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Cave pearls from Almopia Speleopark (Greece): preliminary results

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Cave pearls are speleothems concentrically developed around a nucleus in shallow cave pools (Hill and Forti, 1997). Their name derives from their structure and appearance that commonly resembles pearls produced by mollusks. However, their shape varies greatly from spherical to cylindrical, cubic, hexagonal and disc-shaped. Their size can range from smaller than sand to about 20 cm in diameter and they can grow in few decades. They are commonly composed by calcite. However, the nucleus may be fragments of speleothems, rocks, organic material such as bones, wood etc. In contrast to most speleothems, cave pearls are not cemented on the substrate they are formed due to small occasional vibrations. Their shape, structure and texture is indicative of formation conditions.

In Greece, cave pearls have been studied only in few caves (Dermitzakis et al., 1993). In this study a number of cave pearls have been sampled from the Almopia Speleopark caves (Lazaridis, 2005, 2006) in order to investigate their structure and composition.

Methods

The cave pearls have been divided into categories and the conditions of formation are interpreted according to Table 1.

Electron microprobe analyses were carried out in the Scanning Microscope Laboratory, A.U.Th., using a JEOL JSM-840A Scanning Electron Microscope (SEM) equipped with an Energy Dispersive Spectrometer (EDS) with 20kV accelerating voltage and 0.4mA probe current. Pure Co was used as an optimization element. For SEM observations, the samples were coated with carbon - to an average thickness of 200 A° - using a vacuum evaporator JEOL-4X.

Table 1. Variation in the shape, texture and structure of cave pearls in respect to the corresponding conditions of formation (according to Hill and Forti, 1999 and references therein).

Shape	cubic, hexagonal	round	cementation to the floor	formation of cave cup	random
conditions	restricted precipitate supply, regular packing, calm mode of deposition or precipitation due to water freezing	small size	water pool level below the base	water pool level below the top	nucleus shape
Texture	smooth, polished surface		rough surface		
conditions	rapid water circulation		slow water circulation		
Structure	porosity variation				
conditions	strong water agitation, composition, abnormal rates of precipitation, high temperature				

Results

In total, more than 70 specimens were measured and examined macroscopically. More than 10 specimens were cut in order to examine their internal structure and two were studied in SEM. Their large diameter ranges from about 6.6 to 47.3 mm. According to their shape and texture, they are divided in the following categories.

- Round to irregular shape with smooth to polished surface; cave caps absent, their base may be less polished but smooth with facets due to contact with adjacent cave pearls. Small to intermediate size. Condition: Fast to rapid water circulation, possibly dense packing of cave pearls.
- Oval-shaped with coarse surface covered by coralloids. Intermediate size. Condition: slow water circulation.
- Oval-shaped with smooth to polished surface. Large size. Condition: Rapid water circulation, high water pool level.
- Disc-shaped with smooth to polished surface. Intermediate to large size. Condition: fast water circulation, high water level.
- Disc-shaped with coarse surface and cave cups. Their edge may be irregular. Intermediate to large size. Condition: relatively fast water circulation at early stages of development succeeded by a stage of pool level fluctuations.

Regarding the nucleus of the examined cave pearls it has been found to consist of speleothem fragments, aggregate of fine-grained sediment, tooth fragment or coal. The latter has been found in cave pearls from the Bear Cave, where two samples of coal have been dated with radiocarbon in 4920-4720 B.C. and another in 5220-5050 B.C. (Kambouroglou et

al., 2006).

As far as their structure is concerned, a variation in their porosity related to conditions seen in Table 1 has been noticed. In four out of six rounded to irregular shaped with polished surface pearls, layers of fine-grained clastic sediment are noticed. These layers are separating a more porous cave pearl from a less porous external layer. In three of those the nucleus consists of similar sediment. The other two cave pearls with polished surfaces are more porous close to the nucleus and the clastic sediment is absent. Another two cave pearls with irregular shape and coralloids on their surface have a porous part in their core and more dense external layers. Five disc-shaped specimens are more porous in comparison to the external layers of polished cave pearls. Their porosity varies among layers. The structure of a cave cup in some of them is clearly seen. Apart from the clastic material, only calcium carbonate was found in the layers of the analyzed specimens.

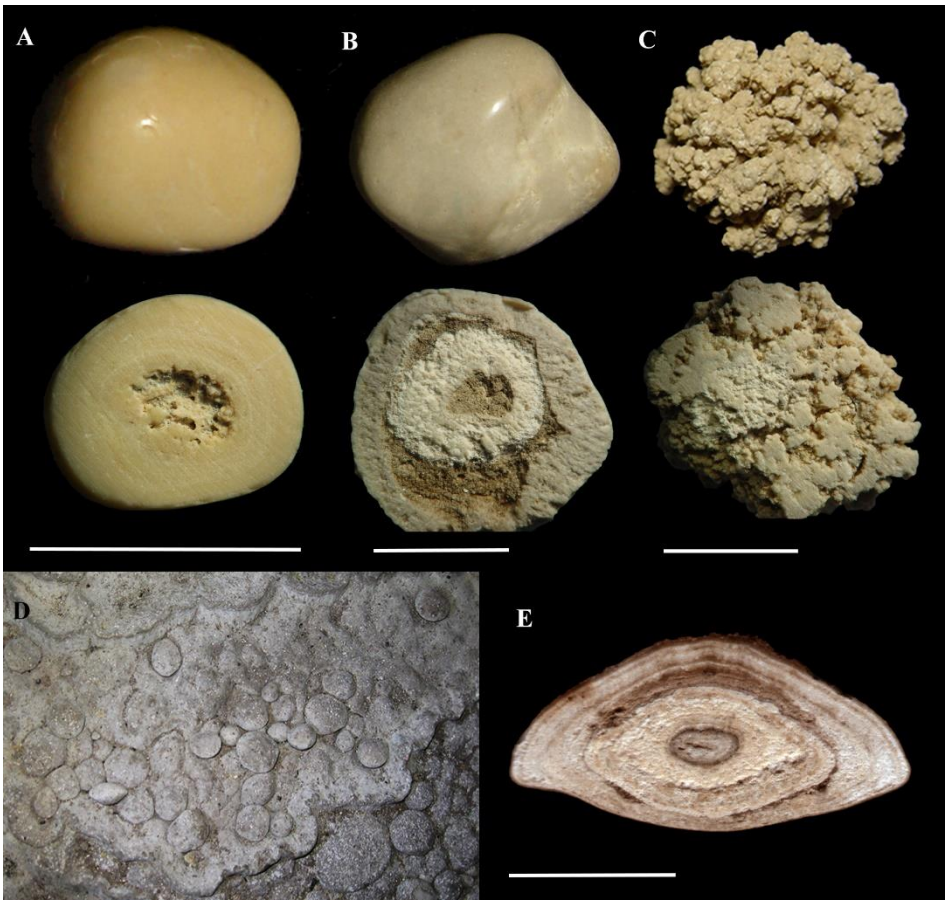

Figure 1. Cave pearls and their cross-sections: A. Almost rounded and polished cave pearl with porous core and probably dissolved nucleus; B. Almost rounded and polished cave pearl with clastic nucleus and one layer that separates internal relatively porous layers and external dense layers; C. Oval-shaped with coarse surface covered by coralloids and a more porous core; D. Disc-shaped cave pearls in situ; E. Longitudinal section of a disc-shaped cave pearl; dark layers on the upper half represent cave caps. Scale bar is 1 cm.

Conclusions

Cave pearls in the Almopia Speleopark caves display a significant variation that depends on the sampling site and the conditions during their development. Despite their differences, specimens from the same chambers are clustered together according to their characteristics, such as shape, texture and structure or by similar nucleus. Based on the cave pearls with coal nucleus, it is estimated that their radius is increased with at least a mean rate of 1.2 mm/1000 years.

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