MORPHOLOGIC TYPES OF SPELEOTHEMS IN MAGMATIC ROCK CAVES

Tipos morfológicos de espeleotemas en cuevas de rocas magmáticas.

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Abstract: Since they were described for the first time by Caldcleugh in 1829, 4 criteria have been used: mineralogical that only considers the chemical-mineralogical compositions of the sample; morphologic that assimilates them to the ones belonging to marine (coralloids and marine stromatolites) or continental (terrestrial or superficial stromatolites) environments; sedimentary that assimilates them to their karstic counterparts (stalactites, stalagmites and flowstone) assuming that they are due to water dripping; and biological (biospeleothems) due to their relationship with microorganisms. The classification presented in this paper is based on the morphology and the most influential factors on their formation such as water circulation regime (dripping, capillarity, superficial stress, etc.), association of microorganisms that occupy the magmatic rock caves, and chemical-mineralogical composition of the bedrock.

Palabras clave: espeleotemas, cuevas de rocas magmáticas.
Key words: speleothems, magmatic rock caves.

1. INTRODUCTION

Because of the small dimensions of these speleothems and their inconspicuous aspect, they have been unnoticed during a long time since 1928 when they were described in the scientific literature for the first time. Considering the great complexity to study them due to both their mineralogical features and their interaction with microorganisms, their description and scientific classification were based on different criteria: (1) mineralogic that distinguishes if the speleothem is formed by cryptocrystalline or amorphous minerals being identified by their chemical composition (pigotite, evansite, opal-A). (2) Morphological based on their similarities with marine bioconstructions (coralloids) (Woo et al., 2008) stromatolites or terrestrial stromatolites (Wright 1989). Another criterion was (3) genetic assimilating them to their karstic counterparts which are originated by water dripping from the ceiling (stalactites) (Caldcleugh, 1829) to the bottom of the cave (stalagmites and flowstone). Speleothems of magmatic rock caves are not related to dripping or loss of CO_2 dissolved in water but to the evaporation or the interference with troglobiont microorganisms (biominerals). However, its main features are due to the fact that water circulation is produced at low velocity in slow flows where gravity (the stress responsible for the dripping processes) is not so significant in the formation of speleothems. The geomorphic stress vector is secondary if compared with other stresses: capillary, superficial or water adhesion to the rocky surface.

2. FORMATION OF SPELEOTHEMS IN MAGMATIC ROCK CAVES.

In the systems developed in massifs of magmatic rocks, there is a clear relationship between continuity of rainfalls and dimensions of speleothems. Another circumstance that constrains the formation and development of speleothems in caves of magmatic rock massifs is undoubtedly the low solubility of these rock types in water.

Another constraining factor is that water moves slowly (trickles or seepage). Both factors explain that in a first stage water drags mineral particles which are produced by physical or mechanical weathering of the rock, mainly by moistering – drying. In this stage, speleothems form an agglomerate of angular mineral grains which will evolve toward their final aspect due to successive contributions of water and organic matter as well as the chemical and biological weathering carried out by troglobiont organisms of the environment.

3. CLASSIFICATION OF SPELEOTHEMS

The following types of speleothems are distinguished: cylindrical or planar speleothems (Vidal Romaní et al 2010 a y b).

3.1. Cylindrical speleothems:

3.1.1. Individualized cylindrical speleothems: They are speleothems associated with slow water movement, and thus they may develop independently from gravity on the wall, ceiling or bottom of the cave (Fig. 1). The speleothems grow by capillary circulation of the water from a clast agglomerate mass of grain minerals soaked in water. They are usually thicker (up to 4 mm of diameter) and cylindrical to club-shaped reaching longitudinal developments between 4 and 10 mm.

3.1.2. Grass-shaped speleothems: Numerous associations of very thin cylindrical forms (maximum 1 mm of diameter) are associated with the ceiling, walls or even the bottom of cavities (Fig. 2). These speleothems grow by capillary movements of the water through the clast agglomerate mass of clastic accumulations of angular grains soaked in water. They usually develop gypsum or calcite whiskers on their ends and the sediment matrix is opal-A.

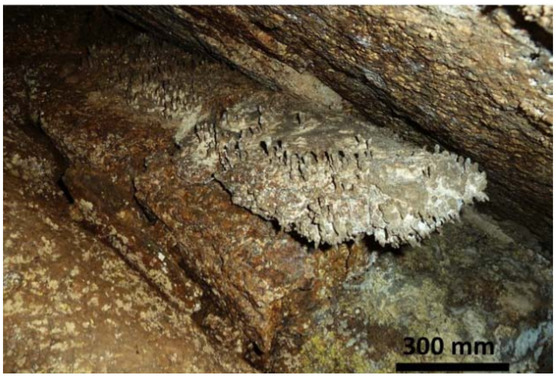

Fig. 1. Espeleotemas cilíndricos típicos de techo, suelo y pared en una arista rocosa. Gruta *Irmã de Fora.* Isla de Santa Catarina, Brasil. Foto cortesía del Grupo Pierre Martin de Espeleologia

Fig. 1. Bottom, ceiling and wall cylindrical speleothems in Gruta Irmã de Fora (Ilha de Santa Catarina, Brazil. Courtesy photo of Grupo Pierre Martin de Espeleologia

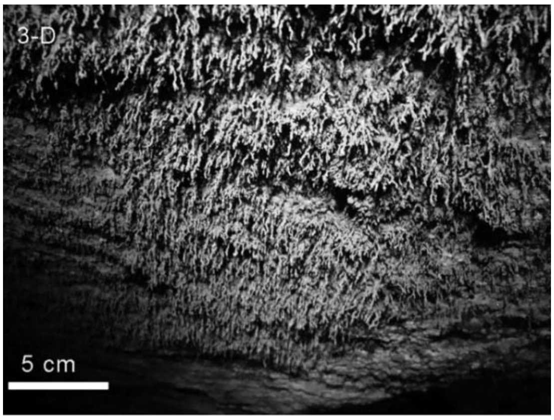

Fig. 2. Espeleotemas cilíndricos en césped resultado de movimientos capilares de agua. Castelo da Furna. Portugal.

Fig. 2. Grass-shaped speleothems grown by capillary movements of water. Castelo da Furna. Portugal.

3.1.3 Stalactites s.s.: They are formed on the upper part of rock fissures (ceiling or eaves of cavities) when the weight of the drop overcomes the superficial stress (then dripping is produced). They usually develop as individual elongated forms and develop gypsum whiskers on their ends.

3.1.4. Stalagmites s.s.: These speleothems are not frequently found in magmatic rock caves. They are formed by the precipitation of the substances dissolved and/or dragged by the water which falls from stalactites s.s. (Fig. 3).

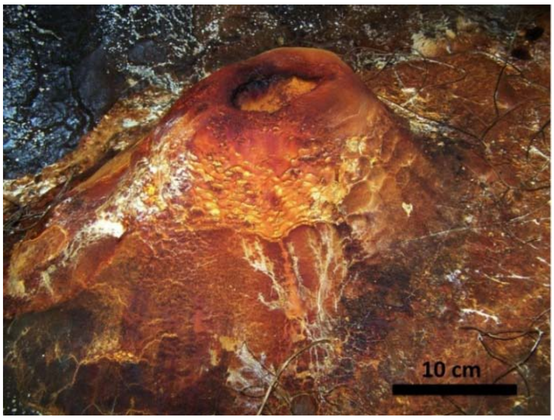

Fig. 3. Estalagmita de pigotita. Cueva Galilleiro. Islas Ons. Galicia. España. Foto cortesía de Espeleoclub Aradelas.
Fig. 3. Pigotite stalagmite. Galilleiro, Ons Island, Galicia, Spain. Courtesy Photo of C.E. Aradelas

3.1.5. Terrestrial microstromatolites: this speleothem has been initially described in caves related to sandstone but not in magmatic rock caves up to now. In magmatic rock caves, are formed by the growth of biofilms of cyanobacteria which live as long as there is humidity in the cave, becoming a mineral organic substratum in dry periods for the new formation of algae in the next humid stage of the cave. Therefore, the longitudinal growth of the speleothem is produced by the development of algae and/or cyanobacteria which act as trap for sediments and water consolidating when water evaporation stops the development process of organisms when they disappear by evaporation. In cross-section, their growth may be seen in rhythmical layers (Fig. 4).

Fig. 4. Microestromatolito terrestre con típica estructura en capas. Trapa. Galicia. España
Fig. 4. Terrestrial microstromatolite with layered accretionary structures. Trapa cave. Galicia. Spain

3.2. Planar speleothems

They are continuous covers of the rocky surface with variable thicknesses and may also hide the rock micro rugosity. They are chaotic accumulations of angular clasts produced first by weathering of the rock along the discontinuity planes (diaclases and fracturation) and then dragged by the water. In the planar speleothems, the water movement may be in small water masses or individualized in drops which adhere to the ceiling, walls or bottom of the cave developing a detailed morphology into microgour fields, which are formed on all types of smooth surfaces or even associated with rocky edges by the edge effect. The key of the sedimentation lies in the slow movement velocity of the water film which does not go beyond the adhesion force of the sand-water slurry and the rocky surface on which it moves (Vidal Romaní et al. 2010)

3.2.1. Features of planar speleothems. Microgour.

They are formed by the successive advance of the water film during the humid phases being marked by lineal accumulations with sinuous development with interference patterns which indicate the way in which the water moved. Depending on the area of the cave in which they are formed (wall, ceiling or floor), they will have a different appearance due to the different velocity of the water. Obviously, the greater velocity is on sloped surfaces.

In these cases, the pattern of the microgour is homogenous though the edges may have a preferential enlargement towards the direction of the individualized water flow (Fig. 5).

The most irregular patterns of microgour fields coincide with speleothems associated with the ceiling of caves (Fig. 6). In such cases, the accumulation of detritic grains has a similar pattern as that of the one of the foam-like textures of the sand grains dragged by waves on the backshore with a characteristic distribution of voids and edges formed by accumulation of sand grains. When the accumulation is very thick (some micra), the water retained in the pores may go outside leaving fungi-like forms which are cemented by the amorphous opal when water evaporates.

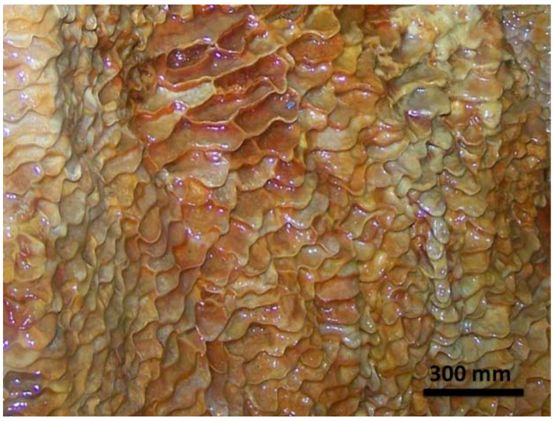

Fig. 5. Microgour de pared de pigotita. Furna da Lameira. Islas Ons. Galicia. España. Foto cortesía de Espeleoclub Aradelas
Fig. 5. Wall pigotite microgours in Furna da Lameira, Ons Island, Galicia, Spain. Courtesy photo of C.E. Aradelas

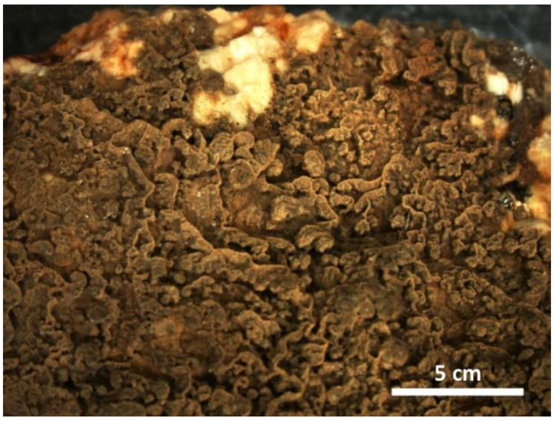

Fig. 6. Microgour de techo. Peña del Hierro. Huelva. España.
Fig. 6. Ceiling microgour. Peña del Hierro. Huelva. Spain.

Fig. 7. Microgour de suelo. Ézaro, Galicia. España.
Fig. 7. Bottom microgour. Ézaro, Galicia, Spain.

Finally, in the flowstone developed on the floor of caves (Fig. 7) the pattern that the microgour fields show is more regular with the regularly spaced sinuous lines depending on the features of the water flow.

4. CONCLUSIONS

The types of speleothems found in the magmatic rock caves are defined by the features of the water flows from which they are formed. Though dripping processes in exceptional cases give rise to some kind of speleothem, gravity has usually a secondary role in the formation of these deposits which are essentially ruled by capillarity, superficial stress and adhesion of the water to rocky surfaces disregarding their slopes. Likewise, the interference of the sedimentary processes with microorganisms that live in these environments are incompatible with too quick water flows, therefore both variables, life and water dynamics, are closely related.

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