

# Proceedings of the International Ocean Discovery Program

## Volume 402

### Tyrrhenian Continent–Ocean Transition

Expedition 402 of the R/V *JOIDES Resolution*

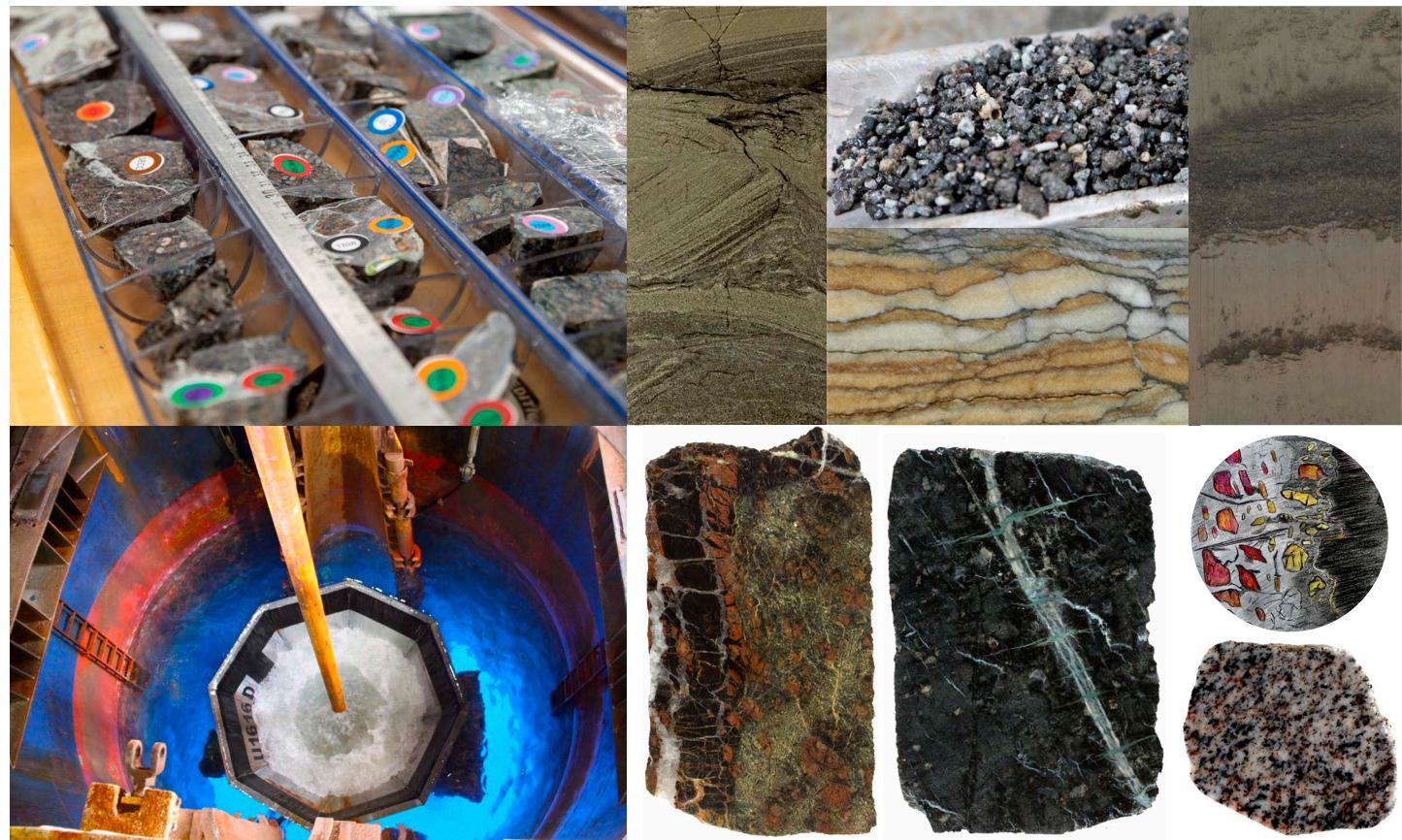
from and to Napoli, Italy

Sites U1612–U1617

9 February–8 April 2024

#### Volume authorship

Zitellini, N., Malinverno, A., Estes, E.R., and the Expedition 402 Scientists



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The bulk of the shipboard-collected core data from this expedition is accessible at <https://zenodo.org/comunities/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](mailto: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](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 ([logdb@ldeo.columbia.edu](mailto: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 photographs show notable events from the cruise, including basement samples flagged for personal sampling with colorful stickers (top left: Tiffany Liao, IODP JRSO) and the deployment of the reentry cone and casing system at Site U1616 (bottom left: Kevin Grigar, IODP JRSO), as well as lithologies and structures encountered in the sediment and basement of Expedition 402 sites. Top right, clockwise from left: finely laminated sediment at Site U1614 (IODP JRSO), volcaniclastic gravel recovered in the core catcher at Site U1615 (Tiffany Liao, IODP JRSO), turbidite and tephra deposits at Site U1616, and evaporite deposits from U1617 (IODP JRSO). Bottom right: veined harzburgite and lherzolite from Site U1614 (IODP JRSO), a color pencil sketch of a serpentinized lherzolite in thin section (Eirini Poulaki, IODP JRSO), and granite from Site U1612 (IODP JRSO).

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### Core descriptions

Visual core descriptions (VCDs) are presented in PDF files for each site. Thin sections, smear slides, and/or tabular core description information for each site or hole are presented in tab-separated value (TSV) format or PDF in the CORES directory. The entire set of core images in PDF is available in the IMAGES directory.

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### Supplementary material

Supplementary material for the Volume 402 expedition reports includes moisture and density and structural data 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 402 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 402 site map](#)

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## Dedication

### Maria Bianca Cita (1924–2024)

We dedicate this volume to Maria Bianca Cita (MBC), a trailblazer in the geological sciences. She received her geology degree at the University of Milano in 1946, completing her studies during World War II. MBC's commitment and grit were clear from the beginning: in 1944, she traveled by bicycle with her sister for about 90 miles from a village on Lake Garda to Milano to attend to her university studies. War was raging at the time, and British planes regularly attacked boats on the lake. After completing her degree, MBC decided to carry out by herself a detailed geologic survey of the Italian valley that borders the Mont Blanc massif. The publication she wrote (Cita, 1953) resulted in her eventual appointment as a professor of geology at the University of Milano, where she remained for the rest of her career. MBC then became an expert in the emerging field of micropaleontology, the study of microscopic fossils used to date sediments and reconstruct environmental conditions in the geologic past.

MBC's excellence in stratigraphy led to an important connection with scientific ocean drilling. At a time when women were rarely allowed on seagoing expeditions, MBC was one of the first two women to participate in the second cruise (Leg 2, 1968) of the Deep Sea Drilling Project (DSDP) on the drilling vessel (D/V) *Glomar Challenger*. Leg 2 drilled a transect of five sites across the Atlantic, and MBC's expertise was critical to dating the oldest sediments and providing key evidence to support the fledgling theory of plate tectonics. Her participation in another DSDP expedition (Leg 13, 1970) led to the fundamental discovery of a vast deposit of evaporites buried under the bottom of the Mediterranean Basin. Together with William B.F. Ryan and Kenneth J. Hsü, MBC put forward the innovative theory of the desiccation of the Mediterranean about 5.5 million years ago (Hsü et al., 1973). She continued her association with DSDP by sailing on Leg 42A in the Mediterranean and Leg 47A on the Atlantic margin of Northwest Africa. MBC's achievements in marine geology included diving in the Human Occupied Vessel (HOV) *Alvin* in canyons offshore New England and on the Bahama escarpment, organizing a number of seagoing expeditions on Italian ships, and contributing to the establishment of a European consortium to participate in international scientific ocean drilling. She authored over 300 publications over a span of almost seventy years and received numerous awards, including the Feltrinelli Prize of the Accademia Nazionale dei Lincei (of which she became a member) and the Francis P. Shepard Medal for Marine Geology from the Society for Sedimentary Geology (SEPM), and was named an Honorary Fellow of the Geological Society of America.

Last but not least, with her combination of intellectual curiosity, scientific rigor, passion, and determination, MBC was an extraordinary teacher and source of inspiration for generations of students to whom she gave exceptional opportunities for professional development. One of them, a Co-chief of International Ocean Discovery Program (IODP) Expedition 402 (A. Malinverno), wishes to offer his deepest thanks to MBC on behalf of all the students who grew under her stellar example. Grazie, Maria Bianca.

Cita, M.B., 1953, Studi geologici sulla Val Ferret italiana (Alta Val d'Aosta). *Boll. Servizio Geol. d'Italia*, 65, 66–172.  
Hsü, K.J., Cita, M.B., and Ryan, W.B.F., 1973. The origin of the Mediterranean evaporites. In Ryan, W.B.F., Hsü, K.J., et al. *Initial Reports of the Deep Sea Drilling Project*. 13: Washington, DC (US Government Printing Office), 1203–1231. <https://doi.org/10.2973/dsdp.proc.13.143.1973>

Photo credit: Scripps Institution of Oceanography Deep Sea Drilling Project Records, 1961–1987.  
<https://library.ucsd.edu/dc/object/bb3721209v>



Maria Bianca Cita during DSDP Leg 2, 1968.

## Acknowledgments

We would like to thank the International Ocean Discovery Program (IODP), the IODP Technical Support staff, and the research vessel (R/V) *JOIDES Resolution* crew for the successful execution of this challenging expedition. We are very grateful to the copropONENTS of the Tyrrhenian Magmatism and Mantle Exhumation (TIME) proposal. In particular, Cesar Ranero contributed a wealth of seismic data that were essential to the success of the project. We thank the Italian Hydrographic Institute of the Navy, the Italian Ministry of Foreign Affairs, and the Italian Ministry of Universities and Research for their support.

This project would not have been possible without the contributions of so many researchers who have preceded us in the study of the Tyrrhenian Sea. Among them we express our deep gratitude to William B.F. Ryan, Maria Bianca Cita, and Augusto Fabbri.

## 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 scientific collaboration; one of the greatest and ongoing strengths of scientific ocean drilling.

Henk Brinkhuis  
Chair, IODP Forum

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## IODP publications

### Scientific Prospectus

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### Preliminary Report

Malinverno, A., Zitellini, N., and Estes, E.R., 2024. Expedition 402 Preliminary Report: Tyrrhenian Continent–Ocean Transition. International Ocean Discovery Program. <https://doi.org/10.14379/iodp.pr.402.2024>

### Proceedings volume

Zitellini, N., Malinverno, A., Estes, E.R., and the Expedition 402 Scientists, 2025. Tyrrhenian Continent–Ocean Transition. Proceedings of the International Ocean Discovery Program, 402: College Station, TX (International Ocean Discovery Program). <https://doi.org/10.14379/iodp.proc.402.2025>

### Expedition reports

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## Site map

