Climate extremes and volcanic eruptions: Trace elements, isotopes and U-series geochronology recorded by a [1]Late Quaternary stalagmite

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Documenting the timing of large volcanic eruptions is critical in climate change research because volcanic gas and ash spreading globally from equatorial eruptions can cause a significant change in global temperatures [*1,2,3,4*]. Cave carbonate deposits provide an unprecedented opportunity to reconstruct climate changes, volcanic eruptions, and recurrence patterns of paleo-seismic events [*5*]. Through high-precision U-series dating and micro-chemical analysis, speleothems are capable of providing tandem records of climate and environmental change, and thus can offer new insights into the complex interplay of seismic, volcanic and hydrological processes.

We investigated a stalagmite sample from a cave in a volcanically active region in Indonesia by a high-resolution micro-sampling, high-precision U-series dating combined with trace element, C, O, and Sr isotope analysis. The stalagmite contains several dark laminas that record major volcanic eruption cycles and/or episodic climatic shifts. A sharp increase in the trace element abundance, which correlates clearly with increasing $\delta^{18}O$ and $\delta^{13}C$ values and a drop in $^{87}Sr/^{86}Sr$ values, is conspicuous in the black layers. Strikingly, the pattern of $^{87}Sr/^{86}Sr$ values of the investigated stalagmite sample parallels their U/Th age spectra. Voluminous CO_2 emission due to phreatic eruptions and/or a sudden turnover to dry climate episodes are interpreted as leading to carbonate growth hiatuses before the precipitations of black layers. More future studies of millimetre to submillimetre-scale geochemical investigations and precise age dating of speleothems from volcanically active regions will provide detailed insight into interplay among volcanic cycles, fluid flow events and climate changes.

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