GIFT 2025 | WS 4 | From the sea floor to the classroom

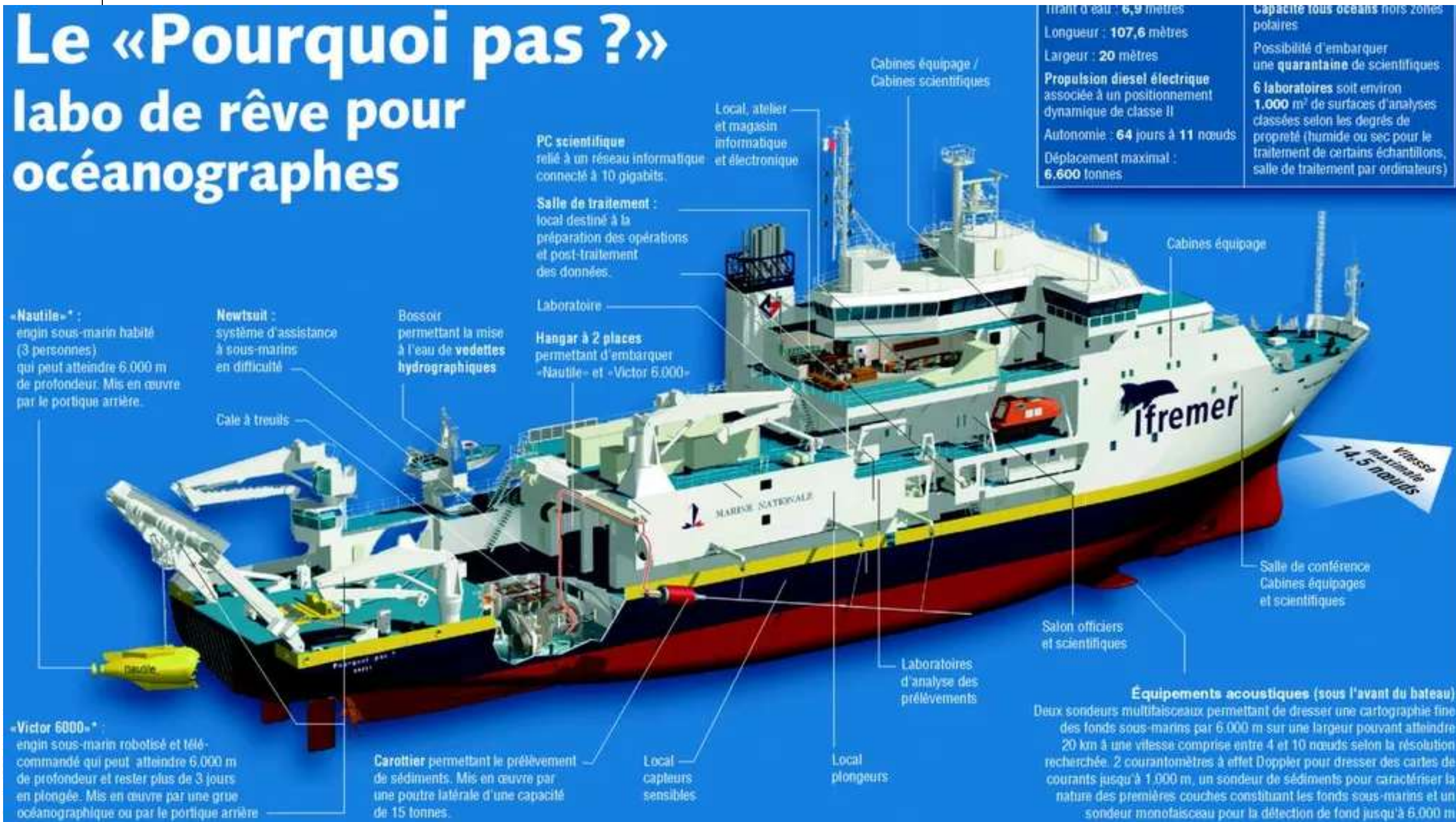
Hélder Pereira & Faustine Gendron - Part I

Le Pourquoi pas ?

Credit: IODP/Adam Kurtz

Discover Ifremer's missions

Le Pourquoi pas ?



A teacher aboard the ship Pourquoi pas ?

SUPER-MOUV in Ecuador :

***SU*b-seafloor effects of the *P*edernales *E*arthquake *R*upture, Ecuador and associated vertical MOUVements**

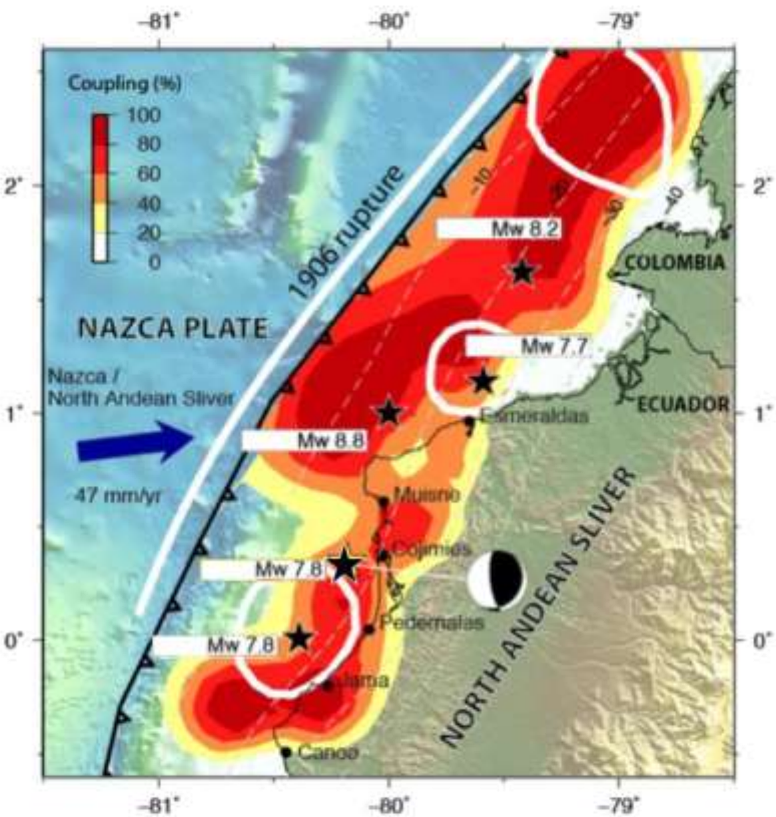
8 January 2024 – 21 February 2024

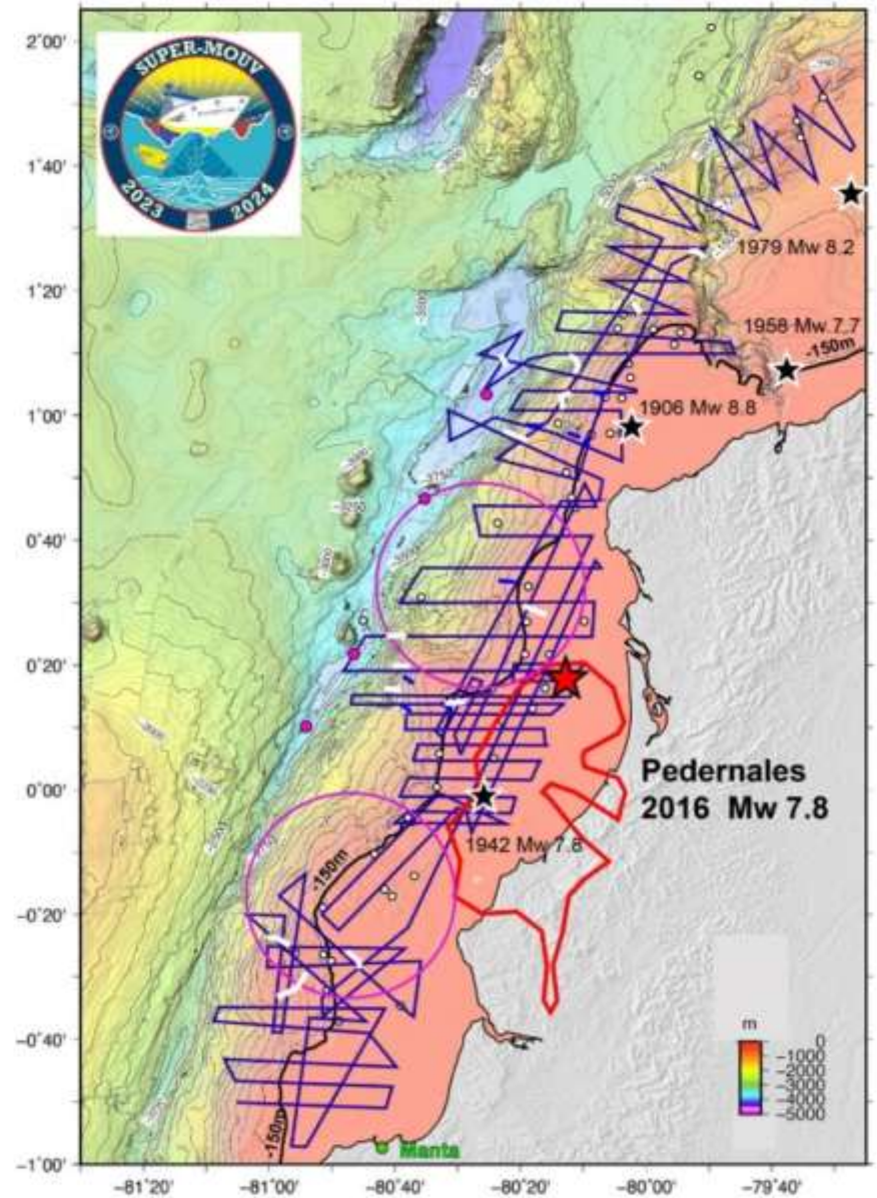
SUPER-MOUV :

8 January 2024 – 21 February 2024

SUPER-MOUV :

8 January 2024 – 21 February 2024

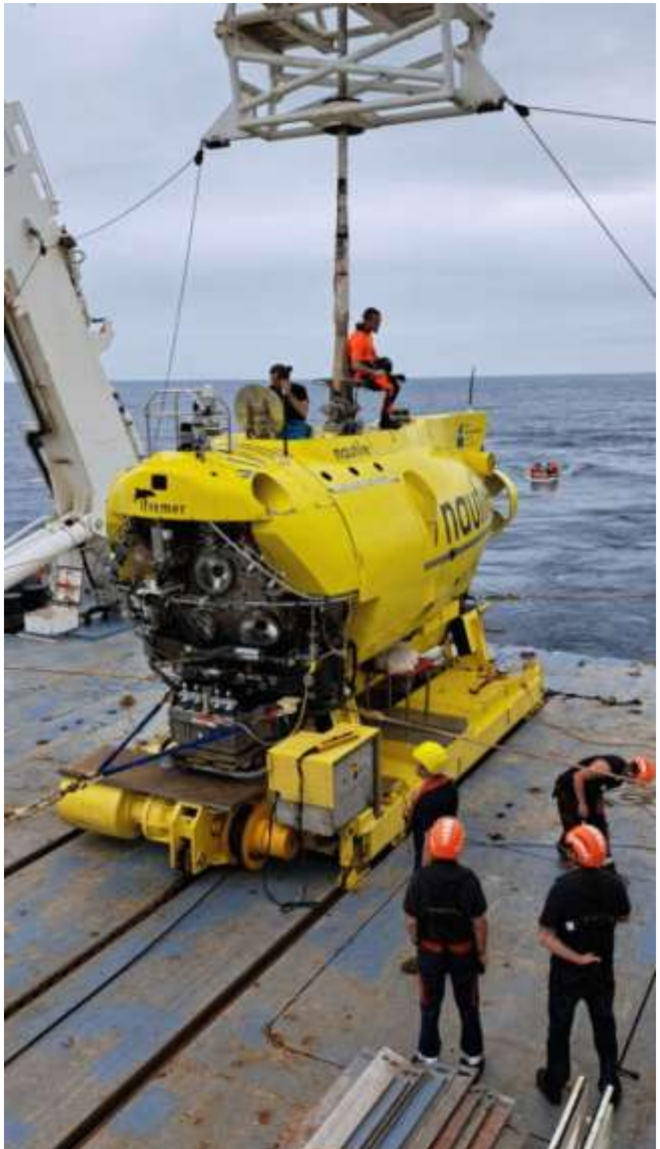


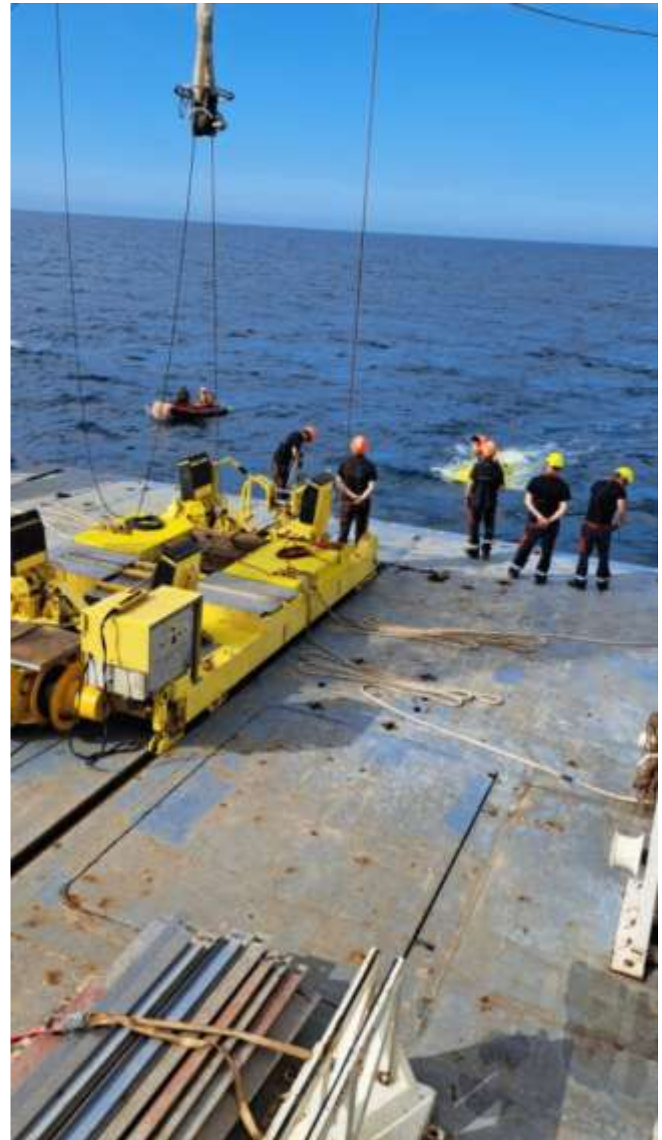


★ **very big earthquakes since 1906**

SUPER-MOUV :

8 January 2024 – 21 February 2024





Nautile lauching daytime

SUPER-MOUV :

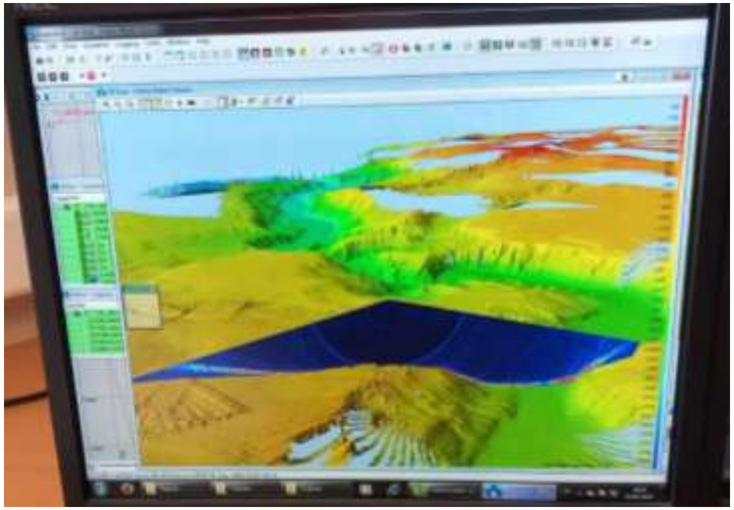
8 January 2024 – 21 February 2024

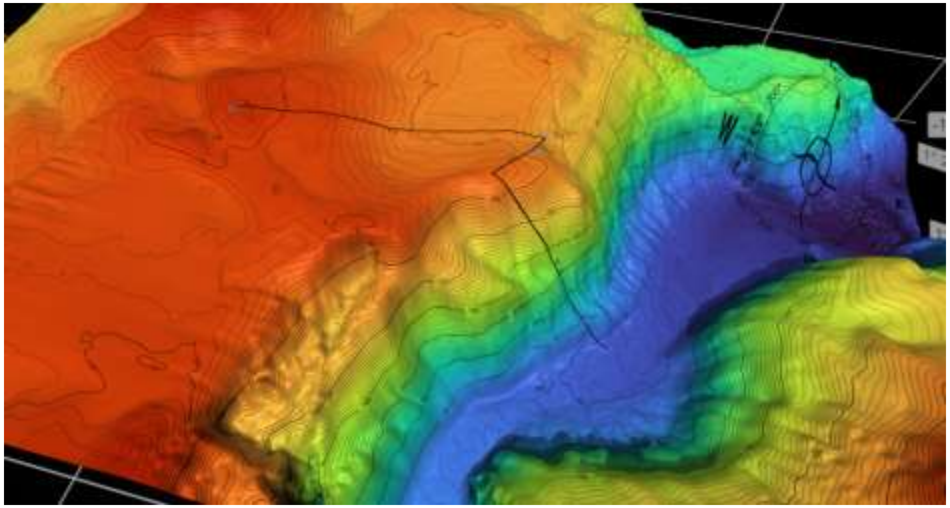
Dredging rocks by night

CTD : Conductivity, Température, Depth profiler

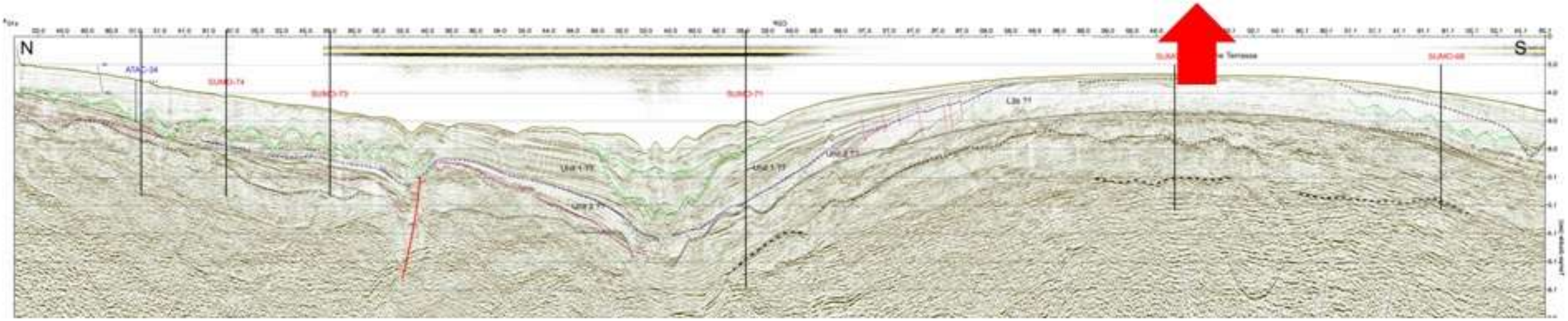
SUPER-MOUV :

8 January 2024 – 21 February 2024





Bathymetry and seismic



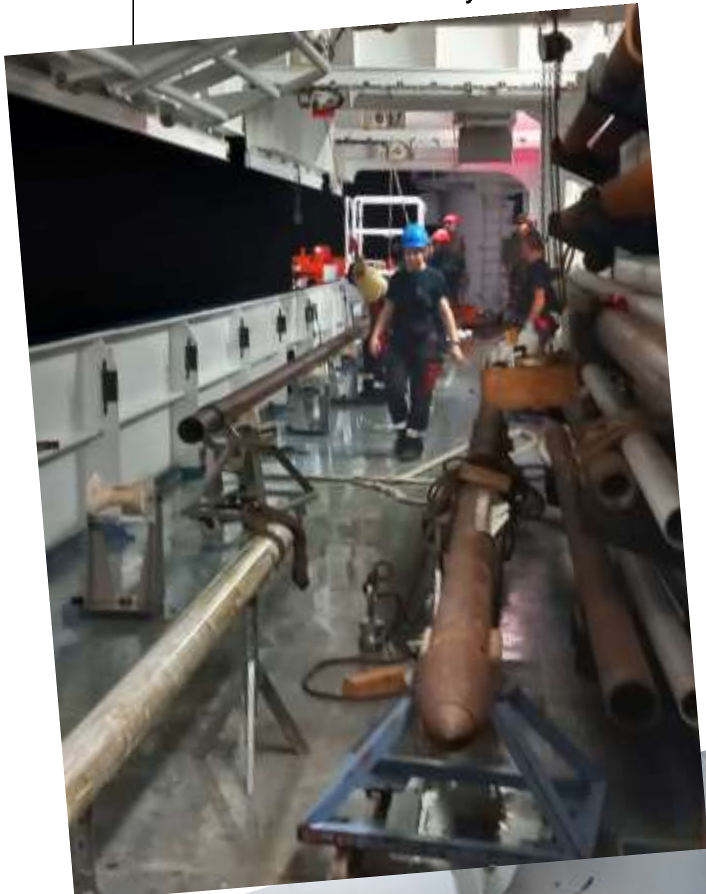
SUPER-MOUV :

8 January 2024 – 21 February 2024

Videoconferencing on board with schools all over the world

SUPER-MOUV :

8 January 2024 – 21 February 2024

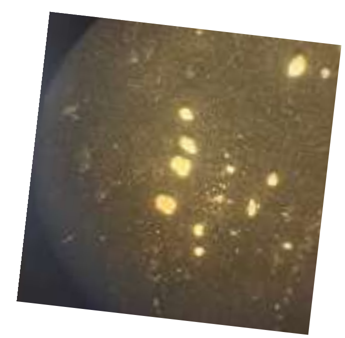


Coring by night…

SUPER-MOUV :

8 January 2024 – 21 February 2024

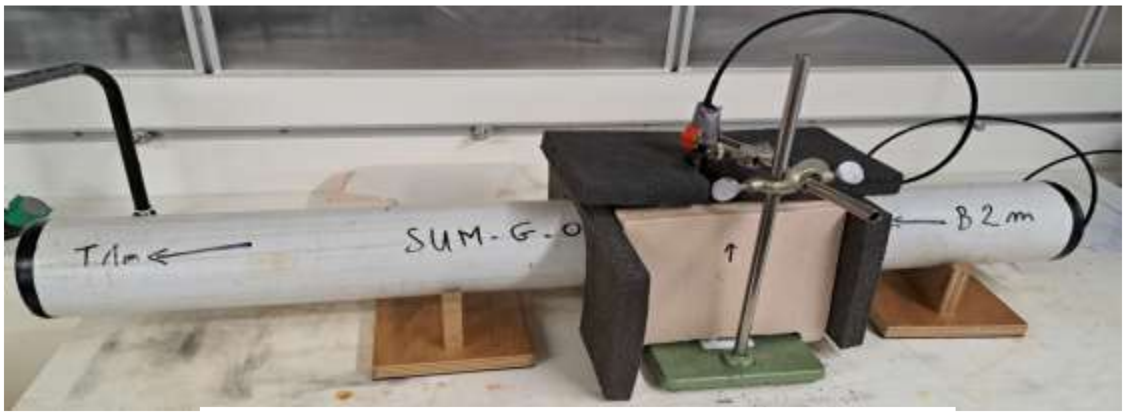
… to collect sediment cores and study microfossils

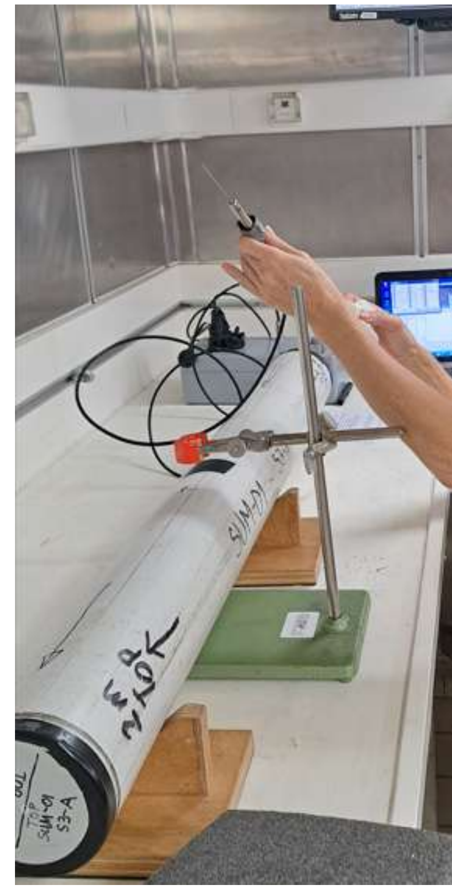


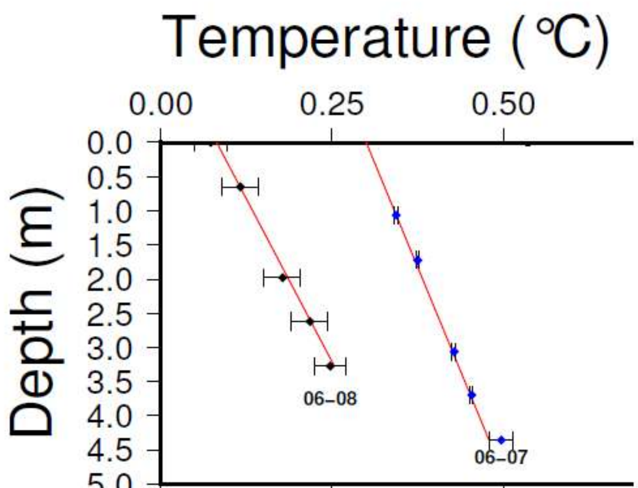
SUPER-MOUV :

8 January 2024 – 21 February 2024

… to study heat flow near the trench by measuring thermal gradient and thermal conductivity of sediments







SUPER-MOUV Website :

https://edumed.unice.fr/data-center/oceano/supermouv.php

La vie à bord

Les scientifiques au travail

Le Nautile

Carottes sédimentaires

Fonctionnement du Pourquoi Pas ?

Analyses de l'eau de mer

Localiser le Pourquoi Pas ?

Envie de savoir où se trouve le navire en ce moment même ? Il suffit de consulter le lien suivant : ***Localisation du Pourquoi Pas ?***

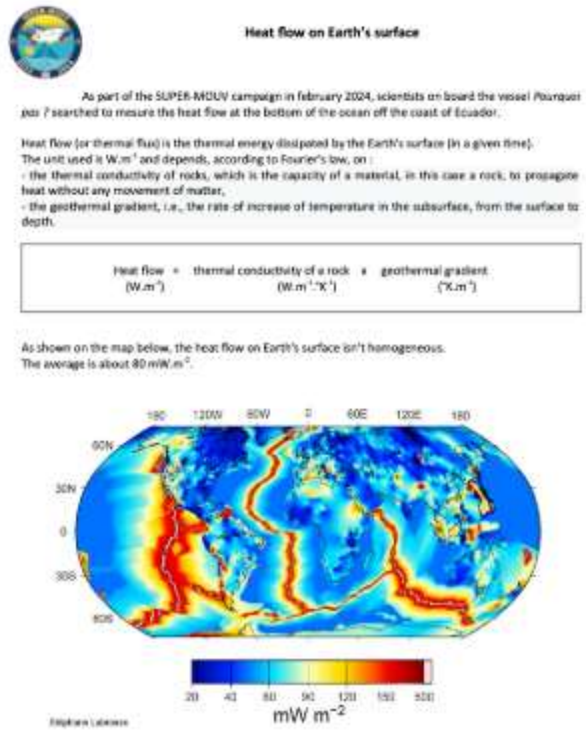
Using Ready-to-use Classroom Activities

Heat flow on Earth's surface

How to get heat flow beneath the ocean surface, how does it vary from differents area ? Try to give answers by study documents available below.

For this 6th meeting, we suggest you work on the variability of this flow, and on the notion of back-and-forth between data and modeling.

The new riddles are ready and available for download in the .PDF file below :



Heat flow on Earth's surface

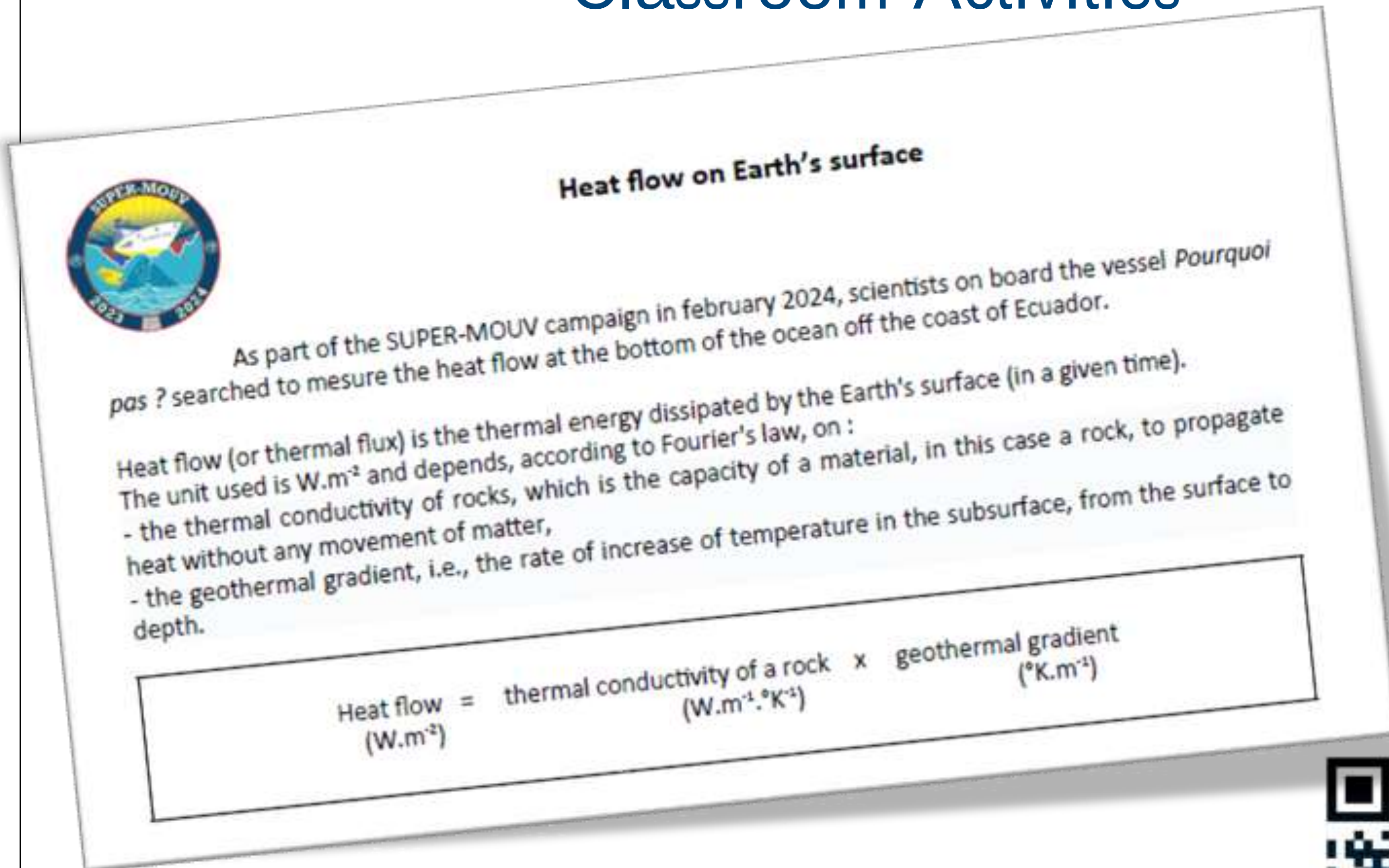
As part of the SUPER-MOUV campaign in february 2024, scientists on board the vessel *Pourquoi pas ?* searched to mesure the heat flow at the bottom of the ocean off the coast of Ecuador.

Heat flow (or thermal flux) is the thermal energy dissipated by the Earth's surface (in a given time).
The unit used is $W.m^{-2}$ and depends, according to Fourier's low, on :
- the thermal conductivity of rocks, which is the capacity of a material, in this case a rock, to propagate heat without any movement of matter,
- the geothermal gradient, i.e., the rate of increase of temperature in the subsurface, from the surface to depth.

Heat flow ($W.m^{-2}$)	=	thermal conductivity of a rock ($W.m^{-1}.°K^{-1}$)	x	geothermal gradient ($°K.m^{-1}$)

As shown on the map below, the heat flow on Earth's surface isn't homogeneous.
The average is about 80 $mW.m^{-2}$.

Using Ready-to-use Classroom Activities



Heat flow on Earth's surface

As part of the SUPER-MOUV campaign in february 2024, scientists on board the vessel *Pourquoi pas ?* searched to mesure the heat flow at the bottom of the ocean off the coast of Ecuador.

Heat flow (or thermal flux) is the thermal energy dissipated by the Earth's surface (in a given time).
The unit used is $W.m^{-2}$ and depends, according to Fourier's law, on :
- the thermal conductivity of rocks, which is the capacity of a material, in this case a rock, to propagate heat without any movement of matter,
- the geothermal gradient, i.e., the rate of increase of temperature in the subsurface, from the surface to depth.

$$\text{Heat flow } (W.m^{-2}) = \text{thermal conductivity of a rock } (W.m^{-1}.°K^{-1}) \times \text{geothermal gradient } (°K.m^{-1})$$

Using Ready-to-use Classroom Activities

***Questions for students** about heat flow*

First level :

Using https://ihfc-iugg.org/viewer/ and a mid-oceanic ridge, a subduction trench and a volcanic arc of your choice, show that heat flow isn't homogeneous on Earth's surface (figures 1 & 2).

For help, use : *https://www.pedagogie.ac-nice.fr/svt/productions/tectoglob3d/*

Second level :

- Knowing that Iceland is mostly made of basaltic rocks, and that the average geothermal gradient in Earth's crust is around 30°K/km, use figure 4 to estimate the average heat flow in this part of the world.
- Using https://ihfc-iugg.org/viewer/, compare heat flow expected in Iceland to real heat flow measured in Iceland.
- Try to explain the difference between the expected results and the real heat flows in Iceland.

For help, use :
https://www.pedagogie.ac-nice.fr/svt/productions/tectoglob3d/
and/or
https://www.pedagogie.ac-nice.fr/svt/productions/tomographie2/

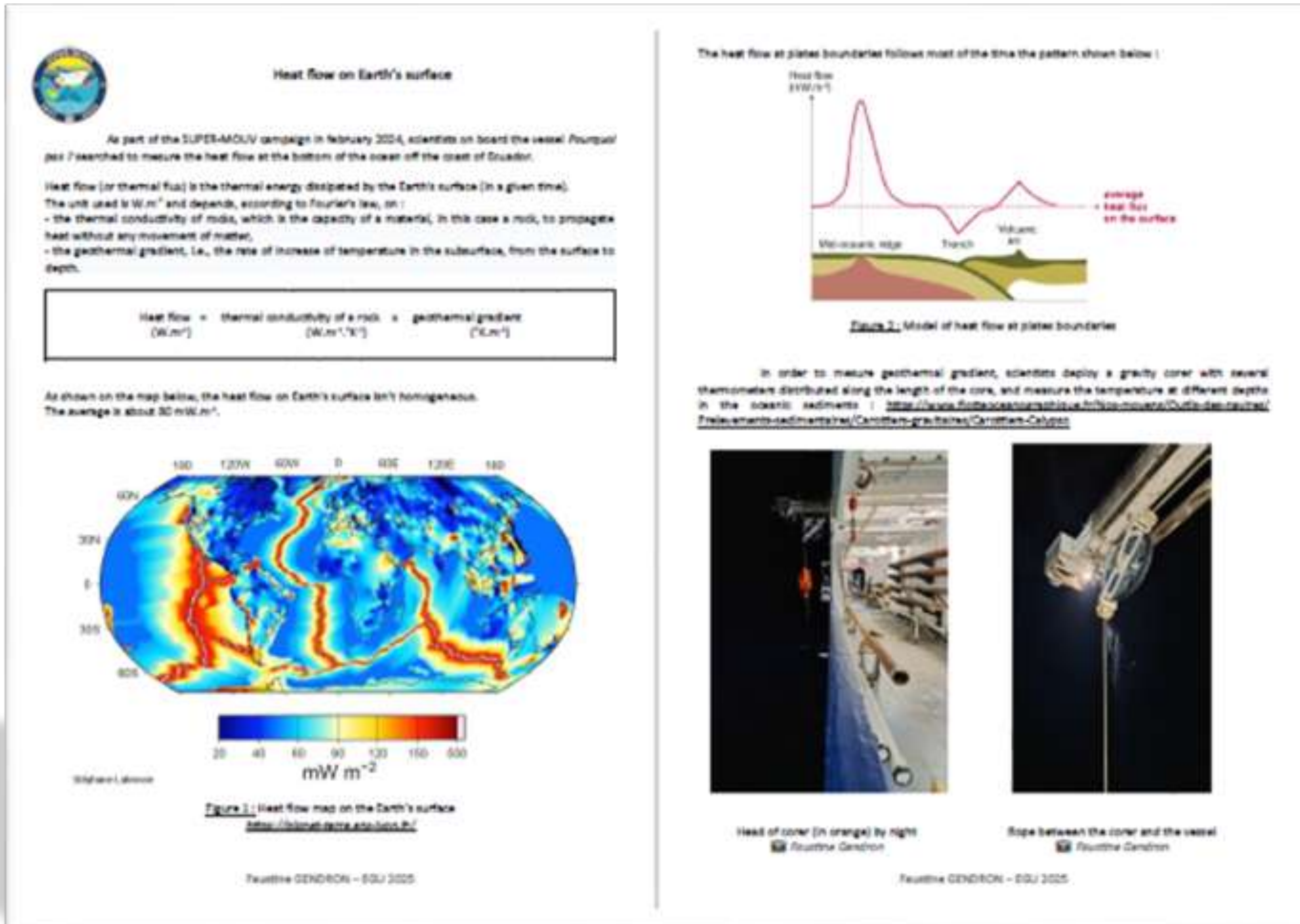
Using Ready-to-use Classroom Activities

Third level :

Heat flow studies were carried out in 2014 during the oceanographic campaign *Antithesis*.
Two geothermical gradient measurements made during this campaign are shown in figure 3.
The thermal conductivity measurements carried out in the sediments collected during these gradient measurements are shown in figure 5.

- Find the place where this campaign took place.
- Indicate, with justification, which of the points (06-07 or 06-08) should be the better one to calculate the geothermal gradient, then calculate the gradient for this point (in °C/m).
- Knowing that the estimated gradient in °C/m is equivalent to the gradient in °K/m, estimate the geothermal flow at the point chosen previously.
- Discuss your result compared with datas available on https://ihfc-iugg.org/viewer/

Using Ready-to-use Classroom Activities



Heat flow on Earth's surface

As part of the SUPER-MOUV campaign in february 2024, scientists on board the vessel *Pourquoi pas ?* searched to measure the heat flow at the bottom of the ocean off the coast of Ecuador.

Heat flow (or thermal flux) is the thermal energy dissipated by the Earth's surface (in a given time).
The unit used is W.m⁻² and depends, according to Fourier's law, on :
- the thermal conductivity of rocks, which is the capacity of a material, in this case a rock, to propagate heat without any movement of matter,
- the geothermal gradient, i.e., the rate of increase of temperature in the subsurface, from the surface to depth.

Heat flow (W.m⁻²) = thermal conductivity of a rock (W.m⁻¹.°K⁻¹) x geothermal gradient (°K.m⁻¹)

As shown on the map below, the heat flow on Earth's surface isn't homogeneous.
The average is about 80 mW.m⁻².

Figure 1 : Heat flow map on the Earth's surface

The heat flow at plates boundaries follows most of the time the pattern shown below :

Figure 2 : Model of heat flow at plates boundaries

In order to mesure geothermal gradient, scientists deploy a gravity corer with several thermometers distributed along the length of the core, and measure the temperature at different depths in the oceanic sediments :

Head of corer (in orange) by night

Rope between the corer and the vessel

Using Ready-to-use Classroom Activities

Thermometer place on the corer
Faustine Gendron

Thermometers for corer
Faustine Gendron

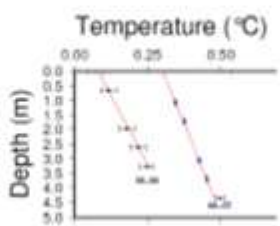


Figure 3 : temperature measurements based on depth
(GPS coordinates for 06-07 and 06-08 available on figure 5)

Faustine GENDRON – EGU 2025

In order to measure thermal conductivity, scientists have to collect sediment core samples (simultaneously with geothermal gradient measurements or not) using the corer on board the ship. Then, they use a heating thermometric probe, connected to a computer to find the thermal conductivity of the sediments present inside a core.

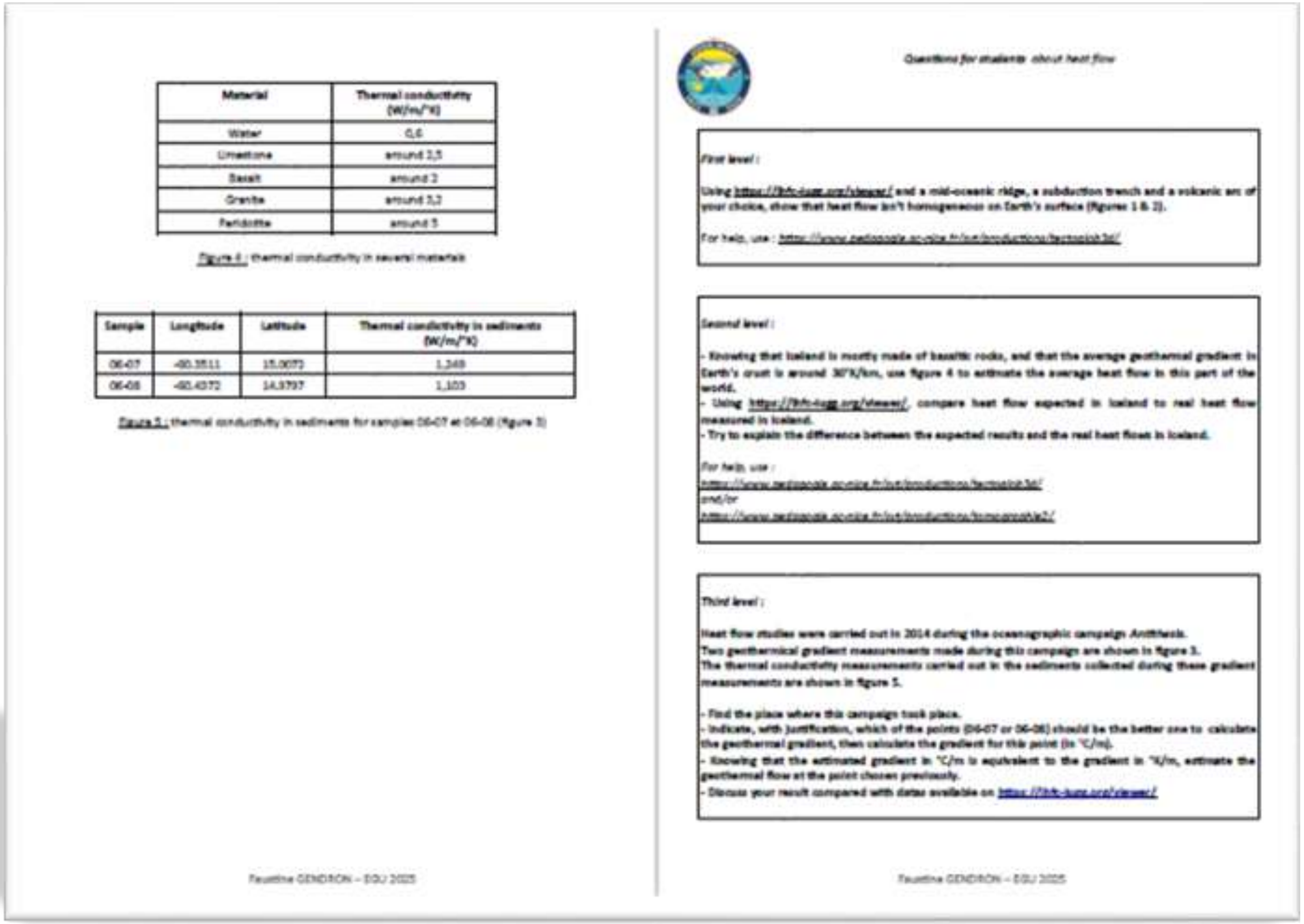
Crew taking a core out of water
Faustine Gendron

Heating needle temperature probe
Faustine Gendron

Thermal conductivity measurement in oceanic sediments in a core
Faustine Gendron

Faustine GENDRON – EGU 2025

Using Ready-to-use Classroom Activities



Material	Thermal conductivity (W/m/°K)
Water	0,6
Limestone	around 2,5
Basalt	around 2
Granite	around 3,2
Peridotite	around 3

Figure 4 : thermal conductivity in several materials

Sample	Longitude	Latitude	Thermal conductivity in sediments (W/m/°K)
06-07	-60.3511	15.0073	1,249
06-08	-60.4372	14.9797	1,103

Figure 5 : thermal conductivity in sediments for samples 06-07 et 06-08 (figure 3)

Questions for students about heat flow

First level :

Using https://ihfc-iugg.org/viewer/ and a mid-oceanic ridge, a subduction trench and a volcanic arc of your choice, show that heat flow isn't homogeneous on Earth's surface (figures 1 & 2).

For help, use : https://www.pedagogie.ac-nice.fr/svt/productions/tectoglob3d/

Second level :

- Knowing that Iceland is mostly made of basaltic rocks, and that the average geothermal gradient in Earth's crust is around 30°K/km, use figure 4 to estimate the average heat flow in this part of the world.
- Using https://ihfc-iugg.org/viewer/, compare heat flow expected in Iceland to real heat flow measured in Iceland.
- Try to explain the difference between the expected results and the real heat flows in Iceland.

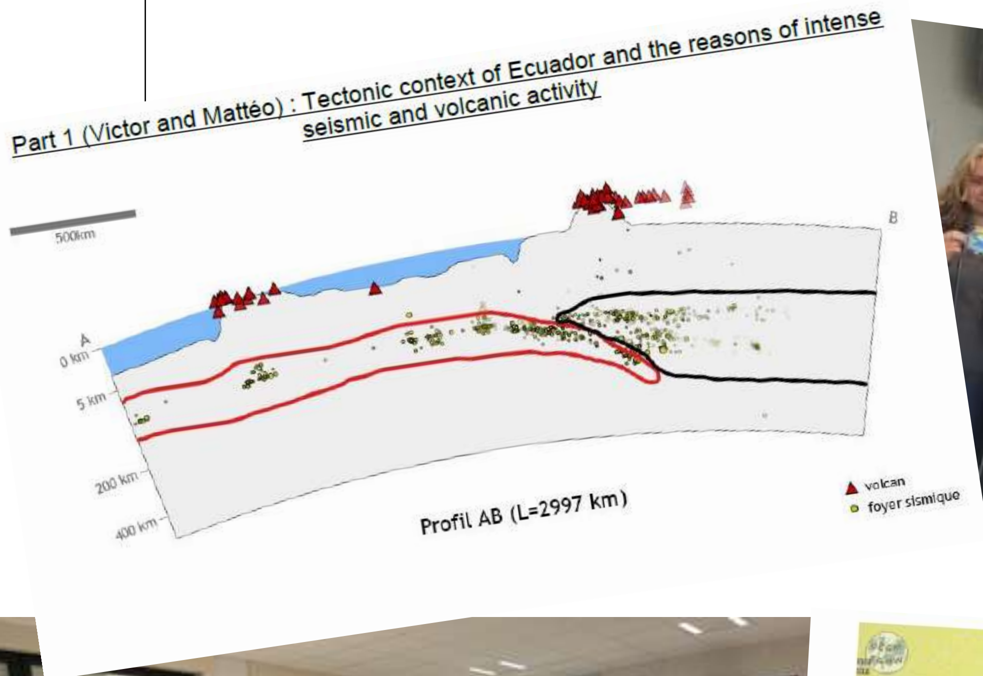
For help, use :
https://www.pedagogie.ac-nice.fr/svt/productions/tectoglob3d/
and/or
https://www.pedagogie.ac-nice.fr/svt/productions/tomographie2/

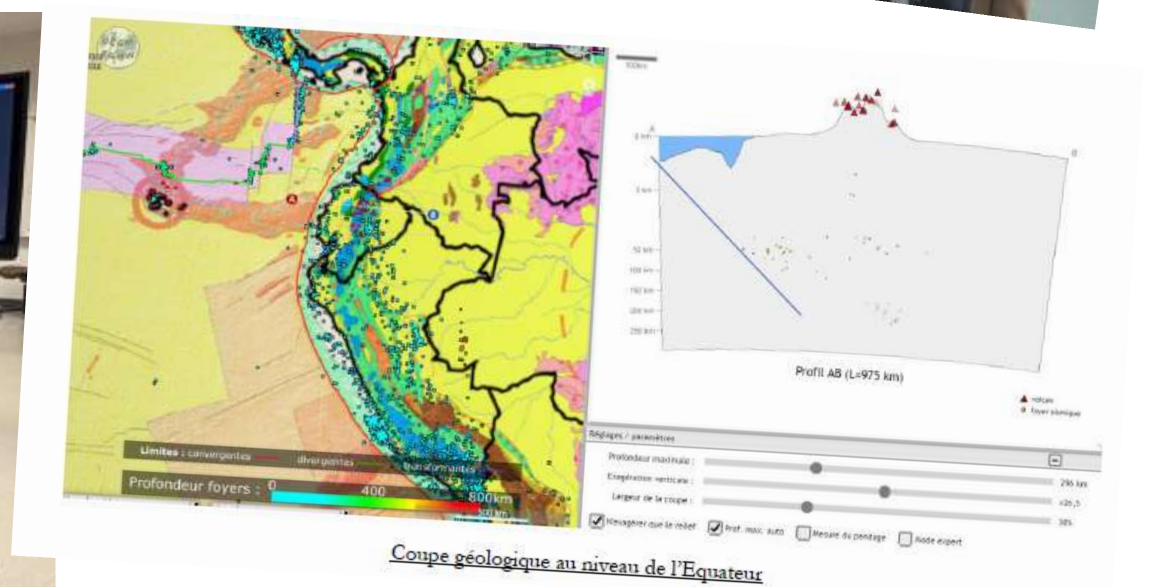
Third level :

Heat flow studies were carried out in 2014 during the oceanographic campaign Antithesis.
Two geothermical gradient measurements made during this campaign are shown in figure 3.
The thermal conductivity measurements carried out in the sediments collected during these gradient measurements are shown in figure 5.

- Find the place where this campaign took place.
- Indicate, with justification, which of the points (06-07 or 06-08) should be the better one to calculate the geothermal gradient, then calculate the gradient for this point (in °C/m).
- Knowing that the estimated gradient in °C/m is equivalent to the gradient in °K/m, estimate the geothermal flow at the point chosen previously.
- Discuss your result compared with datas available on https://ihfc-iugg.org/viewer/

Using Ready-to-use Classroom Activities

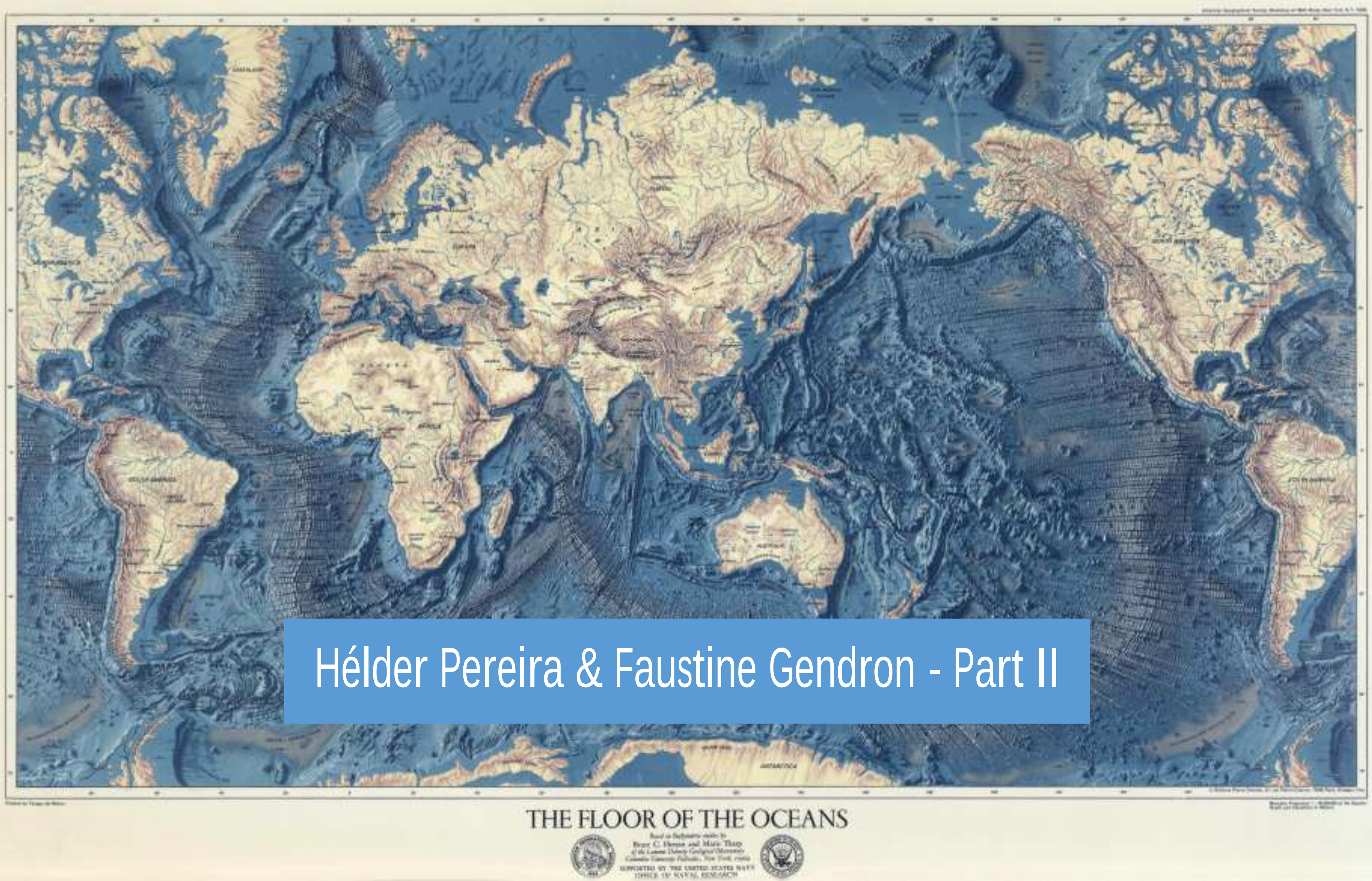





FLOTTE
OCÉANOGRAPHIQUE
FRANÇAISE
PAR L'IFREMER
Pourquoi pas ?

European Geosciences Union

GIFT 2025 | WS 4 | From the sea floor to the classroom



Hélder Pereira & Faustine Gendron - Part II

EGU European Geosciences Union

GIFT 2025 | WS 4 | From the sea floor to the classroom

*"**When I think of the floor of the deep sea, the single, overwhelming fact that possesses my imagination is the accumulation of sediments.** I see always the steady, unremitting, downward drift of materials from above, flake upon flake, layer upon layer – a drift that has continued for hundreds of millions of years, that will go on as long as there are seas and continents..... **For the sediments are the materials of most stupendous 'snowfall' the Earth has ever seen...**"*

— Rachel Carson

Brief history of scientific ocean drilling programs

Deep Sea Drilling Project
(DSDP)
1966
Legs 1-96

Glomar Challenger

Ocean Drilling Program
(ODP)
1983
Legs 101-210

JOIDES Resolution (JR)

Integrated Ocean Drilling Program
(IODP)
2003
Expeditions 301-346

JR

CHIKYU

Mission specific platforms

International Ocean Discovery Program
(IODP)
2013
Expeditions 349-405

Brief history of scientific ocean drilling programs

International Ocean Drilling Program
(IODP^3)
2025
Expeditions 501 onwards

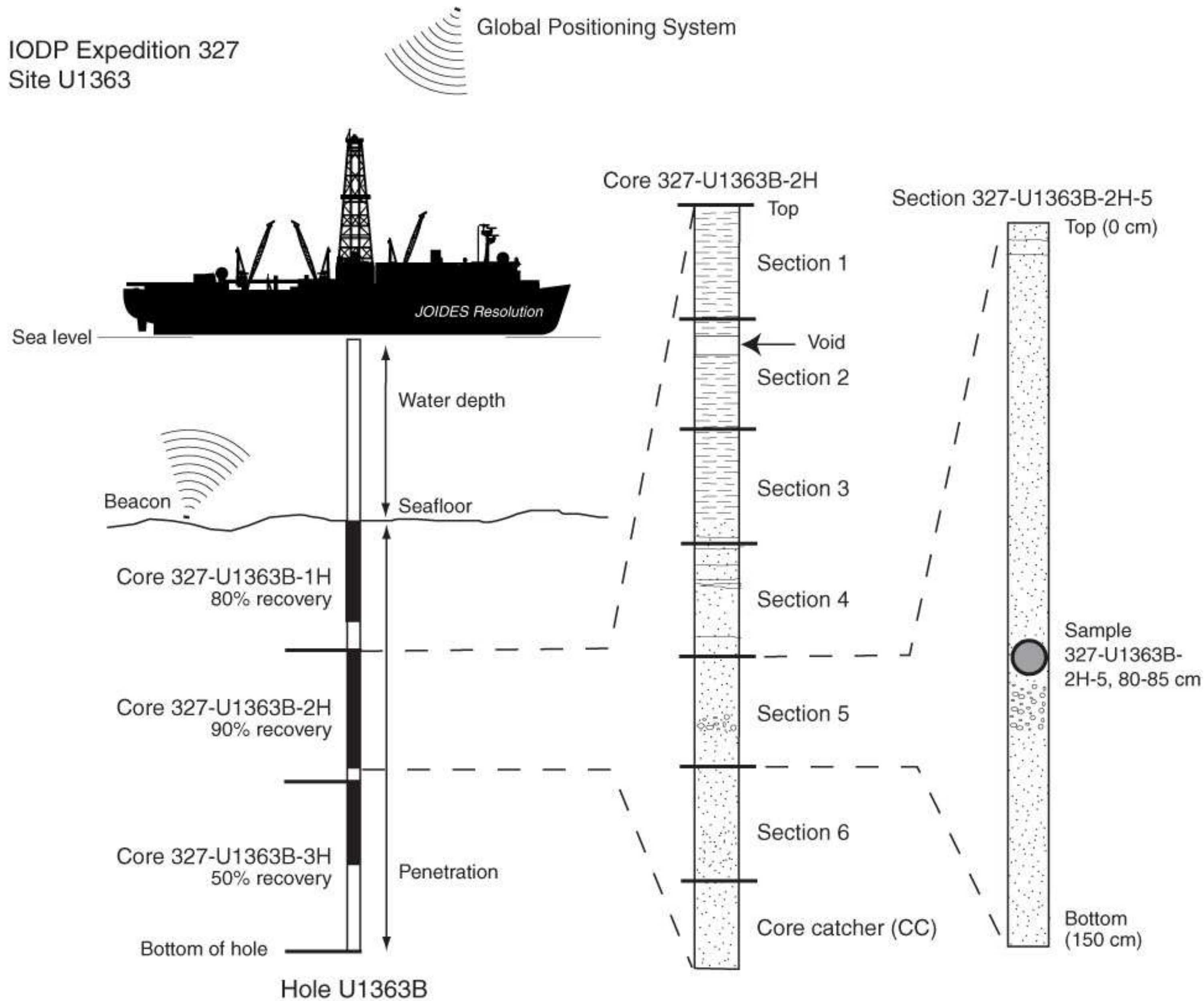
JR

CHIKYU

Mission specific platforms

JOIDES Resolution

JOIDES Resolution



An educator aboard the JOIDES Resolution

Juan de Fuca hydrogeology:

Cementing operations at the Hole U1301A and Hole U1301B borehole observatories (CORKs)

22 June–5 July 2009

321 TRANSIT

school of rock
www.JOIDESRESOLUTION.org

Credit: John Beck, IODP/TAMU

An E&O officer aboard the JOIDES Resolution

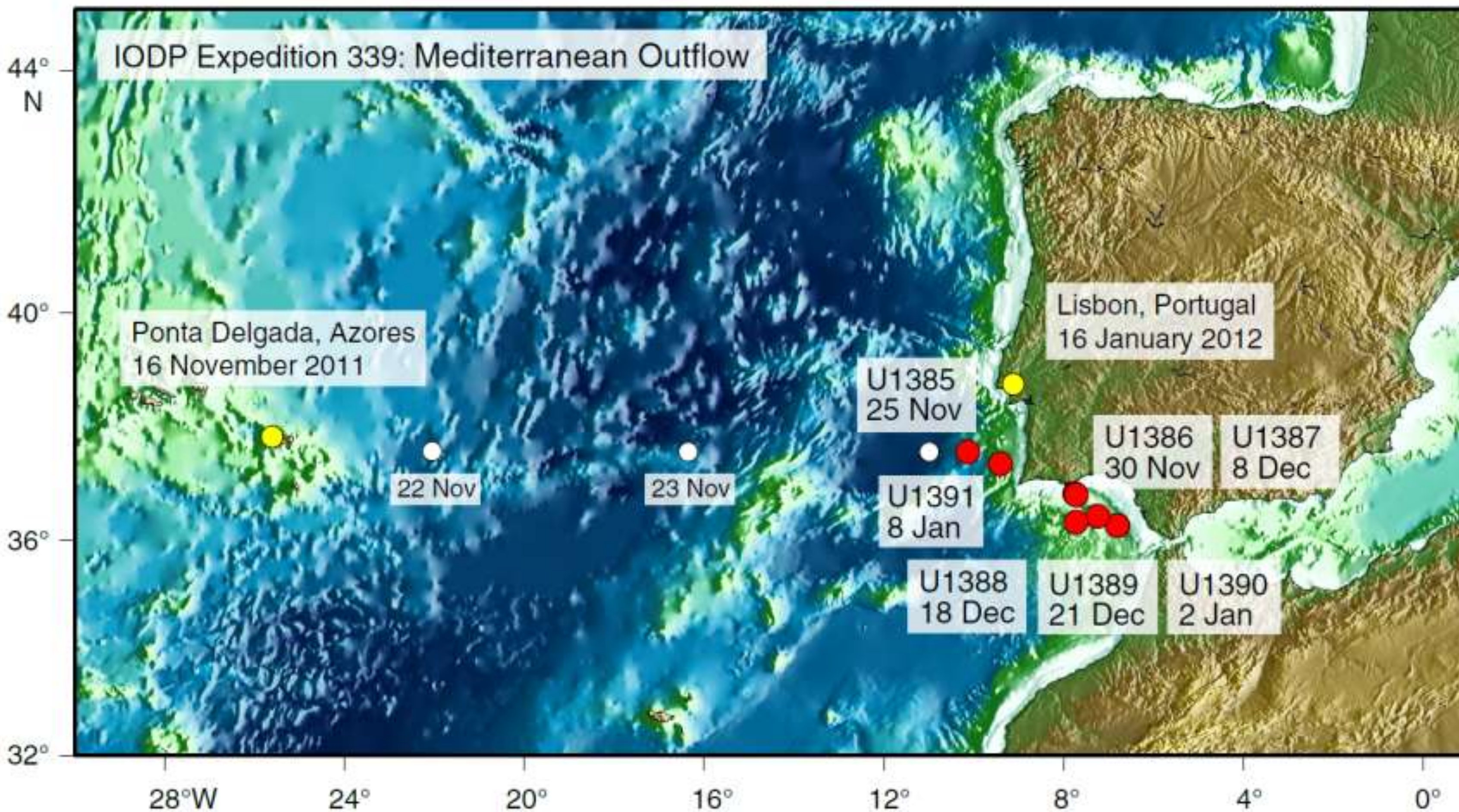
Mediterranean Outflow:

Environmental significance of the Mediterranean Outflow Water and its global implications

16 November 2011–16 January 2012

IODP Expedition 339

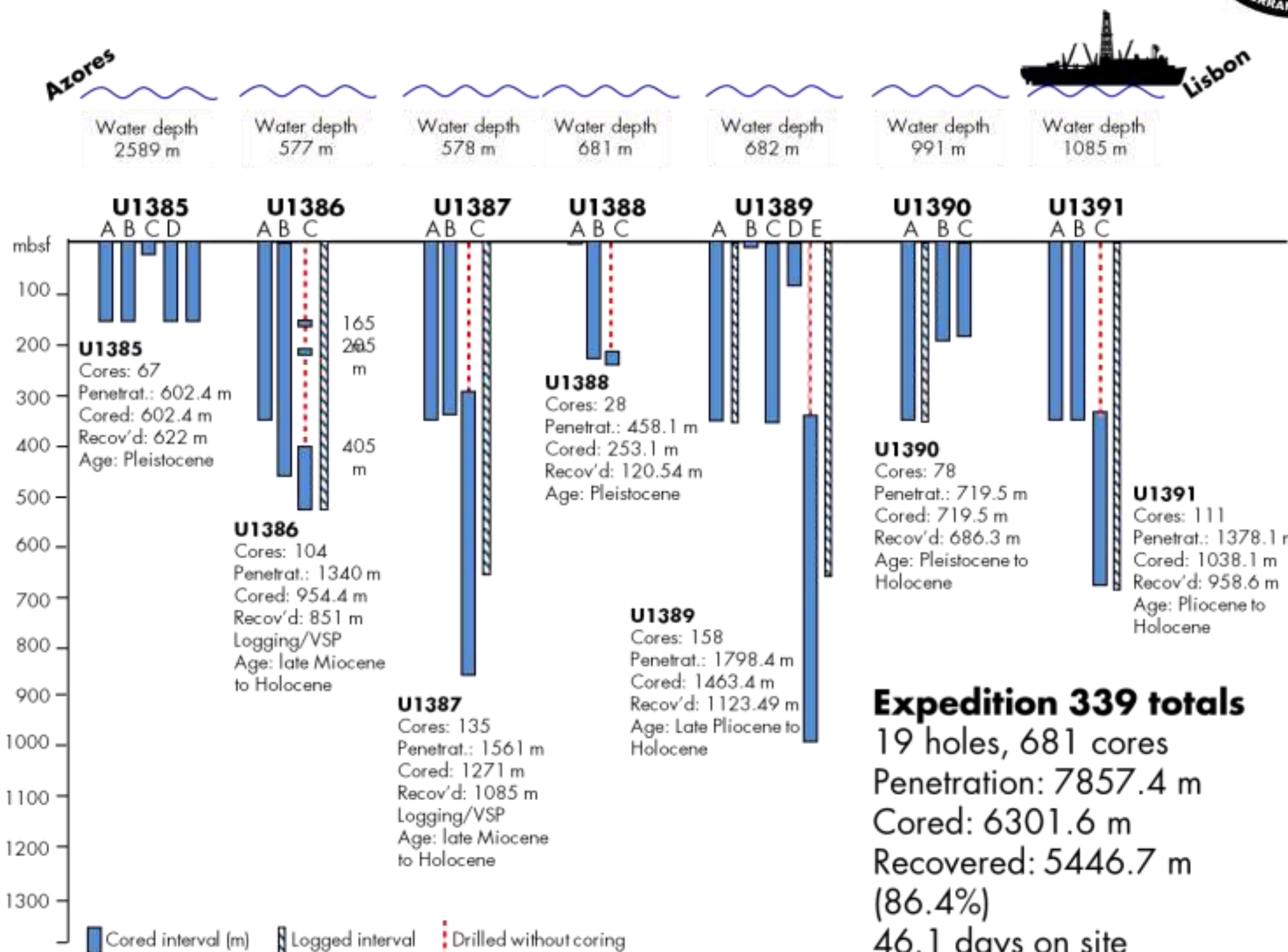
Mediterranean Outflow



IODP Expedition 339 transit and drill sites map
https://iodp.tamu.edu/scienceops/expeditions/mediterranean_outflow.html

IODP Expedition 339

Mediterranean Outflow



Expedition 339 totals
19 holes, 681 cores
Penetration: 7857.4 m
Cored: 6301.6 m
Recovered: 5446.7 m
(86.4%)
46.1 days on site

IODP Expedition 339

Mediterranean Outflow:

Environmental significance of the Mediterranean Outflow Water and its global implications

16 November 2011–16 January 2012

IODP Expedition 339

Mediterranean Outflow:

Environmental significance of the Mediterranean Outflow Water and its global implications

16 November 2011–16 January 2012

IODP Expedition 339

Mediterranean Outflow:

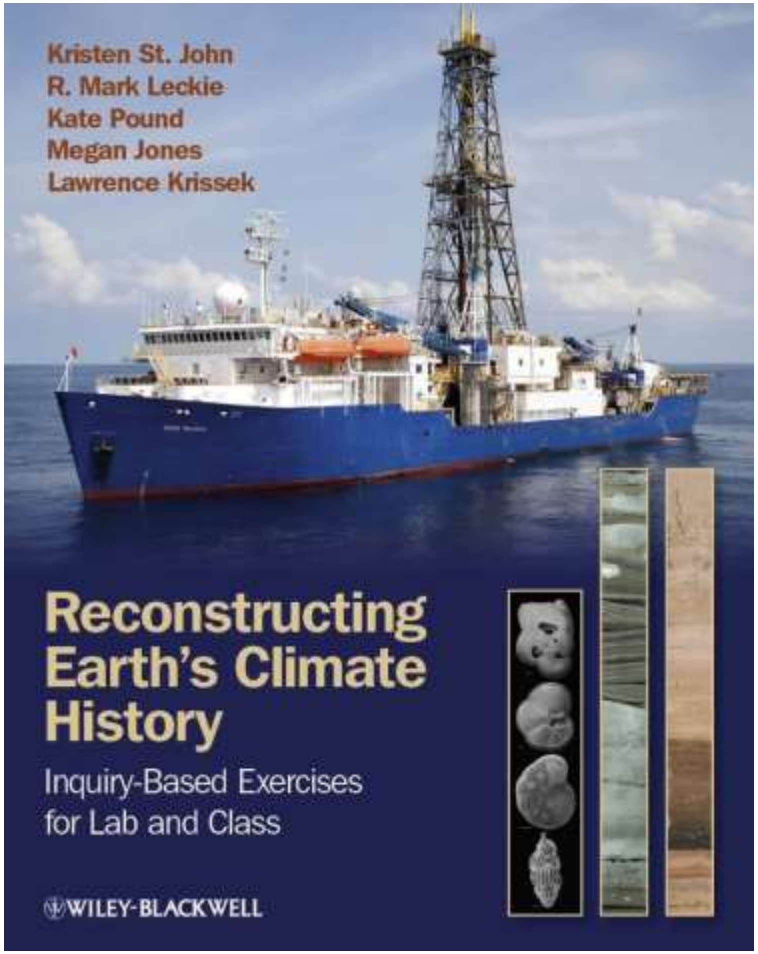
Environmental significance of the Mediterranean Outflow Water and its global implications

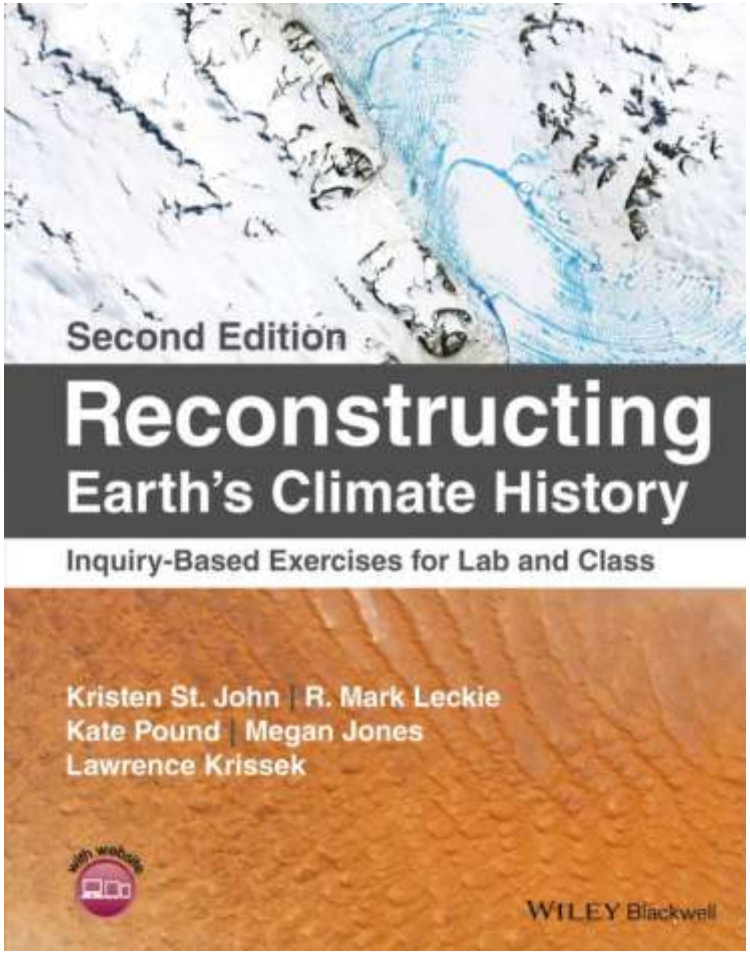
16 November 2011–16 January 2012

European Geosciences Union

GIFT 2025 | WS 4 | From the sea floor to the classroom

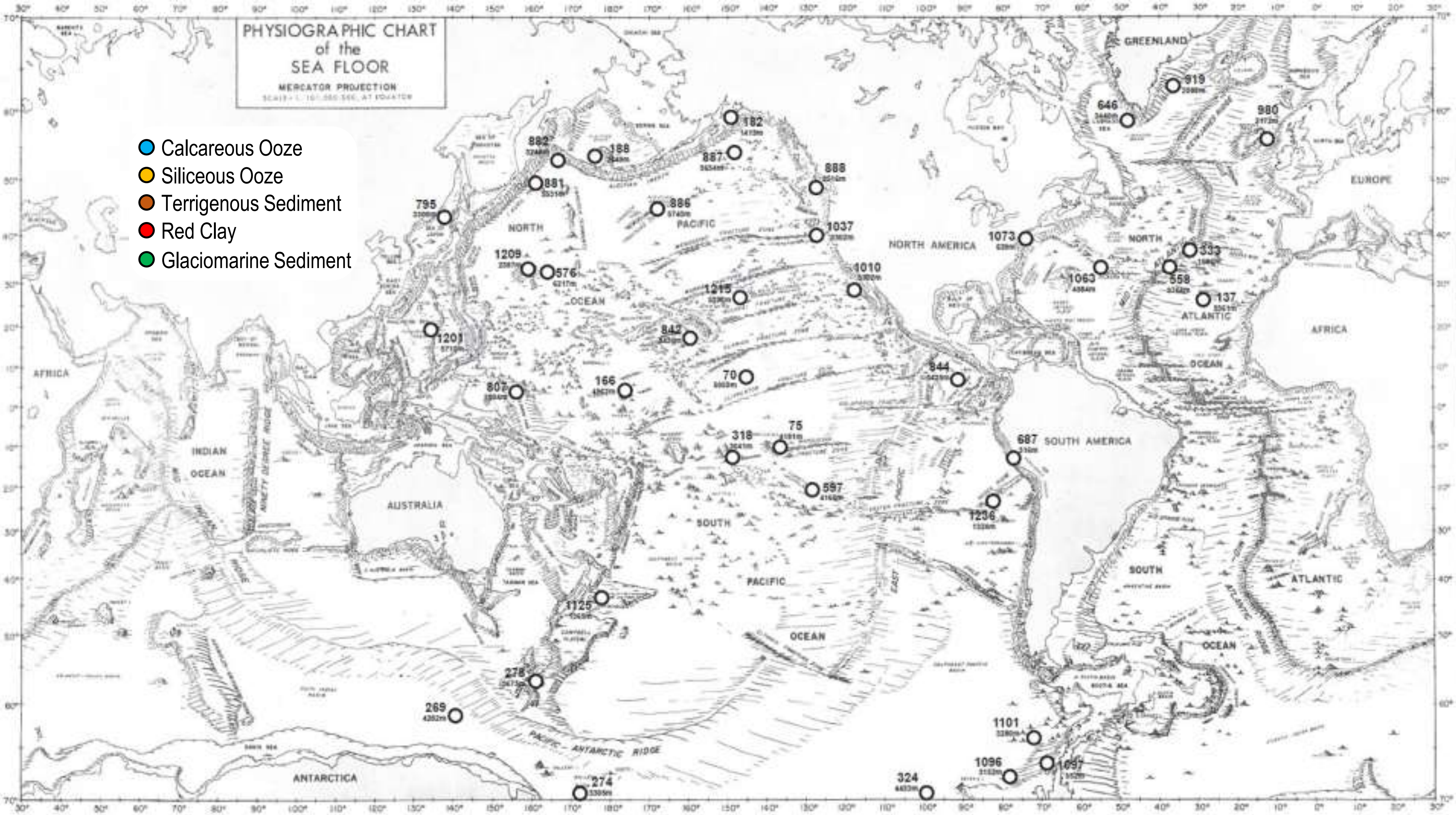
Doing Inquiry-Based Exercises for Lab and Class





Doing Inquiry-Based Exercises for Lab and Class

Seafloor Sediments | Geographic Distribution and Interpretation



For the sediments are the materials of most stupendous 'snowfall' the Earth has ever seen..."

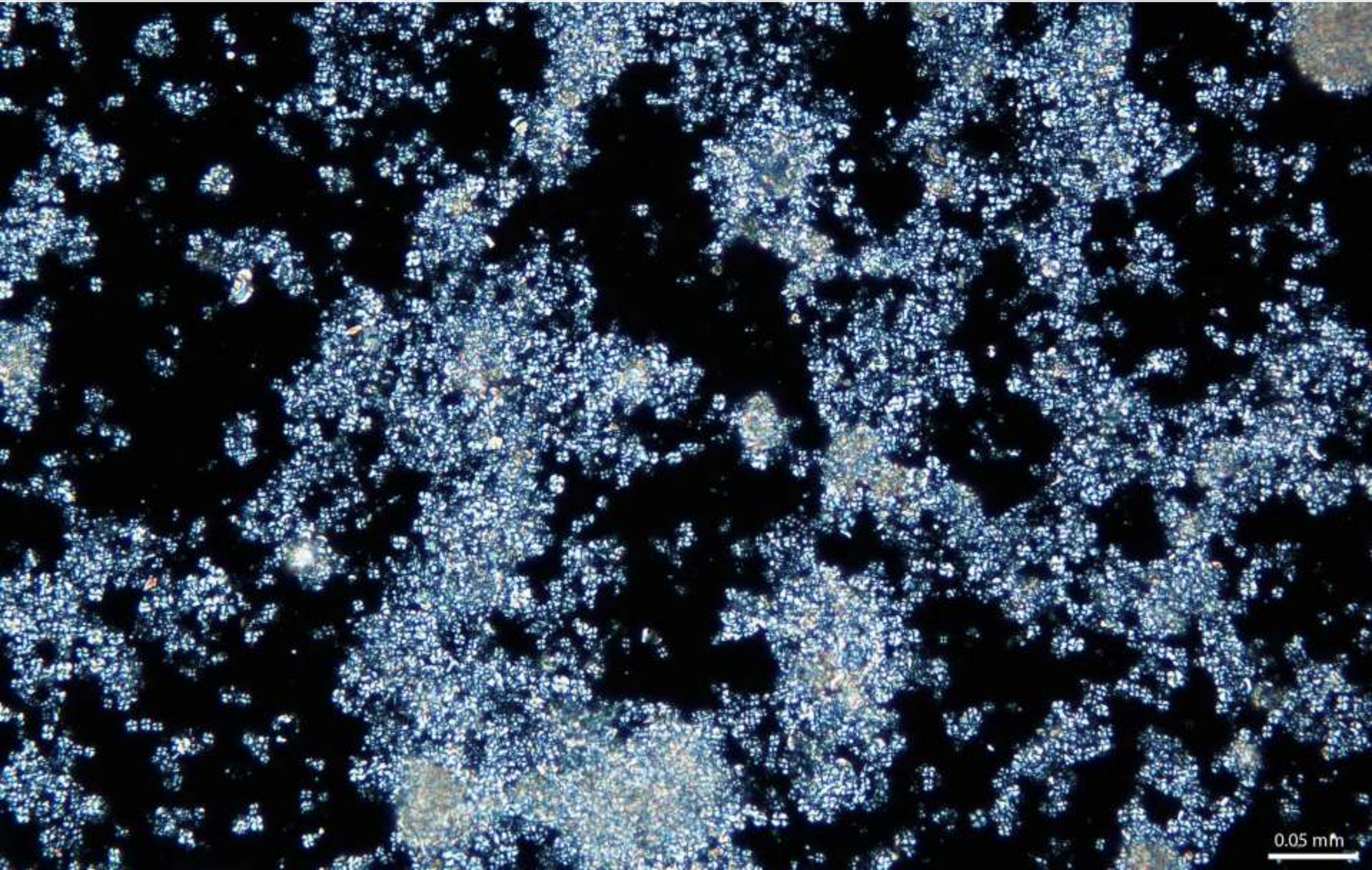
— Rachel Carson

Calcareous ooze (foraminifera) | ODP Leg 202-1236A-1-1, 90-95 cm

For the sediments are the materials of most stupendous 'snowfall' the Earth has ever seen…"

— Rachel Carson

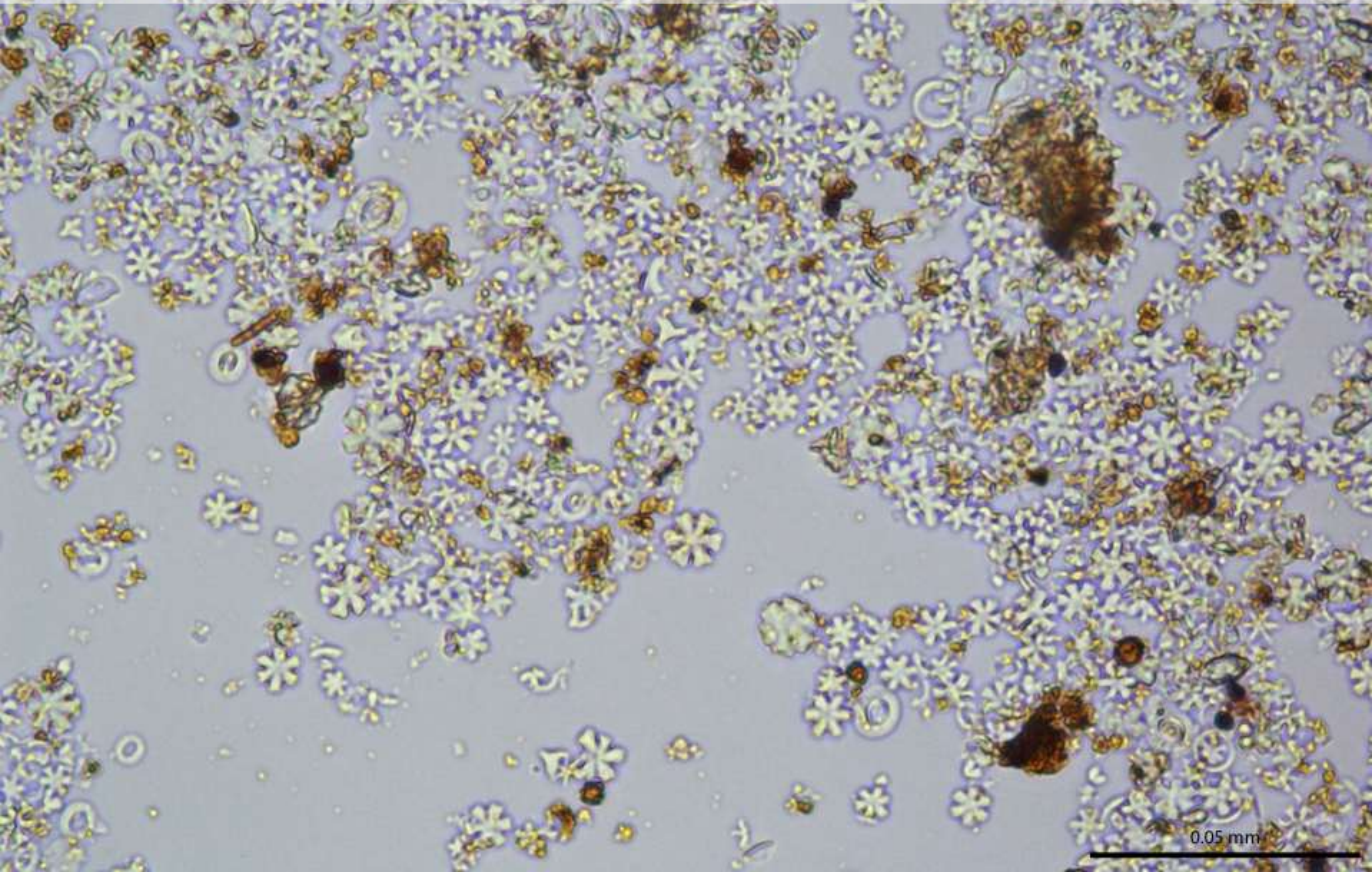
Calcareous ooze (coccoliths) | DSDP Leg 82-558-3-6, 75 cm



For the sediments are the materials of most stupendous 'snowfall' the Earth has ever seen..."

— Rachel Carson

Calcareous ooze (discoasters) | DSDP Leg 8-75-1-3,10 cm



For the sediments are the materials of most stupendous 'snowfall' the Earth has ever seen..."

— Rachel Carson

Siliceous ooze (diatoms) | ODP Leg 145-887C-2H-1,75 cm

For the sediments are the materials of most stupendous 'snowfall' the Earth has ever seen..."

— Rachel Carson

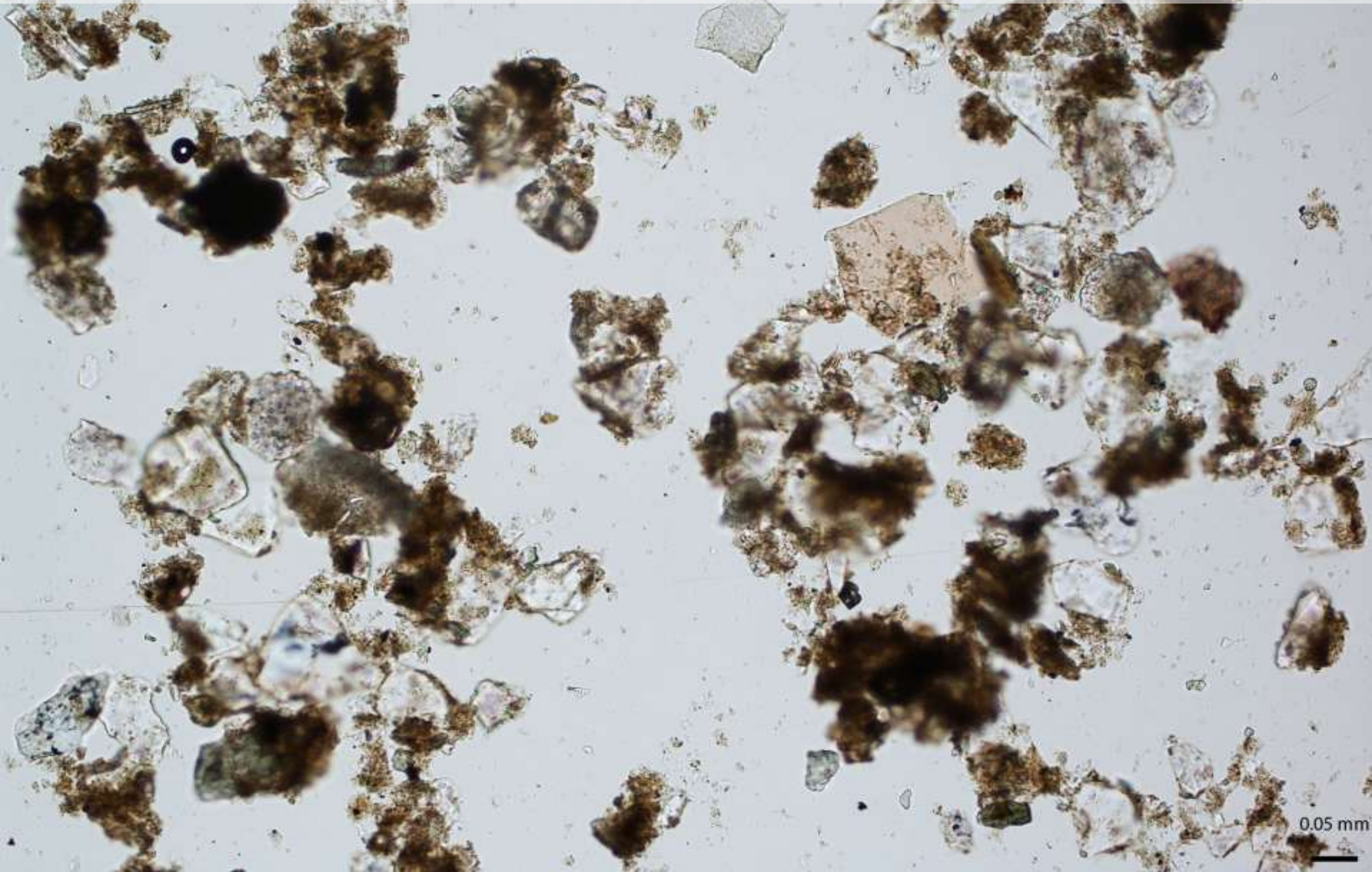
Siliceous ooze (radiolarians, fraction > 63µm) | IODP Exp 320-U1334A-27X-6, 43–45 cm

Wade et al. (2020)
https://doi.org/10.1016/j.earscirev.2020.103403

For the sediments are the materials of most stupendous 'snowfall' the Earth has ever seen..."

— Rachel Carson

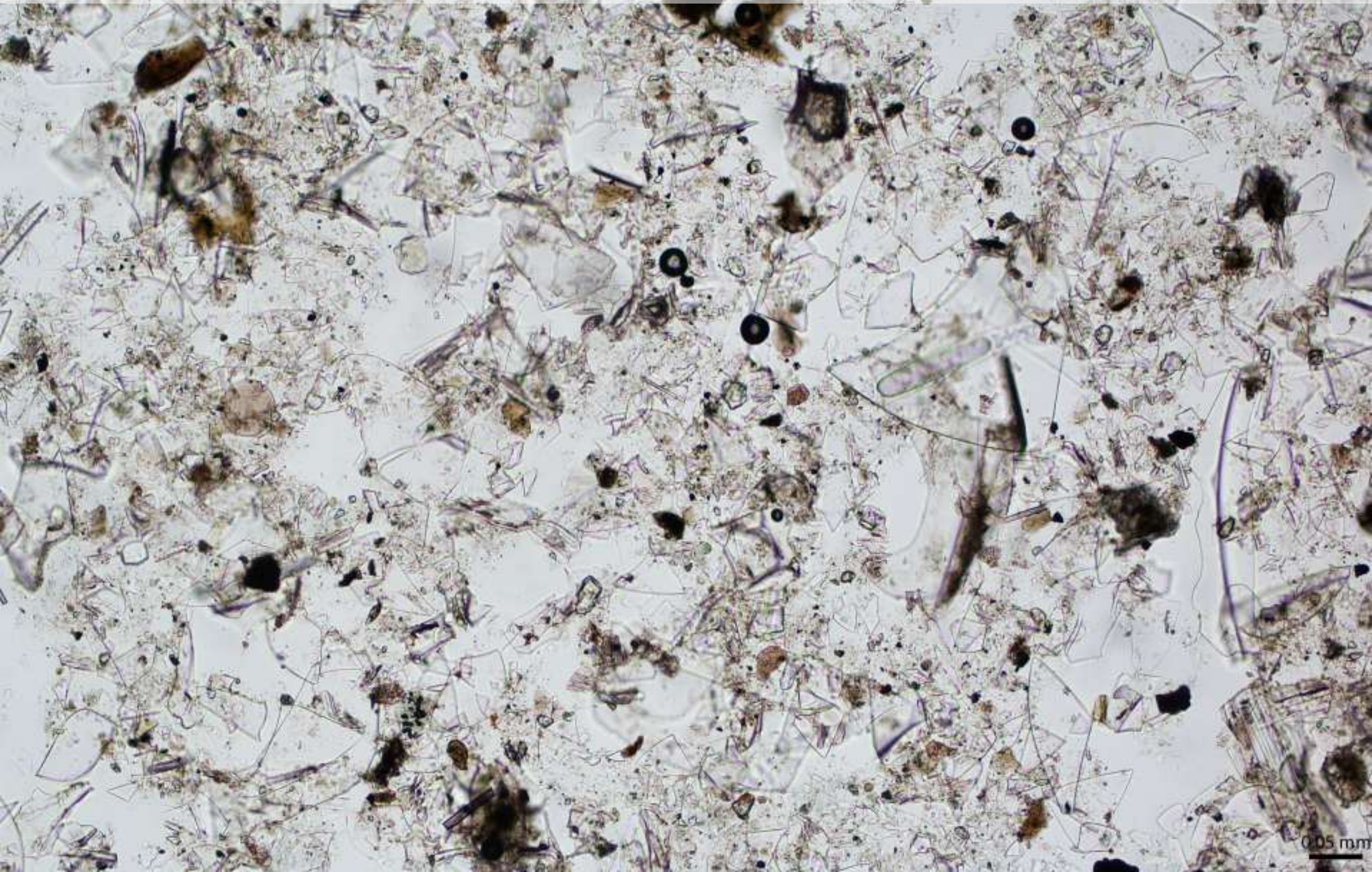
Terrigenous Sediment (Continental shelf quartz grains) | ODP Leg 174-1073A-1H-1,10 cm



For the sediments are the materials of most stupendous 'snowfall' the Earth has ever seen..."

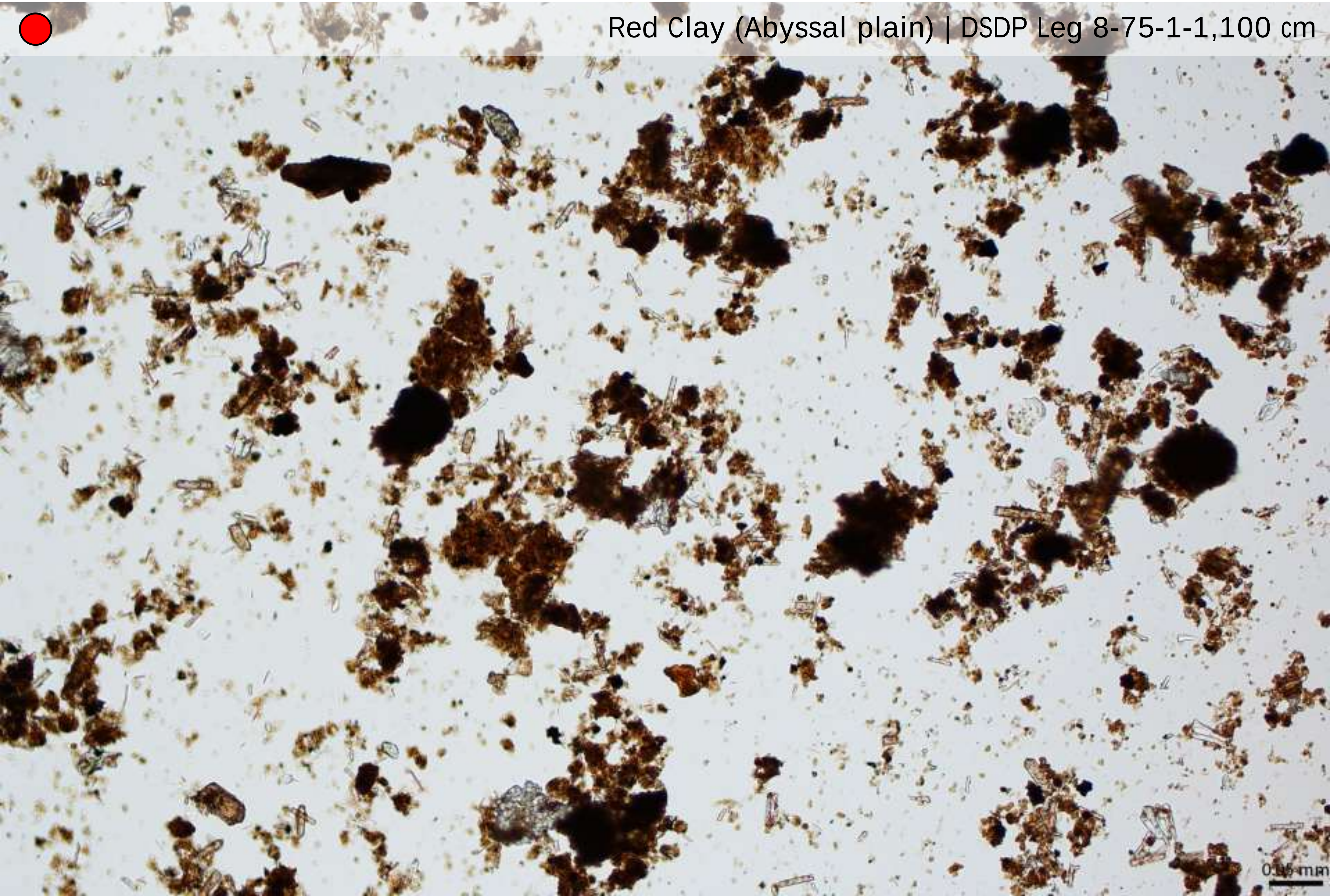
— Rachel Carson

Terrigenous Sediment (volcanic ash) | ODP Leg 152-919A-2H-3,18 cm



For the sediments are the materials of most stupendous 'snowfall' the Earth has ever seen..."

— Rachel Carson



Red Clay (Abyssal plain) | DSDP Leg 8-75-1-1,100 cm

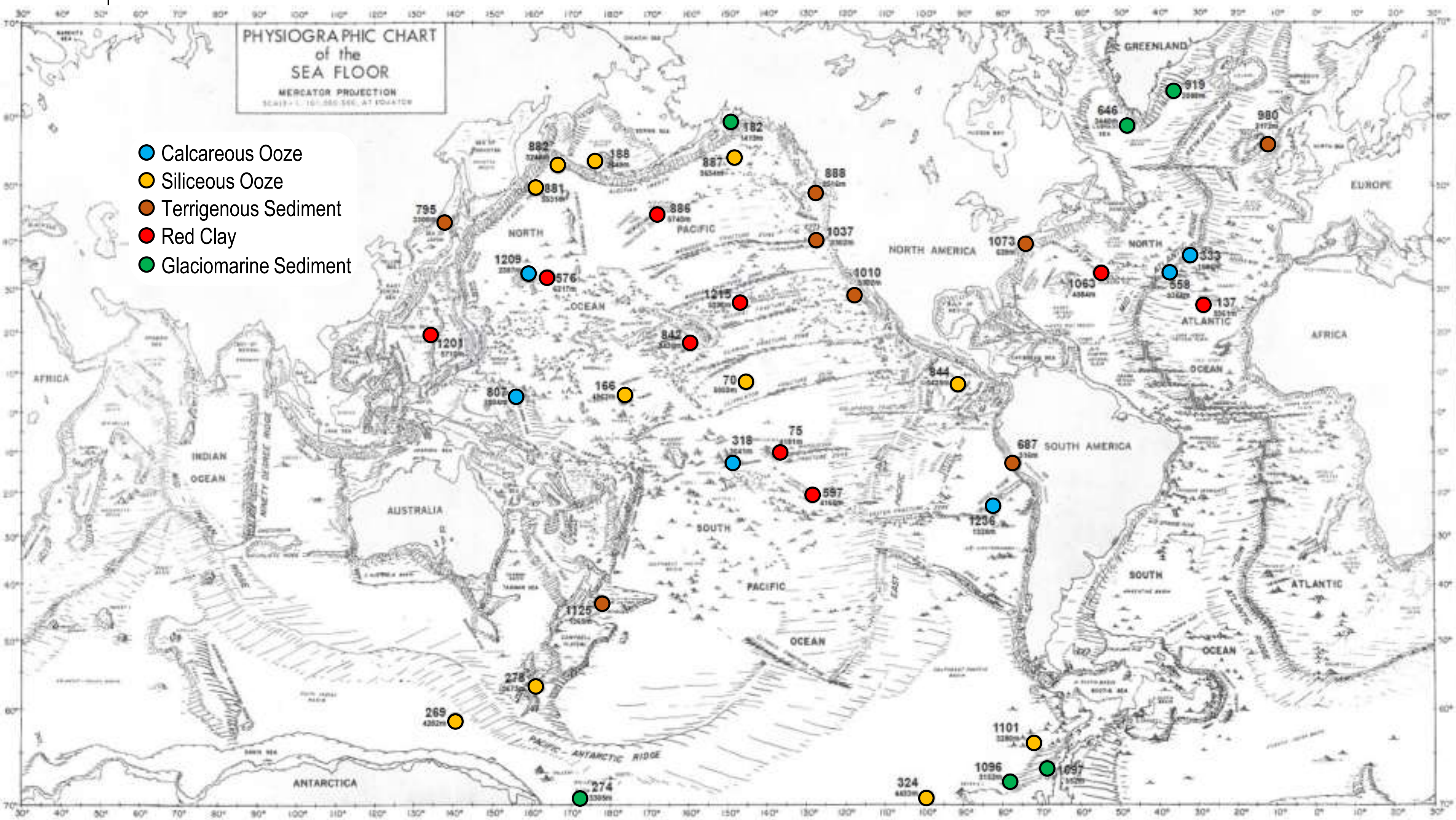
For the sediments are the materials of most stupendous 'snowfall' the Earth has ever seen..."

— Rachel Carson

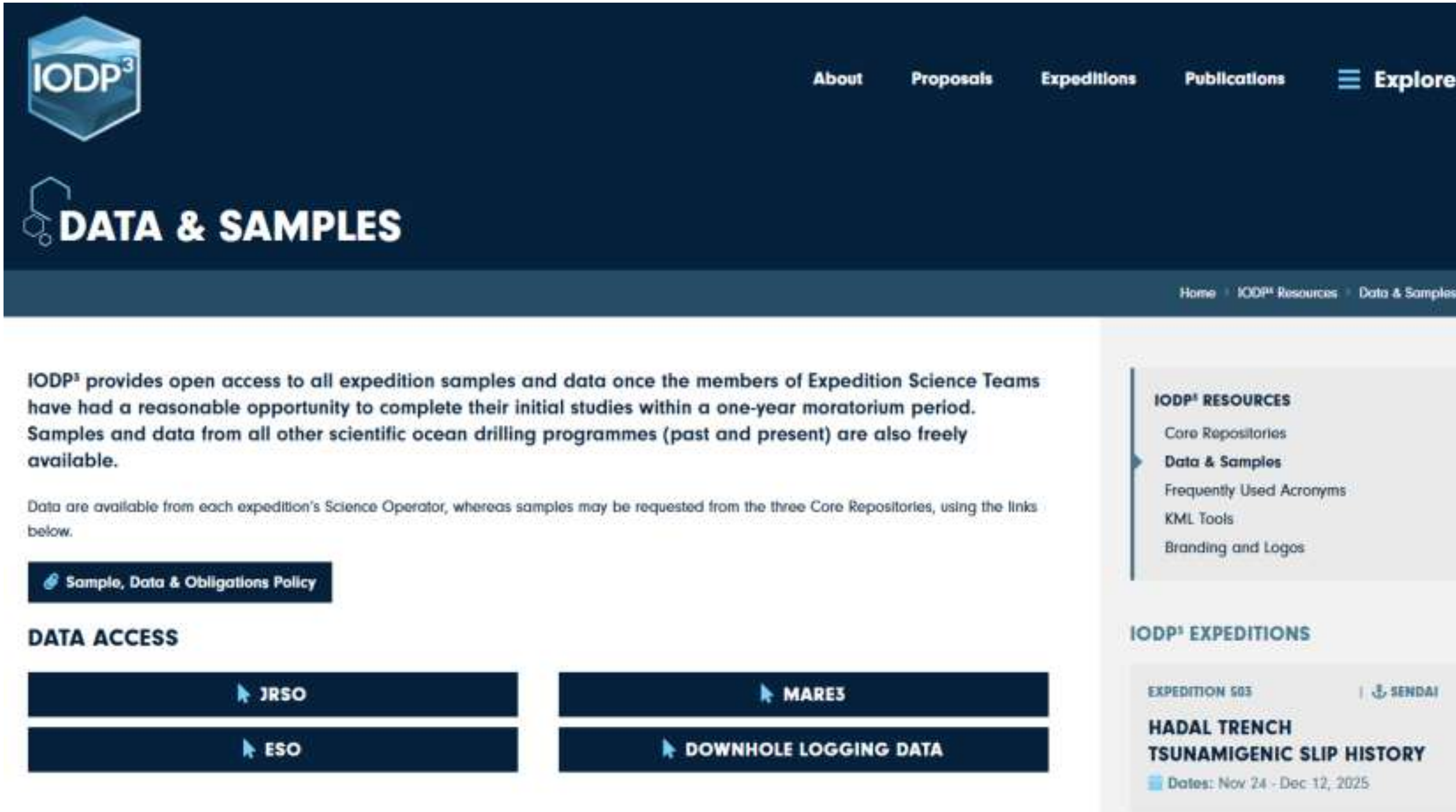
Glaciomarine Sediment (Antarctica) | ODP Leg 178-1101A-2H-2,106 cm

Doing Inquiry-Based Exercises for Lab and Class

Seafloor Sediments | Geographic Distribution and Interpretation

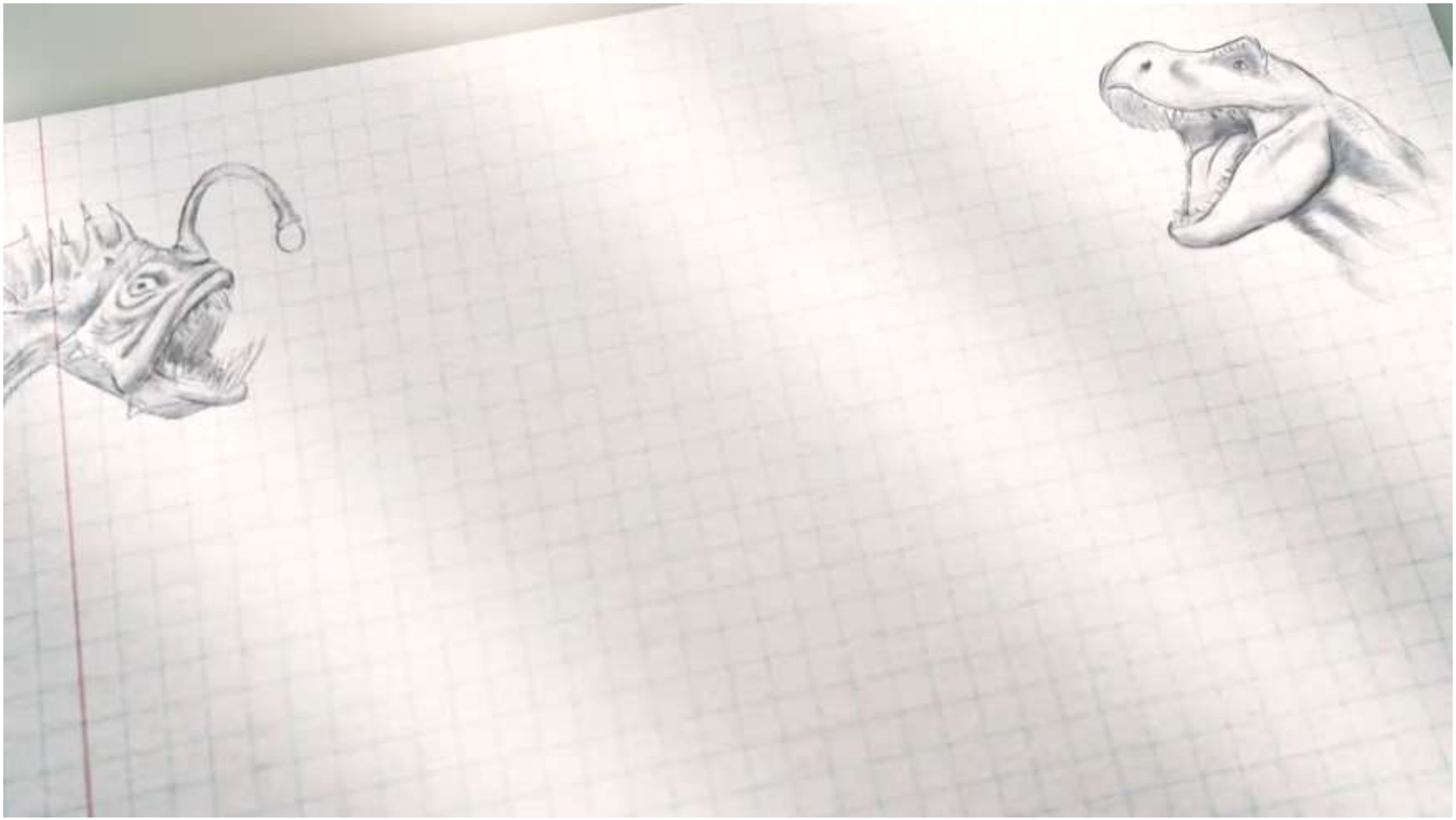


Requesting sediment samples…



…and extracting microfossils

…and extracting microfossils



…and extracting microfossils

...and extracting microfossils

For the sediments are the materials of most stupendous 'snowfall' the Earth has ever seen..."

— Rachel Carson

Using Core Photographs and Digital Images

International Ocean Discovery Program
***JOIDES Resolution* Science Operator**

Home | Expeditions | Participants | Travel & Meetings | Technology | Data | Samples | Publications | Outreach | Related Sites | About | Search

Samples / Sample/Data Request / Core Photographs and Digital Images

Core Samples

Information | Requests | Sample Types | Policies | **Images** | Repositories | Archives | Moratorium

Core Photographs and Digital Images

Whole-Core Photographs

Whole-core photos are available in black-and-white 8 × 10 inch prints, 35-mm color slides, or scanned images (high-resolution TIFF files). Requests can be made to the Data Librarian. Please include the DSDP/ODP/IODP core-naming convention when placing requests (i.e., Leg-Site-Hole-Core). IODP whole-core photos are available only through Expedition 312.

Low-resolution whole-core images (300 dpi; PDF files) can be obtained from the Janus database Core Photo query.

Digital Images of Core Sections

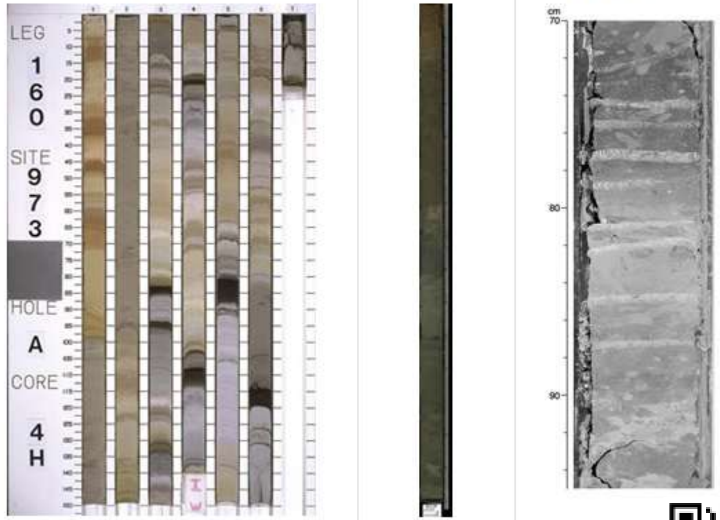
Line-scan digital images of the archive-half core sections captured with the Digital Imaging System can be obtained starting with ODP Leg 198 from the Janus database Core Photo query or LIMS.

Close-up Photographs

Close-up photographs are available in black-and-white 8 × 10 inch prints, 35-mm color slides, or scanned digital images (high-resolution TIF files). Requests can be made to the Data Librarian. Please include the ODP/IODP core-naming convention when placing requests (i.e., Leg-Site-Hole-Core-Section-Top interval). Requests can only be made for close-up photos taken during a cruise. Close-up photos can be obtained starting with DSDP Leg 46 from the Janus database Closeup Photo query or LIMS.

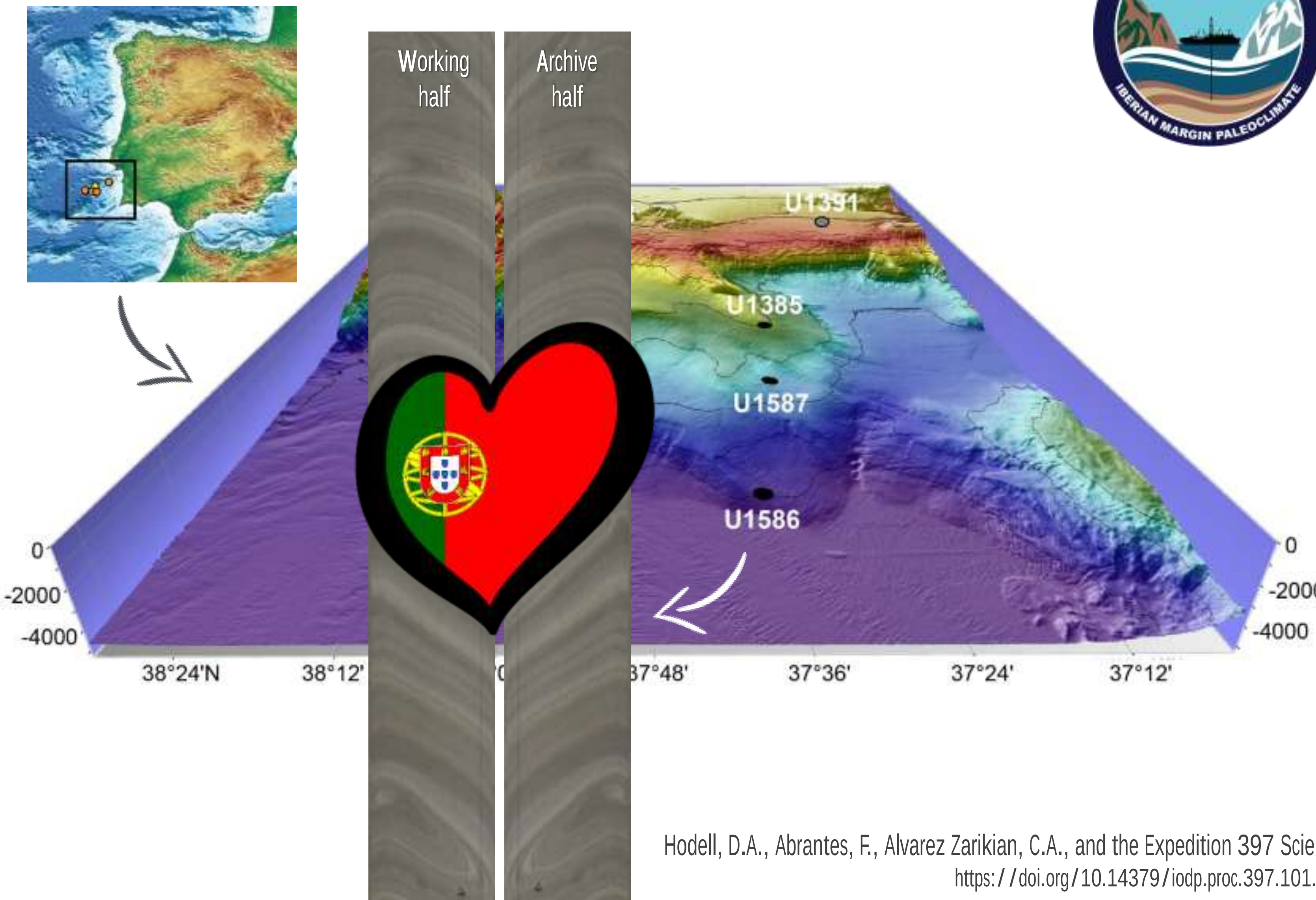
Examples

Whole-core photo	Section scan	Close-up photo



Using Core Photographs and Digital Images

IODP Expedition 397: Iberian Margin Paleoclimate

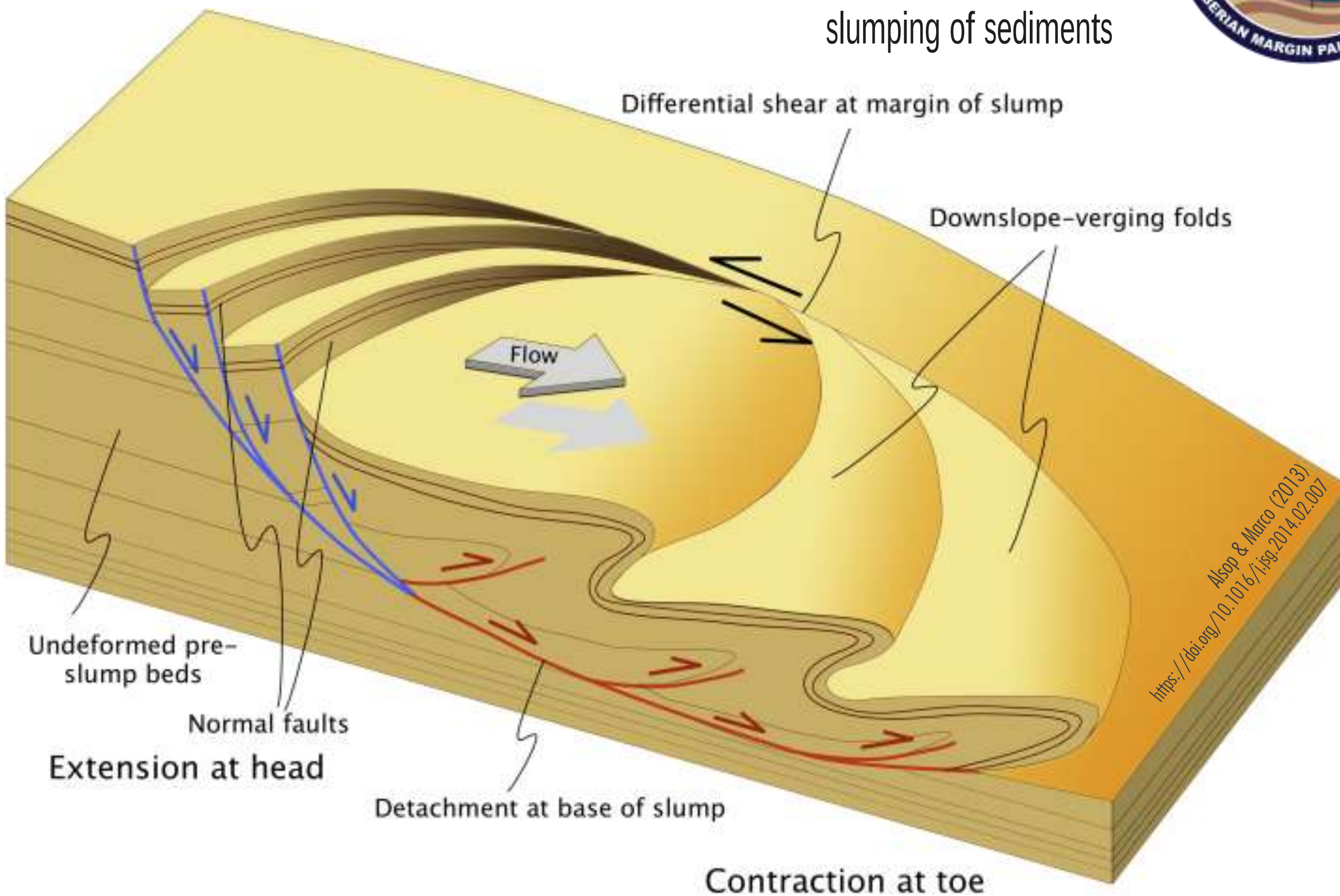


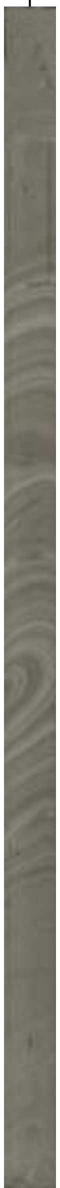
Hodell, D.A., Abrantes, F., Alvarez Zarikian, C.A., and the Expedition 397 Scientists
https://doi.org/10.14379/iodp.proc.397.101.2024

Using Core Photographs and Digital Images

IODP Expedition 397: Iberian Margin Paleoclimate

Schematic 3D cartoon illustrating gravity-driven downslope slumping of sediments





397 U1586A-6H-5

Requesting ODP/IODP core replicas

ECORD
European Consortium for Ocean Research Drilling

ABOUT ECORD ⌄ EXPEDITIONS ⌄ SCIENCE ⌄ OUTREACH ⌄ EDUCATION ⌄ RESOURCES ⌄

Core replica: Chicxulub Impact Sequence I – IODP Expedition 364

Core replica

Chicxulub Impact Sequence I - IODP Expedition 364 Replica of core section: Hole M0077, Core 81R, Section 2IODP Expedition 364 Chicxulub K-Pg Impact Crater Replica of a core drilled in the in rocks from the peak ring of the Chicxulub impact crater in the Gulf of...

Core replica: Chicxulub Impact Sequence II – IODP Expedition 364

Core replica

Chicxulub Impact Sequence II - IODP Expedition 364 Replica of core section: Hole M0077, Core 40R, Section 1IODP Expedition 364 Chicxulub K-Pg Impact Crater Replica of a core drilled in the in rocks from the peak ring of the Chicxulub impact crater in the Gulf of...

Cretaceous-Paleogene (K/Pg) Blake Nose Paleoceanographic Transect

Core replica

Cretaceous-Paleogene (K/Pg) mass extinction boundary Replica of core section: ODP Leg 171B, Hole 1049A, Core 17X, Section 2Expedition: ODP Leg 171B Black Nose Paleoceanographic Transect The core contains evidence (tektites) of a huge meteorite impact at 66Ma ago, the...

Core replica: Paleocene Eocene Thermal Maximum (PETM)

Core replica

Paleocene-Eocene Thermal Maximum (56 Ma) Replica of core section: ODP Leg 208, Hole 1262C - Core 5H, Section 4Expedition: Leg 208 Cenozoic Climate Cycles: Walvis Ridge Transect Replica of a core drilled in the early Cenozoic sediments of the Walvis Ridge, Southern...

Core replica: Tahiti Sea-Level – IODP Expedition 310

Core replica

Coral Reefs off Tahiti Replica of core section: 310-M0024A-10R-01IODP Expedition 310 Tahiti Sea-Level Change Replica of a core drilled in Pleistocene fossil coral reefs off the coast of Tahiti by the ECORD Science Operator, Hole 24A, Core 10R, Section 1.Coral...

Core replica: Arctic Coring – IODP Expedition 302 (ACEX)

Core replica

Arctic Coring - ACEX - IODP Expedition 302 Replica of core section: 302-M0004A-11X-03IODP Expedition 302 Arctic Coring (ACEX) Replica of a core drilled in Eocene sediments of the central Arctic Ocean by the ECORD Science Operator, including the Azolla event, Hole 4A,...

Using Ready-to-use Classroom Activities

CLASSROOM ACTIVITIES

Search the database of more then 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.

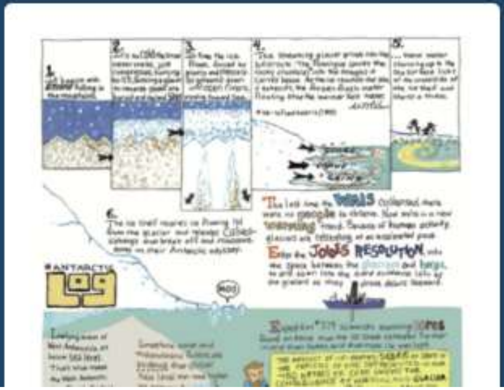
Climate Change

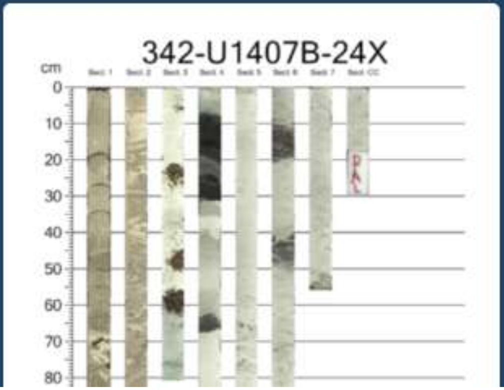
Plate Tectonics

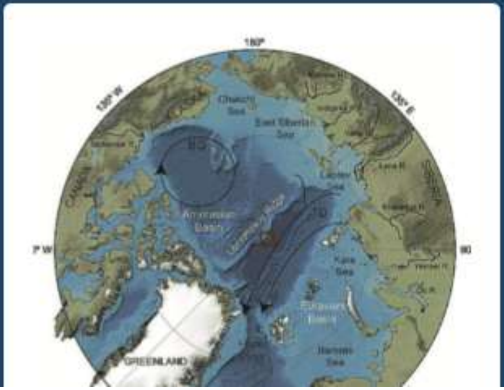
Microbiology

Careers at Sea

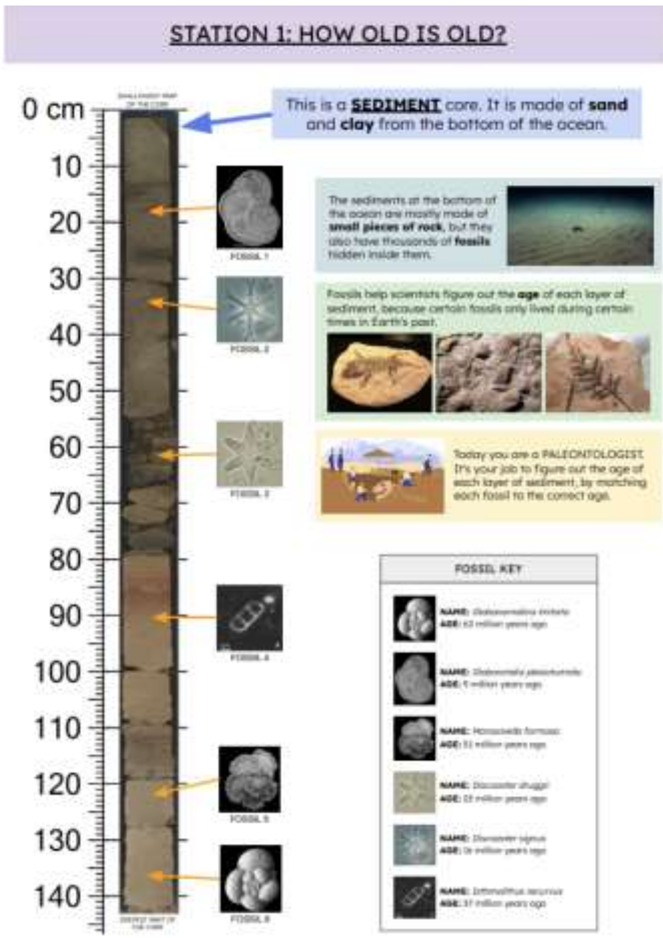
ACTIVITY TYPE | TOPICS COVERED | GRADE LEVEL

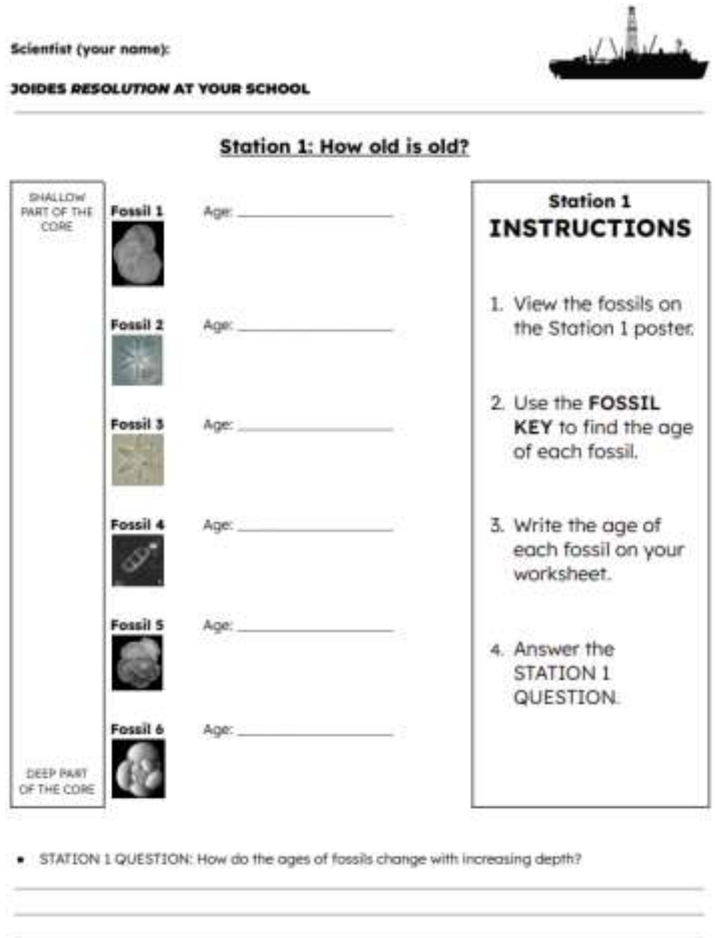






Using Ready-to-use Classroom Activities




Scientist (your name):

JOIDES *RESOLUTION* AT YOUR SCHOOL

Station 1: How old is old?

SHALLOW PART OF THE CORE

Fossil 1 Age: ____

Fossil 2 Age: ____

Fossil 3 Age: ____

Fossil 4 Age: ____

Fossil 5 Age: ____

Fossil 6 Age: ____

DEEP PART OF THE CORE

Station 1

INSTRUCTIONS

1. View the fossils on the Station 1 poster.
2. Use the **FOSSIL KEY** to find the age of each fossil.
3. Write the age of each fossil on your worksheet.
4. Answer the STATION 1 QUESTION.

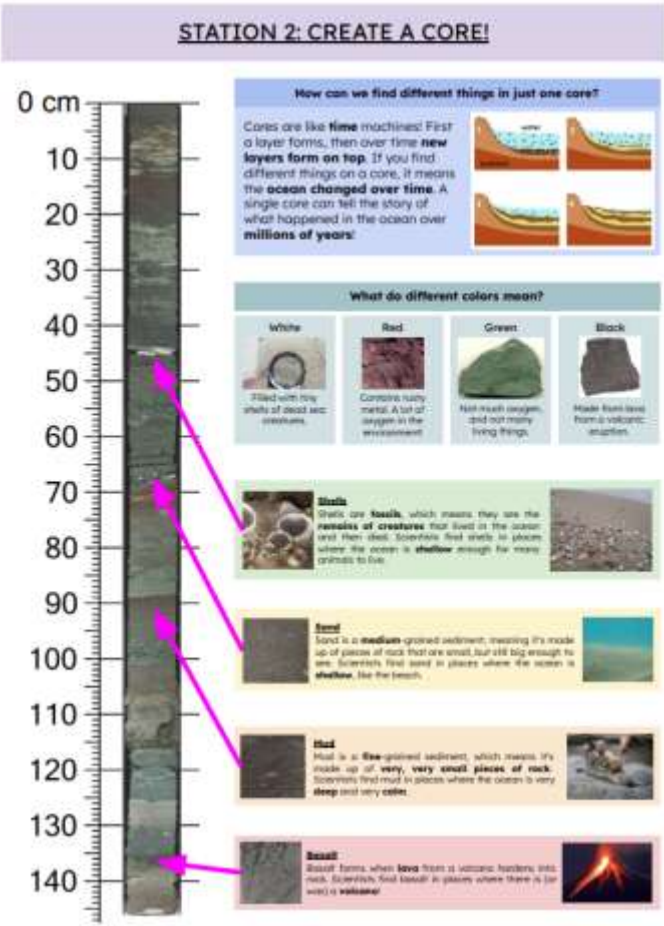
- STATION 1 QUESTION: How do the ages of fossils change with increasing depth?

____

CORES FOR KIDS

Education just for kids Microfossils Sedimentology

Using Ready-to-use Classroom Activities



Station 2: Create a "core"!

YOUR CORE

MOST RECENT

OLDEST

Section 1 Material: ______________

Description: ______________

Section 2 Material: ______________

Description: ______________

Section 3 Material: ______________

Description: ______________

Section 4 Material: ______________

Description: ______________

Station 2
INSTRUCTIONS

1. Read about the different things you can find in a core in the Station 2 poster.
2. Decide what you want each section of your core to be made of.
3. **DRAW** the material on each section of the core in the rectangle on the left of this worksheet.
4. **DESCRIBE** each section of your core.

- **CONCLUSION:** What is your favorite thing you learned today?

____

CORES FOR KIDS

Education just for kids Microfossils Sedimentology

Assembling a paper model of a drillship

From left to right: Hélder Pereira (Portugal), Susan Gebbels (United Kingdom), Markus Fingerle (Germany), Jean-Luc Bérenguer (France) and Norihito Kawamura (Japan)


"That's all Folks!"