Impact of the Toba eruption on rainfall – a speleothem record suggests multi-staged eruption affected EASM

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The Toba eruption, marked by the Younger Toba Tuff (YTT), was the largest volcanic event of the Quaternary. Dated to 73.88±0.6 ka BP (2σ), this eruption must have been witnessed by humans globally, even if only through indirect effects of multi-year adverse weather patterns, or atmospheric phenomena. It has been proposed that the YTT acted as trigger or accelerator for Greenland Stadial 20 (GS20). Its global climatic impact is evidenced by data from as far as southwestern USA, Antarctica, and Greenland (Polyak et al. 2017, Svensson et al. 2013). Whether this event also caused a human population bottleneck (Ambrose 2003) remains debated (Petraglia et al. 2007, Ge et al. 2020).

Here we combine stable isotopes with laser ablation based multi-element data to test the impact of the YTT on the East Asian Summer Monsoon using a stalagmite from China. U-series dating indicates that stalagmite XT5 grew between 87±0.3 to 50±0.4 ka BP. Oxygen and carbon isotope ratios show significant changes linked to GS20, with several large positive excursions between 74 and 70 ka BP suggesting severe droughts. The notion of severe drying is supported by the Sr profile. Several spikes in rare earth elements (REE: Y, La, Ce, Nd, Yb) occurred concurrent with δ18O, δ13C, and Sr increases.

The increasing δ13C and δ18O values resulted from reduced effective infiltration linked to a longer-term reorganization of the EASM system. The observed REE dynamics and can be interpreted as indicative of large eruption events. Assigning REE spikes to individual eruptions like the YTT remains ambiguous, but agreement with acidity peaks in ice cores (Svensson et al. 2013) suggests that our REE events tracks eruption history over the interval discussed here. Our δ18O, δ13C, and Sr records suggest repeated EASM weakening and regional-scale rainfall reduction in response to volcanic events indicated by REE peaks. Comparison of the REE and Sr profiles further suggests that drying was initiated or exacerbated by these eruptions.
Our new multi-proxy record supports the hypothesis of repeated tropical eruptions that led to several significant weakening episodes of the EASM. The current data do not answer the question whether the YTT initiated GS20 but support the notion of multi-decadal impacts on regional circulation and rainfall across East Asia.

References:
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