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Timing and structure of Termination II in north China constrained by a precisely dated stalagmite record

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ABSTRACT

The timing and structure of Termination II (T-II) is still debatable as the number of high-quality records is insufficient. This study presents precisely dated stalagmite $\delta^{18}O$ data between 133.4 ± 0.3 to 126.6 ± 0.3 ka BP (covering most of T-II) from north China, near the northern limit of the East Asian summer monsoon (EASM), an area sensitive to climate change. The onset of the last interglacial is constrained at 129.4 ± 0.3 ka BP, consistent with south Chinese speleothem records, further supporting the idea that Northern Hemisphere summer insolation plays an important role in initiating glacial terminations. An extended interval of heavy $\delta^{18}O$ is observed immediately prior to this abrupt transition, named as the "Weak Monsoon Interval" (WMI) in south Chinese cave records, which was associated with the Heinrich Stadial 11 (H11) in the North Atlantic. A significant millennial-scale interstadial peaking at 132.7 ± 0.3 ka BP is identified preceding the weakest phase of the WMI. A synchronous counterpart is also found in some south Chinese speleothem and North Atlantic alkenone Mg/Ca SST records. It is inferred that the main H11 freshwater penetration possibly occurred after 131.5 ka BP, leaving some aspects of ocean and atmospheric circulation still in interstadial mode from 134 to 131.5 ka BP. Following the onset of the last interglacial, there was a millennial-scale "pause" in our $\delta^{18}O$ record, synchronized with a "slowdown" in the rate of decrease in $\delta^{18}O$ in south Chinese cave records. This is possibly a large regional climate oscillation, as it is also identified in some North Atlantic records, but one which is too weak to be a Younger Dryas (YD)-type event.

In summary, compared to south Chinese cave records, significant millennial-scale climate oscillations before and after the synchronous onset of the last interglacial is the main feature of our record. Nevertheless, the sequence of these climate events remains very different from Termination I (T-I), which is possibly ascribed to the stronger insolation, higher atmosphere CO_2, and the resultant faster and greater meltwater pulse to the North Atlantic during T-II than during T-I.

1. Introduction

Investigations of the sequence of climate events surrounding glacial terminations are important to address the issues associated with rapid climate change such as global warming. To uncover the underlying dynamics responsible for the glacial–interglacial transition, the last two deglaciations have been studied using marine records (Grant et al., 2012; Martrat et al., 2014; Tzedakis et al., 2018), Antarctic ice-core records (Petit et al., 1999) and speleothem records (Bar-Matthews et al., 2003; Cheng et al., 2006, 2009; Wang et al., 2008, 2018). Nevertheless, the penultimate deglaciation (Termination II, T-II) is still enigmatic, compared to the extensively studied last deglaciation (Termination I, T-I) as the number of high-quality records is insufficient.

It is undisputed that T-I was abruptly interrupted by a millennial-scale cold spell, the Younger Dryas (YD), a reversal to near-glacial conditions. In contrast, it is unclear whether there was also a YD-type event during T-II. While some records show no evidence of such an extreme climate reversal, a "climate pause" is

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