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The underground legacy of permafrost carbon: Speleothems as potential high-resolution archives of the local carbon cycle

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Permafrost, defined as perennially frozen ground, is widespread in high latitude and high altitude regions of the globe. Large amounts of carbon are stored in permafrost as frozen organic matter, which could be decomposed and released into the atmosphere upon thawing. This potential positive feedback to climate change could significantly acerbate the global warming trend, and needs to be better understood. Stalagmite geochemical proxies, such as stable C and O isotope ratios, trace element concentrations, ^{14}C, and $\delta^{234}U$, offer an opportunity to study and quantify changes in soil chemistry and the local carbon cycle in permafrost regions. Compared to other archives of permafrost dynamics, stalagmites can be precisely dated using the U-Th method, allowing the reconstruction of thaw rate and soil processes at high temporal resolution.

Here, we present initial results from a study performed on stalagmites from two sites in Eastern Siberia, Botovskaya and Okhotnichya caves, which record intermittent growth during interglacial time periods over at least the past 500,000 years (Vaks et al., 2013). Growth hiatuses during glacial periods are often marked as 1-2 mm thick brown layers, suggesting substantial deposition of detrital material before, during or immediately after the period of no growth. These layers are characterized by increased organic matter content, as defined from fluorescence analysis, and much higher concentrations of certain trace elements (e.g., U, P, Mn, Cd, Ti, Si). This could be indicative of rapid deposition of large amounts of soil-derived material, for example due to colloidal flushing immediately after permafrost thaw. However, a similar geochemical fingerprint can be expected from concentration of elements and organic compounds on the hiatus surface during periods of reduced or stalled growth, and other proxies are needed to distinguish between these two processes. Clear deviations from a decay or mixing trend are apparent from combined $\delta^{234}U$ and ^{14}C data. This suggests either variable dead carbon contributions or changes in initial $\delta^{234}U$, both of which are potentially testable with a high-resolution U-Th chronology. We discuss the results from this study by taking into account issues related to sampling bias and element concentration due to reduced growth at the hiatus, and evaluate the potential of an inherited soil permafrost signal from the surface.

References cited:

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