Geophysical Research Abstracts, Vol. 7, 01160, 2005
SRef-ID: 1607-7962/gra/EGU05-A-01160
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Santa Barbara cave (Sardinia, Italy): some hundred million years of development as recorded in speleothems

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Santa Barbara (Iglesias, Sardinia) is a world renown mine cave system, because it hosts perhaps the best display of barite crystals developed within natural cavities (Forti & Perna, 1981; 1983; Hill & Forti, 1997). The karst system consists of two large subvertical voids (presently not interconnected) developed just in contact with a polysulphide vein in the San Giovanni mine. The caves host huge still active calcite and/or aragonite speleothems partially covering the euhedral barite crystals. Along the vertical shaft connecting the mine gallery with the upper cave a 6 meters thick depositional sequence has been exposed. It consist from bottom (bedrock) to top of: (a) a calcite-aragonite subaqueous speleothem (cave clouds); (b) an earthy layered sediment with sudden colour changes ranging from black to orange; (c) a layer consisting of honey to hazel-brown barite tabular crystals up to 7 cm high and (d) a calcite-aragonite vadose speleothem (flowstone) which represents the still active cave floor.

A few years after the mine intersected the cave in 1952, a study was made on its most interesting mineralogical component, the barite crystals (Rossetti & Zucchini 1957).

Later several authors (Forti & Perna, 1982; Perna, 1983; Bini et al., 1988) discussed the development of the karst system on the basis of morphologic evidences in relationship with the main events that characterized the Iglesias mining district since the

Cambrian age: all authors agreed that the cave should have started its development when the main ore bodies were deposited, therefore Santa Barbara karsts should be among the oldest caves of the world and should have undergone at least 5 speleogenetic cycles.

In 2002 a multidisciplinary research started with the aim to define the speleogenetic history of the karst system by studying in detail the hosted speleothems (De Waele et al., 2004a; 2004b): 4 different drillings were done (2 in the upper and 2 in the lower cave) and the obtained cores were used for different purposes (detailed morphological, mineralogical, petrographical, textural analyses), while the upper part of the speleothems (corresponding to the last and still developing calcite-aragonite speleothems) were also used for luminescence, stable isotope and U/Th analyses to reconstruct the climate and the environmental changes occurred in the cave area in the last 1,000,000 years.

All these studies are still in progress but some important results have already been achieved to detail the speleogenetic history of the system, summarising it as follows:

1- the first stage of development of the karst has been contemporary or even older than the deposition of the ore bodies (Cambrian Ordovician in age);

2- For the first time there is an evidence that the ore bodies were recycled by low thermal fluids when the cavities were already developed as testified by the presence of galena euhedral crystals within the carbonate speleothems;

3- The deposition of barite was not a single event but occurred also before the deposition of the earthy layers;

4- The earthy layers are particularly rich in metallic oxides-hydroxides thus testifying a period of oxidation of the orebodies. Moreover the presence of some rare minerals completely new for the cavern environment (like hetaerolite, hydrohetaerolite, chalcophanite, cesarolite, coronadite, hedyphane) testifies the complexity of the chemistry of the seeping waters as well as the variety of minerogenetic mechanisms active in that period;

5- During this period, for the first time, at least the upper part of the karst system became unsaturated for a short span of time, as testified by the drying cracks filled with calcite boxwork;

6- After the second barite deposition, which occurred in saturate (epiphreatic) conditions, most of the karst system became aerated (only the lower part of the deeper cave was under the piezometric level), allowing the development of gravitational speleothems;

7- the last depositional sequence started after the barite deposition and is still active presently: besides few and short episodes of redissolution, the speleothem growth went on regularly over the last million years or even more as its perfect lamination testifies. The karst base level was placed at +70 m a.s.l. (as testified by the passage from gravitational speleothems (stalactites, flowstones) into epiphreatic ones (cave clouds) at this level in the lower cave;

8- In a very recent time (some thousand years BP) the karst system was partially flooded by clay-silt sediments (Bini et al., 1988) coming from the surface due to a period of fast degradation, which buried the deepest part of the lower cave (Santa Barbara 2), thus causing the stop in the development of the cave clouds and also a partial corrosion of the vadose speleothems up to 30 meters above the mine gallery which intersected this portion of the karst system;

9- Since approximately a century water extraction from the lower levels of the mine transformed the whole karst system into an unsaturated one thus starting the erosion of the mud deposits in Santa Barbara 2;

10- in the early eighties Fabbri & Forti, 1986) a gallery intersected the lower cave (Santa Barbara 2) at +50 m asl: the portion of the cave below this level was filled by waste material before any research could be performed. The water-containing muds that were present in the upper part of the cave partially collapsed andwere eroded, in a second time, by dripping and seeping waters. Presently they are slowly drying up.

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