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Comparison of climate proxies from two "Siamese twin"' stalagmites: Some keys for evaluating paleoclimate reconstructions based on speleothems

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Siamese twin stalagmites are those that grow so close to each other that they develop continuous growth laminae between their apexes. Therefore, the resulting composite stalagmite is deposited by two coeval drips, instead of by a shifting single drip. In polished cross sections, optical correlation of growth layers allows the confident determination of coeval sections in both stalagmites. In these coeval sections, paleoenvironmental proxies should be identical if controlled by paleoclimate. Otherwise the proxies may be influenced by local factors within each drip (the so called "piping effects") or by diagenetic alteration. The study of two Holocene Siamese stalagmites collected in Cueva del Cobre (N Spain) allows a direct calibration of records of growth rates and stable isotopes (C and O), and their suitability for paleoclimate reconstructions.

The composite stalagmite ($\sim$19 cm wide in the base and $\sim$28 cm high) is formed by two cone-shaped Siamese stalagmites with apexes separated $\sim$7 cm from each other. The stalagmites grew in an isolated relict canyon situated $\sim$1 km away from the entrance of the cave, 51 m above the resurgence elevation, and more than 100 m below the ground surface. Both stalagmites appeared to be growing when collected. Present-day temperature in the sampling site remains around 5.5$\pm$0.3ºC and the measured relative humidity is 98$\pm$2%.

The study of 35 thin sections revealed that both stalagmites are composed of columnar calcite with undulose extinction. Growth banding mainly results from variations in the abundance of primary fluid inclusions. Absolute ages of both stalagmites are constrained by ten ICP-MS Th-230 datings. The results further confirm that the Siamese sections grew synchronously for about 5000 years, from $\sim$5400 to $\sim$600 years BP. These dates, integrated with microscopic optical correlation of continuous growth layers using thin sections, allowed us to determine a robust age model. The carbon and oxygen isotopic records are composed of 281 samples drilled along the growth axes of both stalagmites.

According to the proposed age model, the two stalagmites grew at very different rates, despite their proximity and their internal and external resemblance. The differences are very important in both magnitude and trends, suggesting that piping and dripping effects were strong enough to mask any paleoclimate information. On the contrary, the δ^{18}O records of the Siamese sections of the two stalagmites are virtually identical, suggesting that this parameter is independent of stalagmite growth, being mostly controlled by external factors to the dripping system, probably climate variables (e.g., rainfall composition). Finally, important differences were found when comparing the δ^{13}C time-series. These differences concern general patterns and trends, as well as the average values of each series. This could indicate that δ^{13}C is much more influenced by piping effects than δ^{18}O, and thus more difficult to interpret in terms of paleoclimate.

In summary, similar δ^{18}O records have been obtained in both stalagmites, but important differences were found in growth rates and δ^{13}C values. A single record from only one of these stalagmites would have not been representative of the whole environmental system. These results suggest that the paleoclimate interpretations based on growth rates and δ^{13}C records obtained in a single speleothem should be treated with caution.

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