Introduction: Expedition 382 and a Brief History of Scientific Ocean Drilling
ICEBERG ALLEY AND
SUBANTARCTIC ICE
AND OCEAN
DYNAMICS

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http://publications.iiodp.org/scientific_prospectus/382/

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Punta Arenas, Chile to Punta Arenas, Chile
• Polar researchers predict that global sea level will rise about one meter (around 3.2 feet) by 2100. Much of this rise will be due to melting of the Antarctic Ice Sheet, the massive layer of ice, on average 1.3 miles thick, that covers the vast continent of Antarctica. But how much will sea level rise and how fast?

• Icebergs break, or “calve,” off the edges or margins of the Antarctic Ice Sheet. Most travel counterclockwise around the Antarctic coast and converge in the Weddell Sea. From here, they drift northward through “Iceberg Alley” into the warmer waters of the Antarctic Circumpolar Current, which races clockwise around Antarctica.

• Stephanie and Lee will provide more info about the cruise.
Selected News Stories

• https://blogs.ei.columbia.edu/2019/03/25/icebergs-antarctica-climate-change/

• Science News: Antarctica’s iceberg graveyard could reveal the ice sheet’s future

As icebergs melt in these warmer waters, the dust, dirt, and rocks they carry—known as “iceberg rafted debris”—fall down through the ocean and are deposited as sediment on the seafloor. The JOIDES Resolution can drill hundreds of meters into this sediment and retrieve long cylinders of mud called cores. These sediment cores will provide a nearly continuous history of changes in melting of the Antarctic Ice Sheet.

Diagram showing drill sites in the Drake Passage near the Antarctic Peninsula, as well as an insert map of Antarctica showing a counter clockwise circulation of icebergs around the continent.

Figure modified from Weber et al. (2014).

Analyzing the iceberg rafted debris can tell us when the ice sheet calved icebergs and even which part of Antarctica they came from. At times when more debris was deposited, we know the ice sheet was less stable. Much shorter cores previously collected at our drilling sites reveal high sedimentation rates, allowing us to observe climatic and ice sheet changes on timescales ranging from just tens to hundreds of years.

Scientists have discovered that episodes of massive iceberg discharge can happen abruptly, within decades. This has huge implications for how the Antarctic Ice Sheet may behave in the future.

We will also explore how ocean currents, sea ice, and atmospheric conditions in the past are related to changes in melting of the Antarctic Ice Sheet. As we collect cores to the north and the south of the Drake Passage, the narrow waters between Antarctica and the tip of South America, we will be able to see how the Antarctic Circumpolar Current has changed over time. Our northern drilling sites will additionally tell us about another historically important ice sheet: the Patagonia Ice Sheet.
How Did We Get to this Point?
Piston Coring began in the 1940s

- The Swedish R/V “Albatross” went around the world in the 1940s to collect the first cores with this method.

Doc Ewing began collecting cores on the WHOI R/V “Atlantis” in 1947 (before founding of Lamont)
Another Type of Corer

Gravity corers

End of the deployment cable is attached to top of main body and lowered as fast as possible when approaching the bottom to allow gravity and inertia to drive the corer barrel into the sediment

https://www.mooringsystems.com/sediment.htm
Going Deeper:
Project Mohole (1958 – 1966)

• Goal: Retrieve a sample of mantle rock by drilling through the Moho
• Suggested in 1957 (IGY) by Walter Munk
• First organized by American Miscellaneous Society
• Ocean community’s response to the space program

• CUSS I began drilling in 1961

http://www.nas.edu/history/mohole/mohole_gallery.html

• Glomar Challenger  
  • Built by Glomar Marine  
  • Named in honor of “HMS Challenger” (1872 – 1876)  
  • Launched in 1968  
  • Leg 2 discovered salt domes in Gulf of Mexico (major oil fields)

http://www.iodp.tamu.edu/publicinfo/glomar_challenger.html
Leg 3 (1968) – Confirmation of “Continental Drift”

• 17 holes at 10 sites across Mid-Atlantic Ridge between South America and Africa
  • Provided definitive evidence that ocean floor was not all the same age

• Youngest seafloor near rift valley, symmetrically older on either side

• Oceans much younger than continents
Nannofossils Reveal Seafloor Spreading Truth

Summary

Students interpret data from an early leg of the scientific ocean drilling program to determine how scientists solidified their understanding of seafloor spreading.

Background

The goal of the Deep Sea Drilling Project (DSDP) was to investigate the sediments and rocks beneath the deep oceans by drilling and coring. The data featured in this exercise were taken from cores collected by the Glomar Challenger drill ship, at seven sites east and west of the Mid-Atlantic Ridge during DSDP Leg 3, in late 1968 (see Figure 2). The holes were drilled in the South Atlantic between Rio de Janeiro, Brazil and Dakar, Senegal. The age of the contact between the sediment and the basalt of the ocean floor was determined by identifying the nannofossils found at each contact.

Objectives

Learning students will be able to:
• Analyze real data collected from the Deep Sea Drilling Project to discover evidence of seafloor spreading.
• Graph and use slope analysis to determine the relationship between distance from the spreading center and age of the sediments.

National Science Education Standards

A. Science as Inquiry
B. Earth and Space Science
C. Science as Technology

Ocean Literacy Principles

1. The Earth has one big ocean with many features.
2. The ocean and life in the ocean shape the features of the Earth.
3. The ocean is largely unexplored.

Target Grade: 5-8
Time: One class period

Vocabulary
basement rock, nannofossil, core sample, ocean sediment, Deep Sea Drilling Program

Materials
1. Graph Paper
2. Pencil

Methods

1. Using data from Table 1 (from DSDP Initial Reports, Vol. 3), plot coordinates representing the age and distance from the ridge at each site. For time values, use the column labeled Paleontological Age of Sediment (in millions of years). For distance use the column labeled Distance from Ridge Axis. Choose a scale that allows you to plot distance on the Y-axis and age on the X-axis. Label each coordinate with the site number.
2. Locate the position of the core samples relative to the Mid-Atlantic Ridge by looking at Figure 2 (also from Initial Reports of DSDP, Volume 3). (Hint: they are not in order.)

Analysis

(Answer these questions on your own paper.)

1. These DSDP Leg 3 observations were the ground truth needed to test the seafloor spreading hypothesis. Where are the youngest samples? Where are the oldest samples? What do you think might have caused this relationship? Does this relationship support the

2. Calculate the rate of seafloor spreading west of the Mid-Atlantic Ridge in km/My, then convert your answer to cm/My. Be sure to show your work!

3. Calculate the rate of seafloor spreading east of the Mid-Atlantic Ridge in km/My, then convert your answer to cm/My. Don’t forget to show your work!
DSDP Highlights

Total distance penetrated below the seafloor: 325,548 meters
Total core recovered and stored: 97,056 meters
Number of cores recovered: 19,119
Number of sites investigated: 624
Number of expeditions completed: 96
Deepest penetration beneath the ocean floor: 1,741 meters
Maximum penetration into basaltic crust: 1,080 meters
Deepest water (Leg 60 Site 461A): 7,044 meters
Total distance traveled: 375,632 nautical miles

http://www.deepseadrilling.org/about.htm
LDEO Contributions to Coring

• Doc Ewing took cores aboard “Atlantis” (WHOI, 1947)
• Developed directive for “A Core A Day” aboard “Vema,” “Robert C. Conrad,” and other ships
• Housed in L-D Core Repository

http://www.ldeo.columbia.edu/core-repository/facilities
The LDEO Core Repository
https://www.ldeo.columbia.edu/core-repository

- archive of sediment (some terrestrial), rocks and coral from beneath the ocean floor, and

- archive of the digital data pertaining to the material.

- They are used for research in climate, environment, many other studies, and for education.
Lamont’s Ship History

- “Vema” (1953 – 1981)

http://www.ldeo.columbia.edu/research/office-of-marine-operations/history
Other LDEO Research Vessels

• “Eltanin” (1962 – 1975)

• “Maurice Ewing” (1988 – 2005)

Current Vessel “Marcus Langseth”

- Unique seismic capability allows both 2D and 3D maps of the structure miles below the seafloor
- Other capabilities:
  -- collection of sediment cores for understanding climate variations
  -- sampling seawater for determining physical and chemical properties of the oceans
  -- deploying remotely operated vehicles (ROVs) for studying submarine volcanoes

- Part of University-National Oceanographic Laboratory System
- National seismic research facility for the United States academic research community.
LDEO Core Repository

• Core Archives

Instrument Labs
• MST/XRF Lab
  GeoTek multisensor track
• Itrax Corescanner
• Sediment Lab

Orange-peel grab and dredge net

https://www.ldeo.columbia.edu/core-repository/facilities
https://www.ngdc.noaa.gov/geosamples/index.jsp?inst=LDEO
Ocean Drilling Program (ODP)
1985 - 2005
Legs 100 - 210
http://www.odplegacy.org/
Integrated Ocean Drilling Program (IODP) 2003 - 2013

http://www.iodp.org/expeditions/completed-integrated-ocean-drilling-program-expeditions

Expedition 301 First Teacher at Sea
Dr. Jonathan Rice
http://iodp.ldeo.columbia.edu/EDU/TAS/301/
R/V Chikyu

JAMSTEC
Japan Agency for Marine-Earth Science and Technology
http://www.jamstec.go.jp/e/

• JAMSTEC For Kids
  http://www.jamstec.go.jp/e/kids/
ECORD  http://www.ecord.org/

unraveling Earth's history beneath the ocean floor

The European Consortium for Ocean Research Drilling
unites 15 countries and provides mission-specific platforms for IODP expeditions

Next MSP Expeditions
from 2018 to 2020
International Ocean Discovery Program – Began Oct 2013

• [https://iodp.tamu.edu/](https://iodp.tamu.edu/)
FOR EDUCATORS

The Education and Outreach Department is part of the United States Science Support Program (USSSP) for the International Ocean Discovery Program (IODP) at the Lamont Doherty Earth Observatory. Our mission is to raise awareness about ocean drilling science and its central role in our understanding of the Earth’s past, present and future, teach science content and process, and inspire careers in science, technology, engineering and math. Our approach includes use of authentic data, inquiry-centered activities and interdisciplinary explorations drawing from the adventures of the JOIDES Resolution ship and the earlier ocean drilling ship, the Glomar Challenger.

MATERIALS AND RESOURCES

Teaching Kits and Cores
Pencils, Posters, and More
Classroom Activities
CLASSROOM ACTIVITIES

Search the database of more than 60 downloadable activities, posters, and resources for educators. All activities shown by default. To search our database of lessons, hover your mouse over the Activity Type, Topics Covered, or Grade Level and then click the options. Multiple selections are possible by checking multiple fields. To reset your filters and view all activities again, press the top button in each drop down or simply refresh the page.

Don't have time to search through the site to find what you need? The links below house a collection of resources on a specific topic:

- Climate Change
- Plate Tectonics
- Microbiology
- Careers at Sea
Search through the collection of expeditions, blogs, and resources specific to the topic of plate tectonics.

PLATE TECTONICS EXPEDITIONS

TE KURA KOHATU – SCHOOL OF ROCK 2018
School of Rock 2018 will focus on Pacific Rim geology and the science research of the JOIDES Resolution. Field trips will include Tonga and the Kermadec Trough.

BROTHERS ARC FLUX
Expedition 376 will study submarine hydrothermal systems at the Brothers Volcano in the Kermadec-Tonga Arc.

HIKURANGI SUBDUCTION MARGIN CORING AND OBSERVATORIES
Scientists will study core samples and install two observatories to better understand the dynamics of subduction zones.

Read more
TEACHING KITS AND MODELS

We loan core models and interactive kits to educators for use in formal and informal education settings. Below is a list of items currently available.

Please note: Contact Nicole (nkurtz@LDEO.columbia.edu) for information and to reserve a core model for loan.

Cretaceous Impact Kit (ODP 171B)

Sixty five million years ago, a 10 km wide meteorite crashed into what is now Mexico’s Yucatan Peninsula, creating a 177 km wide crater and mass extinctions across the globe. This kit contains materials for audiences to explore the core evidence for the impact.

Glacial / Interglacial Core Model (IODP 303)

Expedition 303 drilled cores from the North Atlantic that helped build a timeline of climate change over the last several million years of Earth’s history. This data has provided invaluable insight into the most recent glacial cycles.
POSTERS, PENCILS AND MORE!

Inspire and educate with our posters, pencils, and other materials designed for a range of audiences. Contact us to order copies at nkurtz@ldeo.columbia.edu or download your own.

POSTERS

How Science Works – Discovering Life Below the Sea Floor

Science is a dynamic, non-linear, creative, and collaborative process that takes researchers on unique journeys of discovery. This poster highlights the pathway one microbiologist and her colleagues follow to unravel the mystery of what is living in the rocks and sediments that make up the ocean floor.

JOIDES Resolution Mini-poster

This mini-poster showcases the JR on the front, and background information about scientific drilling and activities for following the ship on the joidesresolution.org web site on the back. It is appropriate for all ages.
WANT TO SAIL ON THE JR AS AN ONBOARD OUTREACH OFFICER?

We are **not** currently accepting applications to sail as an Onboard Outreach Officer.

*JOIDES Resolution* Onboard Outreach Officers sail on board the ship to share the science story with students, families, and the general public. We welcome applications from classroom teachers, informal science educators, artists, videographers, writers, social media experts and anyone who can make a good case for themselves! Selected applicants will have the opportunity to learn shipboard science alongside the expedition's science party and translate the exciting science happening on board through creation of blogs, videos, social networking sites, **live ship-to-shore video events** and development of educational resources. Successful applicants will be creative, flexible, friendly and hardworking. Some geoscience background is helpful. All expenses for U.S. Onboard Education/Outreach Officers for travel to and from the ports of call, and a stipend are paid by the U.S. Science Support Program for IODP. Onboard Education/Outreach Officers are selected through a competitive application and interview process. The selected individual(s) will also be flown to a 3-day training session prior to their expedition. Non-U.S. applicants will be directed to their country IODP office but are still encouraged to apply.

When a call is open, review the application materials (listed below), then go the **USSSP Application Portal** to submit an online application to the **Onboard Outreach Program**. During the application process, you will be asked to rank the expeditions in which you are interested. Our application has the following components:

- a completed application form
  - an up-to-date C.V.
  - a recommendation letter
  - contact information for two additional references
  - a one-page proposal for what projects you would like to do while on-board
  - answers to several short essay questions
  - a letter of support from your administrator if needed

Also, watch our video about being an Outreach Officer [here.](#)

Read blogs by our former Onboard Outreach Officers for advice on the application process and how the experience has enhanced their profession after sailing.
In Search of Earth’s Secrets is a special project that brings the JOIDES Resolution and its exciting science to communities around the United States!

In Search of Earth’s Secrets is a 5-year project designed to create exciting “pop-up” science events in the style of pop-up restaurants, stores and art fairs. Bringing high quality earth and ocean science content to rural and urban communities with traditionally underserved populations will create a buzz about the intriguing discoveries done around the world’s oceans and create opportunities for further learning. The project involves working with libraries, Girl Scouts and other youth organizations, program scientists, educators, and museums across the country.
Videos
Get an up close and personal look at the JOIDES Resolution.

Free Children’s Books
Download free eBooks that introduce kids to the wonders of JOIDES Resolution science and exploration.