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Direct U-Pb age constraints on Arctic speleothem formation and their implications for climate change in deep time

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Carbonate deposits formed in caves (speleothems) are important proxies of past climate, as regional hydrologic changes controlled by surface moisture and temperature directly impact their formation. Speleothems located in permafrost regions, in particular, can preserve records of past interglacial warming periods, as liquid water under thawed ground conditions is required for their growth. Understanding the precise timing of speleothem growth relative to other well-established climate proxies, such as marine oxygen-isotope stages, is crucial to a quantitative evaluation of its sensitivity to warming and any possible time lags between Milankovitch cycles and speleothem growth.

Previous age determinations of speleothems by the U-Th (disequilibrium) technique have greatly enhanced the utility of this chronometer in the Quaternary climate research. However, the relatively short half-lives of the U-series intermediate daughter isotopes place a limit of ca. 600 ka on calcite specimens that can be dated by this method. In this study, we examine the analysis of speleothems from the Canadian Arctic and Sub-arctic regions by the U-Pb ID-TIMS method in order to extend the records of speleothem growth to early Pleistocene and beyond. The samples were selected from a range of latitudes to represent a variety of permafrost conditions. Our preliminary U-Pb geochronologic results range from 416 $\pm$ 12 ka to 7.74 $\pm$ 0.18 Ma. These dates are corrected for initial 234-U and 230-Th disequilibria by direct measurements of their activities, although the magnitude of these corrections becomes less significant with increasing sample age. Our successful analysis of young (<600 ka) speleothems by the U-Pb ID-TIMS method provides an opportunity for intercalibration of the U-Th and U-Pb geochronologic schemes. Interestingly, our highest latitude speleothems from the continuous permafrost zone in Yukon have so far produced consistent dates at ca. 7.7 Ma, older than those from the majority of previous terrestrial Arctic proxy records.