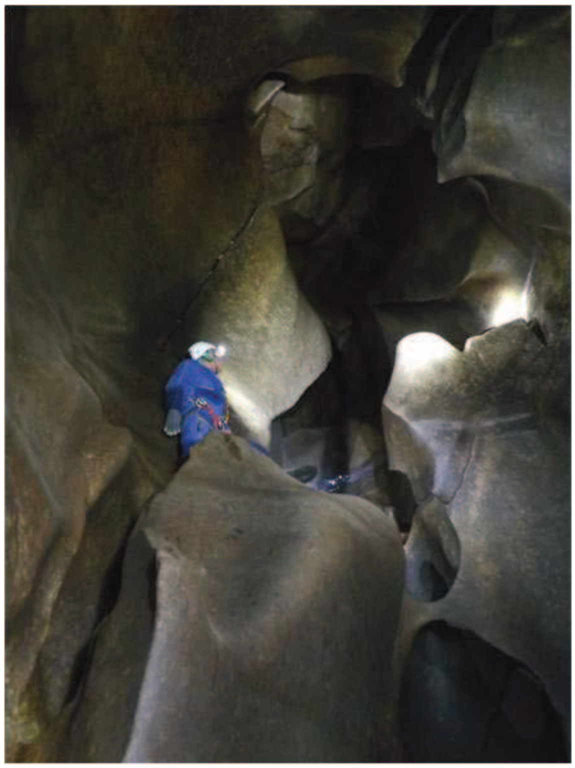

Fig. 3. Marmita F de 11,5 m de altura.
Fig. 3 Pothole type F with 11.5 m high.

The "Gran Cañón" is located between -17 and 21-m deep, with undulating walls, sinuous to small scale due to the coalescence of big potholes of F type. Locally, the potholes go over 11.5 m high reaching fallen blocks that form the roof of the Albarellos System. The intermediate step originates a fall-well. It is partially a pit produced by the collapse of blocks in the entrance room, which allowed the formation of the detritic floor with boulders of decimetric – metric sizes, raising the level of the channel locally. The exit of the well is on a straight sector that ends in a structural fall which we have not still gone beyond (technically), and therefore no underground mapping is available. There are hanging deposits, generally fluvial with heterometric boulders above -6 m. In some high zones, there are deposits of varied granulometry from sand and gravels to mud and organic remains.

2.3. Middle-low course: "Gigantes Sector - Pozo Maravillas"

Though the connection of this section of the cave with the previous one (Gran Cañón) has not been totally mapped. This part of the cave seems to be a continuation of the previous one. The steps of the watercourse in depth are a true reflection in steps of the bottom of the valley on surface. The different erosion forms appear on the external walls, giving continuity to the form, even up to +6 m over the exterior surface.

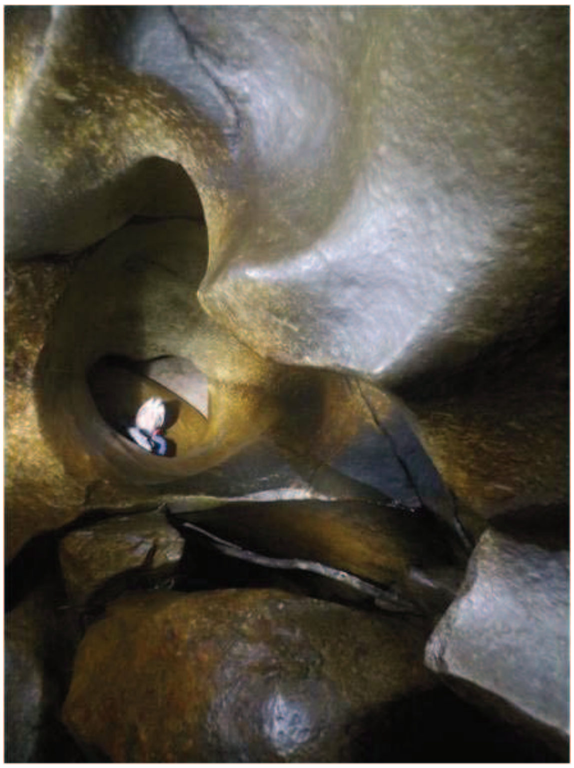

Fig. 4. Pot-hole las "Gigantes", vista desde la base.
Fig. 4. Pothole the "Gigantes" (view from the floor)

The main feature of the "Gigantes" sector is the presence of hanging potholes of large dimensions, mostly flask pothole (type E, Nemex et al. 1982) whose basal widening seems to be associated with a subhorizontal discontinuity. So far, only a part of the channel could be mapped; the existing information is from the upper levels, generally galleries of irregular outline that are between collapsed blocks and are alternated with excavated sections in the rocky substratum with vertical and straight walls. It is a sector of the cave located over the active channel communicated through pits, with rooms over 15 m and 20 m wide and 0.5 and 4m high. The main room of the" Maravillas" sector is "Maravillas Pit", a large pothole of more than 10 m high. The left slope of the canyon presents slides of blocks that caused the break of many potholes and their collapse with the consequent piling of blocks. In spite of the fact that the pothole that form the pit, which is included in the main channel, is not more than 5m of diameter, the head section of the channel is up to 20 m wide. The channel is mainly a succession of straight sections of warped walls when the river is incised in the rocky substratum, alternating with large potholes, some of them hanging of types A and B (Nemec et al. 1982).

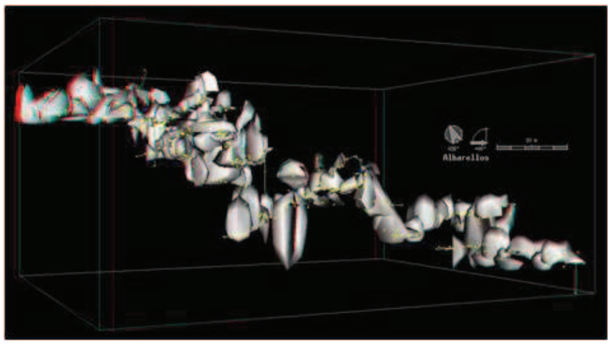

Fig. 5. Maqueta esteresoscópica (rojo-cián) del sistema de Albarellos, sector Gran Cañón.
Fig. 5. Stereoscopic (red-cyan) model of Albarellos system, "Gran Cañón" Sector.

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REFERENCES

Del Hoyo, R. 1979. La presa bóveda de Albarellos. Revista de Obras Públicas. Diciembre 1979, pp. 1061- 1070.

IGME 1981. Puentecaldelas 186 (5-10). Mapa Geológico de España E1:50.000.

Martínez, A., Castillo, F., Pérez, A., Valcárcel, M., Blanco, R. 1999. Atlas climático de Galicia. Norme Editorial, Santiago de Compostela, pp.75.

Nemec, W. Lorenc, M.W. Saavedra, J. 1982. Potholed granite terrace in the Rio Salor valley, western Spain: A study of bedrock erosion by floods. Tecniterrae, 50, 6-21.

Vidal Romaní J.R., Vaqueiro M. Sanjurjo J. 2014. Granite Landforms in Galicia. World Geomorphological Landscapes. Landscapes and Landforms of Spain Ch. 4, Springer Verlag. (ISBN 978-94-017-8627-0)

VV.AA. 2003. Gran Enciclopedia Galega Silverio Cañada. El Progreso-Diario de Pontevedra. Tomo 4, pp. 139-140.