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Rapid response of climatic conditions during the last glacial: evidence from U-series dated Irish speleothems

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Rapid climate change events (Dansgaard-Oeschger and Heinrich events) during the last glacial have been well documented in the Greenland ice cores (e.g. NGRIP), but their impact at lower latitudes is still not fully understood. In Ireland, few climate records older than the Last Glacial Maximum (LGM) exist due to extensive glacial reworking. Exceptions are cave deposits in an environment protected from extensive glacial erosion. Speleothem deposition requires the presence of liquid water implying cave air temperatures above 0ºC. As air temperature in shallow caves (<30m depth) is similar to the mean annual air temperature (MAAT) at the surface; speleothem deposition can only occur in the absence of permafrost or glaciation. In this study, intervals of speleothems deposition in Crag cave, South West Ireland have been determined by U-series-dating to constrain the timing of ice- and permafrost-free conditions prior to the LGM. Here we present evidence for episodic speleothem deposition between the Holocene and the last interglacial. Ninety eight U-Th dates indicate phases of speleothem deposition, interrupted by visible hiatuses e.g. at 131.5 ±0.6; 104.8 ±0.2; 83.9 ±0.3; 71.7 ±0.2; 65.2 ±0.2; 58.9 ±0.3; 47.1 ±0.1; 43.5 ±0.2; 40.0 ±0.1; 38.0 ±0.1; 32.1 ±0.1; 28.8 ±0.1; 27.8 ±0.1; 23.3 ±0.1; 12.5 ±0.2; 11.6 ±0.1; 8.5 ±0.4 ka. These depositional intervals in Crag cave speleothems show an overall synchronicity with Dansgaard-Oeschger (D-O) events recorded in NGRIP. Furthermore, Heinrich events 2, 3, 4, 5 and 6 are characterised by non-deposition. Measured δ18O values in Crag cave speleothems deposited during Marine Isotope Stage (MIS) 5a are similar to the mean value for Holocene speleothems (δ18O = -3.26 ‰ VPDB). A trend to higher δ18O values during the glacial is interpreted to predominantly reflect changes in the ocean source region (ice volume effect). Observed δ13C values down to -10‰ (VPDB) indicate the presence of C3 vegetation above the cave during warmer intervals such as the D-O events. Correlations between δ18O and δ13C in some samples suggest strong kinetic effects. This is particularly evident in calcite deposited prior to the onset of depositional hiatuses, interpreted to reflect gradually decreasing drip rates.