

Proceedings of the International Ocean Discovery Program

Volume 378

South Pacific Paleogene Climate

Expedition 378 of the R/V *JOIDES Resolution*

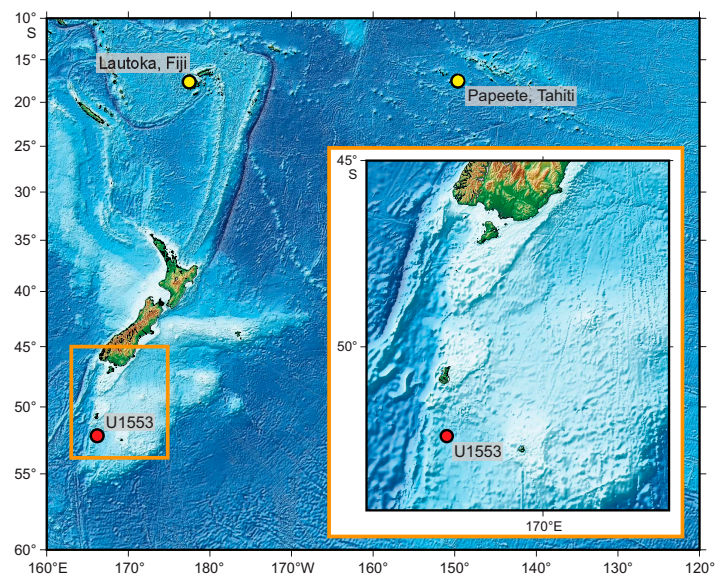
Lautoka, Fiji, to Papeete, Tahiti

Site U1553

3 January–6 February 2020

Volume authorship

Röhl, U., Thomas, D.J., Childress, L.B., and the Expedition 378 Scientists



Publisher's notes

This publication was prepared by the *JOIDES Resolution* Science Operator (JRSO) at Texas A&M University (TAMU) as an account of work performed under the International Ocean Discovery Program (IODP). This material is based upon work supported by the JRSO, which is a major facility funded by the National Science Foundation Cooperative Agreement Number OCE1326927. Funding for IODP is provided by the following international partners:

National Science Foundation (NSF), United States
Ministry of Education, Culture, Sports, Science and Technology (MEXT), Japan
European Consortium for Ocean Research Drilling (ECORD)
Ministry of Science and Technology (MOST), People's Republic of China
Korea Institute of Geoscience and Mineral Resources (KIGAM)
Australia-New Zealand IODP Consortium (ANZIC)
Ministry of Earth Sciences (MoES), India

The JRSO is supported by the NSF. Any opinions, findings, and conclusions or recommendations expressed in this material do not necessarily reflect the views of the NSF, the participating agencies, TAMU, or Texas A&M Research Foundation.

The bulk of the shipboard-collected core data from this expedition is accessible at <http://iodp.tamu.edu/database/index.html>. If you cannot access this site or need additional data, please contact Data Librarian, International Ocean Discovery Program *JOIDES Resolution* Science Operator, Texas A&M University, 1000 Discovery Drive, College Station TX 77845-9547, USA. Tel: (979) 845-8495; Fax: (979) 458-1617; Email: database@iodp.tamu.edu.

A complete set of the logging data collected during the expedition is available at http://mlp.ldeo.columbia.edu/logdb/scientific_ocean_drilling. If you have problems downloading the data, wish to receive additional logging data, or have questions regarding the data, please contact Database Administrator, Borehole Research Group, Lamont-Doherty Earth Observatory of Columbia University, PO Box 1000, 61 Route 9W, Palisades NY 10964, USA. Tel: (845) 365-8343; Fax: (845) 365-3182; Email: logdb@ldeo.columbia.edu.

Supplemental data were provided by the authors and may not conform to IODP publication formats.

JRSO expedition photos are the property of IODP and are public access.

Some core photographs have been tonally enhanced to better illustrate particular features of interest. High-resolution images are available upon request.

Cover photograph shows R/V *JOIDES Resolution* departing Lautoka, Fiji, during Expedition 378. Photo credit: Phil Christie and IODP JRSO.

Copyright

Except where otherwise noted, this work is licensed under the Creative Commons Attribution 4.0 International (CC BY 4.0) license (<https://creativecommons.org/licenses/by/4.0/>). Unrestricted use, distribution, and reproduction are permitted, provided the original author and source are credited.



Examples of how to cite this volume or part of this volume are available at <http://publications.iodp.org/proceedings/378/378title.html#bib>.

ISSN

World Wide Web: 2377-3189

ISBN

978-1-954252-70-7

Volume DOI

<https://doi.org/10.14379/iodp.proc.378.2022>

Publication date

6 February 2022

Contents

Expedition reports

Chapters

[Expedition 378 summary](#)

U. Röhl et al.

[Expedition 378 methods](#)

U. Röhl et al.

[Site U1553](#)

U. Röhl et al.

Core descriptions

Visual core descriptions (VCDs) are presented in PDF files for each site.

[Site U1553](#)

Thin sections and/or smear slides for each site or hole are presented in CSV or PDF format in the CORES directory and in Excel format in DESC_WKB in Supplementary material. The entire set of core images in PDF is available in the IMAGES directory.

Supplementary material

Supplementary material for the Volume 378 expedition reports includes calibration data in SPE format, thin section sampling diagrams in PDF, and DESClogik workbooks in Microsoft Excel format. A full list of directories can be found in SUPP_MAT in the volume zip folder or on the [Supplementary material for Volume 378 expedition reports](#) web page.

Expedition research results

Data reports

Titles are available in [HTML](#).

Syntheses

Titles are available in [HTML](#).

Drilling location maps

A site map showing the drilling locations for this expedition and maps showing the drilling locations of all International Ocean Discovery Program (IODP) expeditions, produced using QGIS (<http://www.qgis.org>), and all Integrated Ocean Drilling Program, Ocean Drilling Program (ODP), and Deep Sea Drilling Project (DSDP) expeditions, produced using Generic Mapping Tools (GMT) of Paul Wessel and Walter H.F. Smith (<https://www.generic-mapping-tools.org>), are available in PDF.

[IODP Expedition 378 site map](#)

[IODP map](#) (Expeditions 349–372, 374–376, 378–383, and 385)

[Integrated Ocean Drilling Program map](#) (Expeditions 301–348)

[ODP map](#) (Legs 100–210)

[DSDP map](#) (Legs 1–96)

Foreword

The International Ocean Discovery Program (IODP) represents the latest incarnation of almost five decades of scientific ocean drilling excellence and is generally accepted as the most successful international collaboration in the history of the Earth sciences. IODP builds seamlessly on the accomplishments of previous phases: the Deep Sea Drilling Project, Ocean Drilling Program, and Integrated Ocean Drilling Program. The 2013–2023 IODP Science Plan (*Illuminating Earth's Past, Present, and Future*) defines four themes and thirteen challenges for this decade of scientific ocean drilling that are both of fundamental importance in understanding how the Earth works and of significant relevance to society as the Earth changes, at least in part in response to anthropogenic forcing. This phase of IODP represents an intense level of international collaboration in bringing diverse drilling platforms and strategies to increasing our understanding of climate and ocean change, the deep biosphere and evolution of ecosystems, connections between Earth's deep processes and surface manifestations, and geologically induced hazards on human timeframes.

The *Proceedings of the International Ocean Discovery Program* presents the scientific and engineering results of IODP drilling projects, expedition by expedition. As in the preceding Integrated Ocean Drilling Program, expeditions in the current IODP phase are conducted by three implementing organizations, each providing a different drilling capability. These are the US Implementing Organization (USIO; through September 2014) and the *JOIDES Resolution* Science Operator (JRSO; as of October 2014), providing the leased commercial vessel *JOIDES Resolution* for riserless drilling operations; JAMSTEC's Institute for Marine-Earth Exploration and Engineering (MarE3), providing the drillship *Chikyu* for riser and occasional riserless operations; and the European Consortium for Ocean Research Drilling (ECORD) Science Operator (ESO), providing "mission-specific" platforms (MSPs) for expeditions that extend the IODP operational range where neither drillship is suitable, for example, in polar environments and in shallow waters. Scheduling decisions for each capability are made by three independent Facility Boards, each of which includes scientists, operators, and platform funding partners: the *JOIDES Resolution* Facility Board (JRFB), *Chikyu* IODP Board (CIB), and ECORD Facility Board (EFB). At the beginning of the current IODP, the three Facility Boards agreed to utilize Publication Services at the USIO and now the JRSO for production of all expedition *Proceedings* volumes and reports.

The current IODP differs from prior scientific ocean drilling programs in that it has neither a central management organization nor commingled funding for program-wide activities. Yet this phase of IODP retains a fundamental integrative structural element: a "bottom-up" evaluation of all proposals for drilling expeditions by a single advisory structure composed of scientists representing all international program partners. International scientists may submit drilling proposals to the Science Support Office; all submitted proposals are then evaluated by a Science Evaluation Panel in the context of the Science Plan.

The current IODP also has an international integrative level for high-level discussion and global consensus-building: the IODP Forum. The Forum is not only charged with assessing program-wide progress toward achieving the current Science Plan, but also with overseeing approaches toward a new bright future of scientific ocean drilling post 2023. At present, IODP involves 22 international funding agencies, including those from the United States, Japan, an Australia/New Zealand consortium (ANZIC), China, India, South Korea, and the fifteen members of ECORD (Austria, Canada, Denmark, Finland, France, Germany, Ireland, Italy, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom). The IODP membership represents an unparalleled level of international scientific collaboration; one of the greatest, and ongoing strengths of scientific ocean drilling.

Henk Brinkhuis
Chair, IODP Forum

International Ocean Discovery Program

JOIDES Resolution Science Operator

Website: <http://iodp.tamu.edu>

IODP JRSO

International Ocean Discovery Program
Texas A&M University
1000 Discovery Drive
College Station TX 77845-9547
USA
Tel: (979) 845-2673; Fax: (979) 845-4857
Email: information@iodp.tamu.edu

IODP JRSO Curation and Laboratories

IODP Gulf Coast Repository (GCR)
Texas A&M University
1000 Discovery Drive
College Station TX 77845-9547
USA
Tel: (979) 845-8490; Fax: (979) 845-1303
Email: curator@iodp.tamu.edu

European Consortium for Ocean Research Drilling, Science Operator (ESO)

Website: <http://www.ecord.org>

IODP ESO Coordinator: Science, Logistics, and Operations

British Geological Survey
The Lyell Centre
Research Avenue South
Edinburgh EH14 4AP
United Kingdom
Tel: (44) 131-667-1000; Fax: (44) 131-668-4140
Email: eso@bgs.ac.uk

IODP ESO Curation and Laboratories

IODP Bremen Core Repository (BCR)
Center for Marine Environmental Sciences (MARUM)
University of Bremen
Leobener Strasse
28359 Bremen
Germany
Tel: (49) 421-218-65560; Fax: (49) 421-218-98-65560
Email: bcr@marum.de

IODP ESO Petrophysics

European Petrophysics Consortium
Department of Geology
University of Leicester
Leicester LE1 7RH
United Kingdom
Tel: (44) 116-252-3611; Fax: (44) 116-252-3918
Email: sjd27@leicester.ac.uk

Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

Website: <http://www.jamstec.go.jp/chikyu/e>

IODP Japan Science Operator

Institute for Marine-Earth Exploration and Engineering (MarE3)
Japan Agency for Marine-Earth Science and Technology
Yokohama Institute for Earth Sciences
3175-25 Showa-machi
Kanazawa-ku, Yokohama
Kanagawa 236-0001
Japan
Tel: (81) 45-778-5643; Fax: (81) 45-778-5704
Email: mare3-exp@jamstec.go.jp

IODP Japan Curation and Laboratories

IODP Kochi Institute for Core Sample Research (KCC)
Japan Agency for Marine-Earth Science and Technology
200 Monobe Otsu
3175-25 Showa-machi
Nankoku City, Kochi 783-8502
Japan
Tel: (81) 88-864-6705; Fax: (81) 88-878-2192
Email: kcc.contact@jamstec.go.jp

Expedition 378 participants*

Expedition 378 scientists

Ursula Röhl

Co-Chief Scientist

MARUM – Center for Marine Environmental Sciences
University of Bremen
Germany
uroehl@marum.de

Deborah J. Thomas

Co-Chief Scientist

College of Geosciences
Texas A&M University
USA
dthomas@ocean.tamu.edu

Laurel B. Childress

Expedition Project Manager/Staff Scientist

International Ocean Discovery Program
Texas A&M University
USA
childress@iodp.tamu.edu

Eleni Anagnostou

Inorganic Geochemist

Ocean Circulation and Climate Dynamics
Helmholtz Center for Ocean Research Kiel
Germany
eanagnostou@geomar.de

Blanca Ausín

Organic Geochemist

Department of Geology
University of Salamanca
Spain
ausin@usal.es

Bruna Borba Dias

Micropaleontologist (benthic foraminifers)

Geochemistry Department
Universidade Federal Fluminense
Brazil
brunaborbadias@id.uff.br

Flavia Boscolo-Galazzo

Micropaleontologist (planktonic foraminifers)

School of Earth and Ocean Sciences
Cardiff University
United Kingdom
boscologalazzo@cardiff.ac.uk

Swaantje Brzelinski

Sedimentologist

Institute of Earth Sciences
Heidelberg University
Germany
swaantje.brzelinski@geow.uni-heidelberg.de

Ann G. Dunlea

Inorganic Geochemist

Marine Chemistry & Geochemistry Department
Woods Hole Oceanographic Institution
USA
adunlea@whoi.edu

Simon C. George

Sedimentologist

Department of Earth and Environmental Sciences
Macquarie University
Australia
Simon.George@mq.edu.au

Laura L. Haynes

Sedimentologist

Institute of Earth, Ocean, and Atmospheric Sciences
Rutgers University
USA
laura.haynes@marine.rutgers.edu

Ingrid L. Hendy

Sedimentologist

Earth and Environmental Sciences
University of Michigan
USA
ihendy@umich.edu

Heather L. Jones

Physical Properties Specialist

Department of Geosciences
Pennsylvania State University
USA
hlj123@psu.edu

Sonal S. Khanolkar

Micropaleontologist (planktonic foraminifers)

Department of Earth Sciences
Indian Institute of Technology Kanpur
India
sonal.k.12@gmail.com

Gabriella D. Kitch

Physical Properties Specialist

Earth and Planetary Sciences
Northwestern University
USA
gabby@earth.northwestern.edu

Hojun Lee

Sedimentologist

Department of Geology
Kangwon National University
Republic of Korea
dlghwns34@kangwon.ac.kr

*Affiliations at time of expedition, except where updated by participants.

Isabella Raffi

Micropaleontologist (nannofossils)

Dipartimento di Ingegneria e Geologia (InGeo)
Università "G. d'Annunzio" di Chieti-Pescara
Italy
isabella.raffi@unich.it

Alex J. Reis

Downhole Measurements/Physical Properties Specialist

Earth and Environmental Sciences
University of Kentucky
USA
alex.reis@uky.edu

Rosie M. Sheward

Micropaleontologist (nannofossils)

Micropaleontology and Paleoceanography Group
Institute of Geosciences
Goethe University Frankfurt
Germany
sheward@em.uni-frankfurt.de

Elizabeth Sibert

Downhole Measurements/Physical Properties Specialist

Earth and Planetary Sciences
Harvard University
USA

Present affiliation (1 July 2020):
Earth and Planetary Sciences
Yale University
USA
elizabeth.sibert@yale.edu

Erika Tanaka

Sedimentologist

School of Engineering
The University of Tokyo
Japan
erika.t@egeo.t.u-tokyo.ac.jp

Shore-based scientist

Anna Joy Drury

Stratigraphic Correlator

Department of Earth Sciences
University College London
United Kingdom
a.j.drury@ucl.ac.uk

Education and outreach

Claire Concannon

Outreach Officer

New Zealand
claire.concannon@otagomuseum.nz

Lindy P. Newman

Outreach Officer

Education Division
USA
newmanl@columbusacademy.org

Roy Wilkens

Stratigraphic Correlator

Hawaii Institute of Geophysics and Planetology
USA
rwilkens@hawaii.edu

Kazutaka Yasukawa

Sedimentologist

School of Engineering
The University of Tokyo
Japan
k-yasukawa@sys.t.u-tokyo.ac.jp

Wei Yuan

Paleomagnetist

School of Ocean and Earth Science
Tongji University
China
yuanwei@tongji.edu.cn

Qiang Zhang

Micropaleontologist (radiolarians)

Key Laboratory of Ocean and Marginal Sea Geology
South China Sea Institute of Oceanology
Chinese Academy of Sciences (CAS)
China
zhangqiang210@scsio.ac.cn

Yang Zhang

Paleomagnetist

Department of Earth and Atmospheric Sciences
Purdue University
USA
zhan2214@purdue.edu

Observer

Christopher J. Hollis

**Observer/Coastal Participant and Micropaleontologist
(radiolarians)**

Paleontology and Environmental Change Section
GNS Science
New Zealand
c.hollis@gns.cri.nz

Yiming Yu

Outreach Officer

Education and Gallery Management Department
Shanghai Natural History Museum
Shanghai Science and Technology Museum
China
yuym@sstm.org.cn

Operational and technical staff

Siem Offshore AS officials

Jacob C. Robinson
Master of the Drilling Vessel

Mark Robinson
Drilling Supervisor

JRSO shipboard personnel and technical representatives

Alejandro Avila Santis
Marine Laboratory Specialist

Susan Boehm
Marine Laboratory Specialist

Lisa Crowder
Laboratory Officer

Aaron de Loach
Assistant Laboratory Officer

Timothy Fulton
Senior Imaging Specialist

Clayton Furman
Logging Engineer (Schlumberger Offshore Services)

Randy Gjesvold
Marine Instrumentation Specialist

Kevin Grigar
Operations Superintendent

Mark Higley
Marine Laboratory Specialist

Michael Hodge
Marine Computer Specialist

Jon Howell
Applications Developer

Rhonda Kappler
Publications Specialist

Nicolette Lawler
Marine Laboratory Specialist

Chang Liu
Marine Laboratory Specialist

Daniel Marone
Marine Laboratory Specialist

Aaron Mechler
Marine Laboratory Specialist

Mike Meiring
Engineer

Beth Novak
Marine Laboratory Specialist

Mackenzie Schoemann
Marine Laboratory Specialist

Catherine Smith
Curatorial Specialist

Steven Thomas
Marine Computer Specialist

Garrick Van Rensburg
Marine Instrumentation Specialist

Hai (James) Zhao
Applications Developer

IODP Publication Services staff*

Corbyn Beach
Graphics Specialist II

Emily Britt
Editor II

Douglas Cummings
Graphics Specialist III

Raleigh Darnell
Production Editor II

Gudelia (“Gigi”) Delgado
Publications Coordinator

Patrick H. Edwards
Supervisor of Production

Willow S. Grosz
Editor II

Jenni Hesse
Editor IV

Rhonda Kappler
Graphics Specialist IV

Ginny Lowe
Reports Coordinator

Amy McWilliams
Supervisor of Editing

Julie Myers
Production Editor IV

Lorri Peters
Manager of Publication Services

Kenneth Sherar
Production Editor IV

Alyssa Stephens
Graphics Specialist IV

Jean Wulfson
Supervisor of Graphics

Ann Yeager
Distribution Specialist

*At time of publication.

Expedition-related bibliography*

Citation data for IODP publications and journal articles in RIS format

IODP publications

Scientific Prospectus

Thomas, D.J., Röhl, U., and Childress, L., 2018. *Expedition 378 Scientific Prospectus: South Pacific Paleogene Climate*. International Ocean Discovery Program. <https://doi.org/10.14379/iodp.sp.378.2018>

Thomas, D.J., Röhl, U., and Childress, L., 2019. *Expedition 378 Scientific Prospectus Addendum: South Pacific Paleogene Climate*. International Ocean Discovery Program. <https://doi.org/10.14379/iodp.sp.378add.2019>

Preliminary Report

Thomas, D.J., Röhl, U., Childress, L.B., and the Expedition 378 Scientists, 2020. *Expedition 378 Preliminary Report: South Pacific Paleogene Climate*. International Ocean Discovery Program. <https://doi.org/10.14379/iodp.pr.378.2020>

Proceedings volume

Röhl, U., Thomas, D.J., Childress, L.B., and the Expedition 378 Scientists, 2022. *South Pacific Paleogene Climate*. Proceedings of the International Ocean Discovery Program, 378: College Station, TX (International Ocean Discovery Program). <https://doi.org/10.14379/iodp.proc.378.2022>

Expedition reports

Röhl, U., Thomas, D.J., Childress, L.B., Anagnostou, E., Ausín, B., Borba Dias, B., Boscolo-Galazzo, F., Brzelinski, S., Dunlea, A.G., George, S.C., Haynes, L.L., Hendy, I.L., Jones, H.L., Khanolkar, S.S., Kitch, G.D., Lee, H., Raffi, I., Reis, A.J., Sheward, R.M., Sibert, E., Tanaka, E., Wilkens, R., Yasukawa, K., Yuan, W., Zhang, Q., Zhang, Y., Drury, A.J., and Hollis, C.J., 2022. Expedition 378 summary. In Röhl, U., Thomas, D.J., Childress, L.B., and the Expedition 378 Scientists, *South Pacific Paleogene Climate*. Proceedings of the International Ocean Discovery Program, 378: College Station, TX (International Ocean Discovery Program). <https://doi.org/10.14379/iodp.proc.378.101.2022>

Röhl, U., Thomas, D.J., Childress, L.B., Anagnostou, E., Ausín, B., Borba Dias, B., Boscolo-Galazzo, F., Brzelinski, S., Dunlea, A.G., George, S.C., Haynes, L.L., Hendy, I.L., Jones, H.L., Khanolkar, S.S., Kitch, G.D., Lee, H., Raffi, I., Reis, A.J., Sheward, R.M., Sibert, E., Tanaka, E., Wilkens, R., Yasukawa, K., Yuan, W., Zhang, Q., Zhang, Y., Drury, A.J., and Hollis, C.J., 2022. Expedition 378 methods. In Röhl, U., Thomas, D.J., Childress, L.B., and the Expedition 378 Scientists, *South Pacific Paleogene Climate*. Proceedings of the International Ocean Discovery Program, 378: College Station, TX (International Ocean Discovery Program). <https://doi.org/10.14379/iodp.proc.378.102.2022>

Röhl, U., Thomas, D.J., Childress, L.B., Anagnostou, E., Ausín, B., Borba Dias, B., Boscolo-Galazzo, F., Brzelinski, S., Dunlea, A.G., George, S.C., Haynes, L.L., Hendy, I.L., Jones, H.L., Khanolkar, S.S., Kitch, G.D., Lee, H., Raffi, I., Reis, A.J., Sheward, R.M., Sibert, E., Tanaka, E., Wilkens, R., Yasukawa, K., Yuan, W., Zhang, Q., Zhang, Y., Drury, A.J., and Hollis, C.J., 2022. Site U1553. In Röhl, U., Thomas, D.J., Childress, L.B., and the Expedition 378 Scientists, *South Pacific Paleogene Climate*. Proceedings of the International Ocean Discovery Program, 378: College Station, TX (International Ocean Discovery Program). <https://doi.org/10.14379/iodp.proc.378.103.2022>

Supplementary material

Röhl, U., Thomas, D.J., Childress, L.B., and the Expedition 378 Scientists, 2022. Supplementary material, <https://doi.org/10.14379/iodp.proc.378supp.2022>. Supplement to Röhl, U., Thomas, D.J., Childress, L.B., and the Expedition 378 Scientists, *South Pacific Paleogene Climate*. Proceedings of the International Ocean Discovery Program, 378: College Station, TX (International Ocean Discovery Program). <https://doi.org/10.14379/iodp.proc.378.2022>

*The Expedition-related bibliography is continually updated online (<http://publications.iodp.org/proceedings/378/378title.html#bib>). Please send updates to PubCrd@iodp.tamu.edu.