Proceedings of the International Ocean Discovery Program

Volume 391

Walvis Ridge Hotspot

Expedition 391 of the R/V JOIDES Resolution
from and to Cape Town, South Africa
Sites U1575–U1578
6 December 2021–5 February 2022

Expedition 397T of the R/V JOIDES Resolution
from Cape Town, South Africa, to Lisbon, Portugal
Sites U1584 and U1585
10 September–11 October 2022

Volume authorship
Sager, W., Hoernle, K., Höfig, T.W., Blum, P., and the Expedition 391 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
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 https://zenodo.org/communities/iodp (see list of available data sets). 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 (database@iodp.tamu.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 pillow lavas and glassy rims, Section 391-U1575A-35R-1 (left), sediment/basement contact, Section 391-U1577A-18R-1 (middle), and massive lava flow, Section 391-U1577A-23R-2 (right). Photo credit: 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/391/391title.html#bib.

ISSN
World Wide Web: 2377-3189

ISBN
978-1-954252-84-4

Volume DOI
https://doi.org/10.14379/iodp.proc.391.2023

Publication date
11 October 2023
Contents

Expedition reports

Chapters

Expedition 391 summary
W. Sager et al.

Expedition 397T summary
W. Sager et al.

Expedition 391 methods
W. Sager et al.

Site U1575
W. Sager et al.

Site U1576
W. Sager et al.

Site U1577
W. Sager et al.

Site U1578
W. Sager et al.

Site U1579
W. Sager et al.

Site U1584
W. Sager et al.

Site U1585
W. Sager et al.

Core descriptions

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

Site U1575: Visual core descriptions · Smear slides · Thin sections
Site U1576: Visual core descriptions · Smear slides · Thin sections
Site U1577: Visual core descriptions · Smear slides · Thin sections
Site U1578: Visual core descriptions · Smear slides · Thin sections
Site U1584: Visual core descriptions · Thin sections
Site U1585: Visual core descriptions · Thin sections

Supplementary material

Supplementary material for the Volume 391 expedition reports includes 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 391 expedition reports web page.

Expedition research results

Data reports

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 391 site map
IODP map
Integrated Ocean Drilling Program map (Expeditions 301–348)
ODP map (Legs 100–210)
DSDP map (Legs 1–96)
Acknowledgments

This research used samples and data provided by the International Ocean Discovery Program (IODP). We are grateful to the IODP Technical Support staff and the R/V JOIDES Resolution crew for their invaluable assistance and dedication during what was a challenging expedition. The resolve of the Technical Support staff was unmatched. Scientific drilling would be impossible without the efforts of many to collect site survey data. We thank the captain, crews, and science/technical teams of the R/Vs *Thomas G. Thompson* (Cruise TN373), *Polarstern, Maria S. Merian* (Cruise ANT23-5), and *Meteor* (Cruise 49-1). The success of the expedition was also enabled by the support of the IODP Science Evaluation Panel and the Environmental Protection and Safety Panel as well as the National Commission on Research, Science and Technology of Namibia and the Namibian Ministry of Environment, Forestry and Tourism. Support for workshops to develop the expedition objectives was provided by the IODP US Science Support Program. Funding for site survey Cruise TN373 was provided by National Science Foundation Grant OCE1832197. For the ANT23-5 cruise, funding was provided by German Research Foundation Grant JO-191/15-1 within the special program “The South Atlantic Margin Processes and Links with Onshore Evolution.” We thank the German Federal Ministry of Education and Research for funding R/V *Sonne* Cruise SO233 to obtain data that helped drill sites. The editorial staff at the IODP *JOIDES Resolution* Science Operator at Texas A&M University is thanked for their help with the publication of this document.
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 15 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 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](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](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 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

**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

**Japan Agency for Marine-Earth Science and Technology (JAMSTEC)**
Website: [http://www.jamstec.go.jp/chikyu/e](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 391 participants*

Expedition 391 scientists

William Sager
Co-Chief Scientist
Earth and Atmospheric Sciences
University of Houston
USA
wwsager@uh.edu

Kaj Hoernle
Co-Chief Scientist
GEOMAR Helmholtz Centre for Ocean Research Kiel
Germany
khoernle@geomar.de

Tobias W. Höfig
Expedition Project Manager/Staff Scientist
International Ocean Discovery Program
Texas A&M University
USA
hoefig@iodp.tamu.edu

Now at:
tobias.hoefig@gmail.com

Aaron J. Avery
Micropaleontologist (nannofossils)
Department of Geology
University of South Florida
USA
aaronavery@usf.edu

Rajneesh Bhutani†
Alteration Petrologist
Department of Earth Sciences
Pondicherry University
India
rbhutani@gmail.com

David M. Buchs
Sedimentologist/Volcanologist
School of Earth and Environmental Sciences
Cardiff University
United Kingdom
buchsd@cardiff.ac.uk

Claire A. Carvallo
Paleomagnetist
Institut de Minéralogie, de Physique des Matériaux et de
Cosmochimie
Sorbonne Université
France
claire.carvallo@sorbonne-universite.fr

Cornelia Class†
Igneous Geochemist
Lamont-Doherty Earth Observatory
Columbia University
USA
class@ldeo.columbia.edu

Yuhao Dai
Inorganic Geochemist
Department of Geology
Lund University
Sweden
yuhao.dai@geol.lu.se

Giacomo Dalla Valle†
Sedimentologist
Institute for Marine Sciences
National Research Council
Italy
giacomo.dalla.valle@bo.ismar.cnr.it

Arianna V. Del Gaudio
Micropaleontologist (foraminifera/nannofossils)
Institute of Earth Sciences
University of Graz
Austria
arianna.del-gaudio@uni-graz.at

Kevin M. Gaastra
Paleomagnetist
Department of Earth, Environmental and Planetary Sciences
Rice University
USA
kmg9@rice.edu

Seunghee Han
Inorganic/Organic Geochemist
School of Earth Sciences and Environmental Engineering
Gwangju Institute of Science and Technology
Republic of Korea
shan@gist.ac.kr

Stephan Homrighausen†
Igneous Geochemist
Dynamics of the Ocean Floor
GEOMAR Helmholtz Centre for Ocean Research Kiel
Germany
shomrighausen@geomar.de

Yusuke Kubota
Igneous Geochemist
Department of Earth and Planetary Sciences
Tokyo Institute of Technology
Japan
kubota.y.al@m.titech.ac.jp

Chun-Feng Li†
Structural Geologist
Ocean College
Zhejiang University
China
cfl@zju.edu.cn

*Affiliations at time of expedition, except where updated by participants.
†Shore-based participant.

https://doi.org/10.14379/iodp.proc.391.2023
Wendy R. Nelson
Igneous Petrologist
Department of Physics, Astronomy & Geosciences
Towson University
USA
wrnelson@towson.edu

Ethan Petrou
Physical Properties Specialist
Department of Earth Sciences
University of Oxford
United Kingdom
Ethan.petrou@univ.ox.ac.uk

Katherine E. Potter
Physical Properties Specialist
Department of Geology
Utah State University
USA
katie.potter@usu.edu

Simone Pujatti†
Physical Properties Specialist
Department of Geoscience
University of Calgary
Canada
pujatti.simone@ucalgary.ca

Jesse Scholpp
Igneous Petrologist
Department of Earth and Planetary Sciences
University of Tennessee
USA
jscholpp@vols.utk.edu

John W. Shervais
Igneous Petrologist
Department of Geology
Utah State University
USA
john.shervais@usu.edu

Sriharsha Thoram
Paleomagnetist
Department of Earth and Atmospheric Sciences
University of Houston
USA
sthoram@uh.edu

Sonia M. Tikoo-Schantz
Paleomagnetist
Department of Geophysics
Stanford University
USA
smtikoo@stanford.edu

Xiao-Jun Wang†
Igneous Geochemist
Department of Geology
Northwest University
China
castorwxj@163.com

Mike Widdowson
Sedimentologist/Volcanologist
School of Environmental Sciences
University of Hull
United Kingdom
m.widdowson@hull.ac.uk

Expedition 391 outreach

Maya Pincus
Outreach Officer
Bushwick Leaders High School
New York City Department of Education
USA
maya.pincus@gmail.com

Expedition 391 observers

Sharmonay Fielding
Physical Properties Specialist
Geology Department
University of Namibia
Namibia
sharmonay97@gmail.com

Mbili Tshiningayamwe
Igneous Petrologist
Geology Department
University of Namibia
Namibia
mtshiningayamwe@unam.na
Expedition 397T scientists

William Sager
Co-Chief Scientist
Earth and Atmospheric Sciences
University of Houston
USA
wwsager@uh.edu

Peter Blum
Expedition Project Manager
International Ocean Discovery Program
Texas A&M University
USA
blum@iodp.tamu.edu

Claire A. Carvallo
Paleomagnetist
Institut de Minéralogie, de Physique des Matériaux et de Cosmochimie
Sorbonne Université
France
claire.carvallo@sorbonne-universite.fr

Daniel Heaton
Igneous Petrologist
College of Earth, Ocean, and Atmospheric Sciences
Oregon State University
USA
daniel.heaton@oregonstate.edu

Wendy R. Nelson
Igneous Petrologist
Department of Physics, Astronomy & Geosciences
Towson University
USA
wrnelson@towson.edu

Mike Widdowson
Sedimentologist/Volcanologist
School of Environmental Sciences
University of Hull
United Kingdom
m.widdowson@hull.ac.uk

Expedition 397T outreach

Maya Pincus
Outreach Officer
Bushwick Leaders High School
New York City Department of Education
USA

Present affiliation (5 December 2022):
Lamont-Doherty Earth Observatory
Columbia University
USA
maya.pincus@gmail.com

Expedition 397T observer

Mbili Tshiningayamwe
Igneous Petrologist
Geology Department
University of Namibia
Namibia
mtshiningayamwe@unam.na
Operational and technical staff

Siem Offshore AS officials

Expedition 391

Jacob C. Robinson
Master of the Drilling Vessel

Mark Robinson
Drilling Supervisor

Expedition 397T

Harm Cornelis Theodoor Nienhuis
Master of the Drilling Vessel

Curtis Wayne Lambert Jr.
Drilling Supervisor

JRSO shipboard personnel and technical representatives

Expedition 391

Alejandro Avila Santis
Marine Laboratory Specialist

Myriam Kars
Marine Laboratory Specialist

Susan Boehm
Marine Laboratory Specialist

Carel Lewis
Curatorial Specialist

Emily Britt
Marine Laboratory Specialist

Daniel Marone
Assistant Laboratory Officer

Lisa Crowder
Laboratory Officer

Aaron Mechler
Marine Laboratory Specialist

Douglas Cummings
Publications Specialist

Stephen Midgley
Operations Superintendent

Clayton Furman
Schlumberger Engineer

Beth Novak
Assistant Laboratory Officer

Fabricio Ferreira
Marine Laboratory Specialist

Brian Swilley
Marine Laboratory Specialist

Randy Gjesvold
Marine Instrumentation Specialist

Steven Thomas
Marine Laboratory Specialist

Sandra Herrmann
Imaging Specialist

Chris Visser
Marine Instrumentation Specialist

Mark Higley
Marine Laboratory Specialist

Hai (James) Zhao
Applications Developer

Michael Hodge
Marine Computer Specialist

Expedition 397T

James Brattin
Applications Developer

Andrew Howard
Engineer

Michael Cannon
Marine Computer Specialist

David Kratz
Marine Computer Specialist

Oscar Cavazos
Marine Laboratory Specialist

Nicholas Logan
Marine Computer Specialist

Bridgette Cervera
Marine Laboratory Specialist

Brittany Martinez
Curatorial Specialist

Etienne Claassen
Marine Instrumentation Specialist

William Mills
Laboratory Officer

Kirby Garrett
Schlumberger Engineer

Eric Moortgat
Assistant Laboratory Officer

Luan Heywood
Marine Laboratory Specialist

Algie Morgan
Applications Developer

https://doi.org/10.14379/iodp.proc.391.2023
Chieh Peng
Assistant Laboratory Officer

William Rhinehart
Operations Superintendent

Alexander Roth
Marine Laboratory Specialist

Brittany Stockmaster
Marine Laboratory Specialist

Kara Vadman
Marine Laboratory Specialist

John Van Hyfte
Engineer

IODP Publication Services staff*

Molly Blaisdell
Production Editor II

Douglas Cummings
Graphics Specialist III

Raleigh Darnell
Production Editor II

Sharon L. Dunn
Editor II

Keith Dupuis
Graphics Specialist II

Anthony Eason
Graphics Specialist II

Patrick H. Edwards
Supervisor of Production

Willow S. Grosz
Editor III

Jennifer Hertzberg
DAM Administrator

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

* At time of publication.


Supplementary material