

# Evidence for Obliquity Forcing of Glacial Termination II

R. N. DRYSDALE, J. C. HELLSTROM, [...], AND I. ISOLA [+7 authors](#) [Authors Info & Affiliations](#)

SCIENCE 13 Aug 2009 Vol 325, Issue 5947 pp. 1527-1531 DOI: 10.1126/science.1170371

495 164

[CHECK ACCESS](#)

## Oblique Reasoning

In Milankovich theory, the canonical theory of glaciation and deglaciation, ice sheets wax and wane in response to the amount of summer insolation at a latitude of 65°N, which is consistent with the observed timing of the last deglaciation. The penultimate glaciation behaved quite differently, however. Now, **Drysdale *et al.*** (p. [1527](#), published online 13 August) offer firmer constraints on the timing of the penultimate deglaciation, by correlating a difficult-to-date marine record of ocean volume to a precisely datable nearby speleothem (terrestrial stalagmite). Ocean volume began to increase about 141,000 years ago, thousands of years before the rise in 65°N summer insolation. Thus, instead of the forcing mechanism proposed by Milankovich, variations in Earth's obliquity may be mostly responsible for the disappearance of ice sheets.

## Abstract

Variations in the intensity of high-latitude Northern Hemisphere summer insolation, driven largely by precession of the equinoxes, are widely thought to control the timing of Late Pleistocene glacial terminations. However, recently it has been suggested that changes in Earth's obliquity may be a more important mechanism. We present a new speleothem-based North Atlantic marine chronology that shows that the penultimate glacial termination (Termination II) commenced  $141,000 \pm 2500$  years before the present, too early to be explained by Northern Hemisphere summer insolation but consistent with changes in Earth's obliquity. Our record reveals that Terminations I and II are separated by three obliquity cycles and that they started at near-identical obliquity phases.

## Get full access to this article

View all available purchase options and get full access to this article.

## Supplementary Material

File (drysdale.som.pdf)

[DOWNLOAD](#)

999.26 KB

## References and Notes

- 1 Shackleton N. J., Opdyke N. D., *Quat. Res.* **3**, 39 (1973).  
[CROSSREF](#) • [GOOGLE SCHOLAR](#)
- 2 Raymo M. E., Nisancioglu K., *Paleoceanography* **18**, 1011 (2003).  
[CROSSREF](#) • [ISI](#) • [GOOGLE SCHOLAR](#)

[SHOW ALL REFERENCES](#)

## eLetters (0)

eLetters is a forum for ongoing peer review. eLetters are not edited, proofread, or indexed, but they are screened. eLetters should provide substantive and scholarly commentary on the article. Embedded figures cannot be submitted, and we discourage the use of figures within eLetters in general. If a figure is essential, please include a link to the figure within the text of the eLetter. Please read our [Terms of Service](#) before submitting an eLetter.

[LOG IN TO SUBMIT A RESPONSE](#)

No eLetters have been published for this article yet.

### Recommended articles from TrendMD

A 550,000-year record of East Asian monsoon rainfall from 10Be in loess

J. Warren Beck et al., *Science*, 2018

Atmospheric Carbon Dioxide Concentration Across the Mid-Pleistocene Transition

Bärbel Hönlisch et al., *Science*, 2009

Persistent influence of obliquity on ice age terminations since the Middle Pleistocene transition

Petra Bajo et al., *Science*, 2020

Pulses of Rapid Ventilation in the North Atlantic Surface Ocean During the Past Century

Ellen R. M. Druffel, *Science*, 1997

Taking the Temperature of Past Ocean Surfaces

Dirk Nürnberg, *Science*, 2000

Historical climate drivers and species' ecological niche in the Beaufort Sea food web

Kristen J Sora et al., *ICES Journal of Marine Science*

Model-based distinct characteristics and mechanisms of orbital-scale precipitation  $\delta^{18}\text{O}$  variations in Asian monsoon and arid regions during late Quaternary

Xiaodong Liu et al., *National Science Review*, 2022

Examining El Niño in the Holocene: implications and challenges

Zhengyao Lu et al., *National Science Review*, 2018

Loss of Foxg1 Impairs the Development of Cortical SST-Interneurons Leading to Abnormal Emotional and Social Behaviors

Dongsheng Chen et al., *Cerebral Cortex*, 2019

The Mid-Pleistocene Transition induced by delayed feedback and bistability

Courtney Quinn et al., *Dynamics and Statistics of the Climate System*, 2018

I consent to the use of Google Analytics and related cookies across the TrendMD network (widget, website, blog). For more information, [see our Privacy Settings and Terms of Use](#).

Yes

No

## CURRENT ISSUE



**Vaccine priming of rare HIV broadly neutralizing antibody precursors in nonhuman primates**

BY JON M. STEICHEN, IVY PHUNG, ET AL.

**mRNA-LNP HIV-1 trimer boosters elicit precursors to broad neutralizing antibodies**

BY ZHENFEI XIE, YING-CING LIN, ET AL.

**Delocalized, asynchronous, closed-loop discovery of organic laser emitters**

BY FELIX STRIETH-KALTHOFF, HAN HAO, ET AL.

**TABLE OF CONTENTS** >

ADVERTISEMENT

**Sign up for ScienceAdviser**

Subscribe to *ScienceAdviser* to get the latest news, commentary, and research, free to your inbox daily.

SUBSCRIBE >

**LATEST NEWS**

NEWS | 17 MAY 2024

**Horses buried alive in medieval funerals came from distant lands**

NEWS | 17 MAY 2024

**Keto diet may cause organ damage, mouse study finds**

SCIENCEINSIDER | 16 MAY 2024

**Researchers reflect on the death of billionaire science donor Jim Simons and his charitable impact**

NEWS | 16 MAY 2024

**News at a glance: Solar storm stuns, COVID-19 vaccine withdrawn, and fossils return to Brazil**

NEWS | 16 MAY 2024

**Tool use keeps these adorable otters out of the dentist's chair**

NEWS FEATURE | 16 MAY 2024

**An inflamed brain can trigger psychosis. The search is on for patients who might be cured**

ADVERTISEMENT

---

## RELATED JOBS

**Henkel Engineering Internships - Fall 2024**

Henkel  
Darien, CT, United States

**Senior Principal Scientist, Lab head - NMR and Mass Spec**

Pfizer  
Groton, Connecticut

**Tenure-Track Position for Assistant Professor in Pharmaceutical Engineering / Drug Delivery**

Nanyang Technological University, Singapore  
Singapore (SG)

[MORE JOBS ►](#)

---

## RECOMMENDED

**REVIEW** | JUNE 2010

**The Last Glacial Termination**

**REPORTS** | SEPTEMBER 2003

**Synchronicity of Tropical and High-Latitude Atlantic Temperatures over the Last Glacial Termination**

**REPORT** | FEBRUARY 2012

**High-Latitude Forcing of the South American Summer Monsoon During the Last Glacial**

**REPORTS** | JANUARY 2001

**Atmospheric CO<sub>2</sub> Concentrations over the Last Glacial Termination**

[View full text](#) | [Download PDF](#)

Science

Science  
Advances

Science  
Immunology

Science  
Robotics

Science  
Signaling

FOLLOW US



GET OUR NEWSLETTER

## NEWS

[All News](#)  
[ScienceInsider](#)  
[News Features](#)  
[Subscribe to News from Science](#)  
[News from Science FAQ](#)  
[About News from Science](#)

## COMMENTARY

[Opinion](#)  
[Analysis](#)  
[Blogs](#)

## AUTHORS & REVIEWERS

[Information for Authors](#)  
[Information for Reviewers](#)

## ADVERTISERS

[Advertising Kits](#)  
[Custom Publishing Info](#)  
[Post a Job](#)

## ABOUT US

[Leadership](#)  
[Work at AAAS](#)  
[Prizes and Awards](#)

## CAREERS

[Careers Articles](#)  
[Find Jobs](#)  
[Employer Hubs](#)

## JOURNALS

[Science](#)  
[Science Advances](#)  
[Science Immunology](#)  
[Science Robotics](#)  
[Science Signaling](#)  
[Science Translational Medicine](#)  
[Science Partner Journals](#)

## LIBRARIANS

[Manage Your Institutional Subscription](#)  
[Library Admin Portal](#)  
[Request a Quote](#)  
[Librarian FAQs](#)

## RELATED SITES

[AAAS.org](#)  
[AAAS Communities](#)  
[EurekAlert!](#)  
[Science in the Classroom](#)

## HELP

[FAQs](#)  
[Access and Subscriptions](#)  
[Order a Single Issue](#)  
[Reprints and Permissions](#)  
[TOC Alerts and RSS Feeds](#)  
[Contact Us](#)

