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Seasonal controls on modern speleothem growth and isotope climate records in St. Michaels Cave, Gibraltar.

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Cave sites on the Gibraltar peninsula provide a unique opportunity to calibrate speleothem climate proxies with long instrumental records extending back to 1792. An actively growing speleothem (Gib04a) sampled from New St. Michaels Cave in 2004 is composed of paired laminae consisting of translucent columnar calcite and a darker microsparitic calcite. An isotope time series measured at 100 micron resolution reveals exceptionally well defined δ^{13}C and δ^{18}O cycles that correlate with trace element cycles identified by synchrotron-radiation micro-XRF, as well as hydrological cycles recorded by the paired fabrics.

Monthly monitoring of microclimate, $p\mathrm{CO_2}$, drip rate and drip water chemistry provides compelling evidence that the fabric, isotope and trace element cycles preserved in the speleothem are annual features, and linked to specific seasons in the calendar year. Continuous multichannel logging of cave air $p\mathrm{CO_2}$ shows that cave ventilation, rather than water excess, is the main factor in controlling calcite growth. The dark microsparitic fabric grows from June – October as a result of rapid degassing under low cave air $p\mathrm{CO_2}$, which results in higher degrees of calcite supersaturation and elevated δ^{13}C. The translucent columnar calcite develops after cave air $p\mathrm{CO_2}$ sharply rises in November due to a reversal in chimney ventilation, resulting in slower degassing rates,

lower calcite supersaturation and lower δ^{13}C values. The cause of δ^{18}O cyclicity in speleothem calcite is a result of both annual recharge and evaporation effects but monitoring shows that drip water with lowest δ^{18}O arriving at the Gib04a site in late spring is the best proxy for the isotopic composition of the new season's winter rain.

An age model for the modern speleothem, based on δ^{13}C cycle counting and the position of the ^{14}C bomb carbon spike yields a precisely dated winter oxygen isotope proxy of cave seepage water for comparison with the GNIP and instrumental climate record for Gibraltar from 1951-2004. The δ^{18}O of reconstructed winter drip water shows an encouraging level of correspondence ($r^2 = 0.47$) with the δ^{18}O of October to March rainfall but the climatic components encoded in the reconstructed precipitation time series are conflicting in terms of amount and temperatures effects, and require further analysis. Speleothem isotope records containing a high component of seasonal variation might yield ambiguous climate signals when sampled at low resolution but provide rich opportunities for recovering climatically significant information.