15th International Congress of the Geological Society of Greece
Athens, 22-24 May, 2019 | Harokopio University of Athens, Greece
Bulletin of the Geological Society of Greece, Sp. Pub. 7 Ext. Abs. GSG2019-159

Volcanic eruption signatures in speleothem archives of Santorini

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Speleothems are useful in detecting past geoenvironmental events and, specifically, variations in their chemical composition on the level of trace elements, constitutes a proxy of volcanic eruptions, enabling both the dating and the assessment of their effects. (Frisia et al., 2005)

Several geochemical studies on speleothems have identified well documented volcanic eruptions in the Mediterranean and the Near East, such as the Minoan eruption of Santorini, the Campanian Ignimbrite eruption, as well eruptions from Nisyros and Etna volcanoes etc. (Fleitmann et al. 2009; Bar-Matthews eta al. 1999; Verheyden et al.2008; Badertscher et al. 2014; Gençalioğlu-Kuşcu et. al, 2018). In the speleothem record, volcanic eruptions are generally identified in the carbonate laminae by sharp spikes in the amount of specific major and trace elements. Typically, high concentrations of S, Br, Bi, Zi, Ba, Mo etc can be indicative of volcanic activity (Frisia et al., 2005; Wynn et al., 2008; Bobrowski et al. 2003; Badertscher et al. 2014).

This study attempts to clarify possible 'signatures' of past volcanic eruptions in speleothems of Santorini. The Santorini volcano has shown significant explosive activity over the last 2 million years, which has not only altered the landscape, but also affected the civilizations of prehistoric and historical ages in east Mediterranean region.

Contrary to mainland, karstic systems in Santorini are poor and limited to the carbonate post- alpine sediments to the south-east. Carbonate rocks are exposed on the Profitis Ilias Mountain and Mesa Vouno mainly. (Heiken and McCoy, 1984). The most important cave is the Zoodochos Pigi, in the southeast part of the island in the vicinity of Ancient Thera. The presence of a permanent spring inside the cave, had been of immense value to the inhabitants of the Archaic city, as testified through the abundance of Archaic inscriptions (Hiller von Gaertringen et al.1904). Despite the poor decoration, speleothems such as flowstone abound in the cave.

During examination of the speleothem deposits in Zoodochos Pigi, we encountered charcoal trapped within the flowstone on a sharp boundary between bioturbated deposits to the bottom and undisturbed CaCO3 precipitation right above it (Fig.1).The unprecedented discovery of charcoal atop a bioturbated horizon shows evidence of sudden cessation of human activity in the cave in far- off times.

In order to explore the nature and the timing of the event, material enveloping the charcoal was submitted for mineralogical and geochemical analysis through optical and electron scanning microscopy (SEM-EDS), as well as XRD analysis, whereas the C-14 dating of the charcoal itself is underway.

Profiling of the chemical composition of the flowstone in the interface of the bioturbated (lower) horizon and the flowstone laminae, yielded several minerals and inclusions, exotic to typical flowstone composition, such as apatite, ilmenite, muscovite, FeS2 and Bi, Zi, Cu, Ni and Zn S, Ba oxides. (Fig.2). The presence of these minerals tails off sharply upwards going over typical (carbonate) flowstone mineralogy with calcite as the main mineral phase. Specifically elements such as Bi, Ba, S, Zi are associated with volcanic eruptions (Bobrowski et al. 2003).

In conclusion, this is the first analysis that has ever disclosed a volcanic eruption in the so far poorly speleothem record of Santorini. Chronological correlation on the basis of radiocarbon dating with the well documented timeline of eruptions of Santorini, as well as assessment of the possible wide - ranging effects on the local-to-regional environment and archaeological record of the said eruption is underway and yet to be announced shortly.

Figure 1. Santo-1 sample.

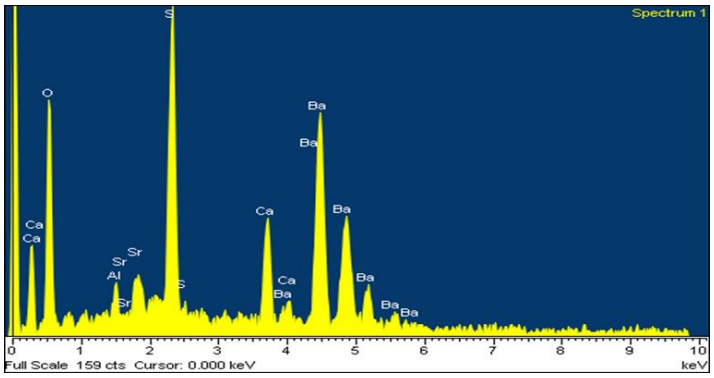

Figure 2. SEM-EDS analysis with high concentrations of S and Ba.

Acknowledgements

Katerina Theodorakopoulou is a post-doctoral fellow of the State Scholarships Foundation (IKY) at the Department of Geology and the Geoenvironment, University of Athens. This study is funded by this post-doctoral fellowship.

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