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MARINE GEOLOGY

# Advanced School

## *Deep Sea Frontiers*

The deep-sea, Earth's final frontier below 200m, remains largely unexplored. Explore the Earth's least-known realms, delving into the geological intricacies of the deep-sea environment. Uncover the geological processes shaping the seabed, study submarine volcanism, and analyze marine sedimentation. Gain insights into plate tectonics, seismic reflections, and magnetic anomalies, offering a comprehensive understanding of the geological frontiers that lie beneath the ocean depths.

Dates: January 27<sup>th</sup>, 2025 - January 31<sup>th</sup>, 2025

Registration deadline: October 13<sup>th</sup>, 2024

Venue: Area della Ricerca CNR - Bologna, room #216

This Advanced School is intended for motivate undergraduate, graduate, post-doctoral students and young researchers of Earth Sciences

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## THE TOPIC

The School offers an advanced exploration of geological processes within the ocean depths, encompassing the entire life cycle of the oceanic lithosphere, from its formation to its eventual subduction and destruction. Topics covered include the in-depth examination of abyssal regions, exploration of ocean ridges, analysis of sediments, and the study of marine bio-geology in extreme environments, as well as the use of advanced exploration technologies. The ocean deeps play a crucial role in the Earth's interconnected systems, facilitating exchanges of heat and matter between the lithosphere and the oceans. The formation and structure of ocean crust and the rates and pathways of interaction with the oceans depend on spreading and magma supply rates. Oceanic core complexes are expressions of a major mode of crustal accretion at slow-spreading ridges, where upper mantle rocks are exhumed along long-lived, low-angle detachment faults. Understanding the interactions between the oceans and the lithosphere is crucial for comprehending Earth's climate, geology, and ecosystems. Ongoing research continues to unveil the complexities of these interconnected processes and their implications for the planet's health and stability. The course intends to actively involve doctoral students and young researchers in research projects, expanding their design skills towards the challenges of the "Deep Sea".

## THE SCHOOL

The initiative seeks to establish a School of Marine Geology dedicated to the study of geological processes in deep marine environments with an international focus. The School is designed for university students enrolled in the Master's program with a thesis in Marine Geology, as well as for PhD candidates, post-doctoral researchers, and young scholars. It will incorporate laboratory exercises and engaging lectures delivered by globally renowned scientists in the field of Deep Sea Research. Participation in the School will equip attendees with the necessary skills for future involvement in research proposals, specifically focusing on mid-ocean ridge processes and, more broadly, on deep-sea environments. The School will make optimal use of the resources provided by the ISMAR laboratories.

### STEERING COMMITTEE:

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\*Chair

### CONTACTS:

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MATTIA VALLEFUOCO ([mattia.vallefuoco@cnr.it](mailto:mattia.vallefuoco@cnr.it))

## LECTURERS

## TOPIC

Fabio CARATORI TONTINI	<i>Marine heat flow, gravity &amp; magnetics</i>
Christian BERNDT	<i>Seismic data acquisition &amp; Processing</i>
Antonio LANGONE	<i>Rock dating</i>
Elisabetta ERBA	<i>Biostratigraphy</i>
Salvatore PASSARO	<i>Seafloor mapping data acquisition</i>
Alessandro BOSMAN	<i>Seafloor mapping data processing</i>
Fabian BONETTI	<i>ROVs, AUVs, and manned submersible</i>
Marcia MAIA	<i>Plate tectonics and seafloor spreading</i>
Xavier ESCARTIN	<i>MOR, faulting, detachment faults &amp; hydrothermal activity</i>
Javier Hernández MOLINA	<i>Deep-sea sedimentary processes</i>
Daniele BRUNELLI & Alessio SANFILIPPO	<i>Geochemistry of oceanic lithosphere</i>
Gert DE LANGE	<i>Sediment geochemistry</i>
Chiara BOSCHI	<i>Fluid circulation</i>
Gert DE LANGE	<i>Sapropels: Climate, Oceanography and Paleoenvironment</i>
Paolo MONTAGNA	<i>Geochemical proxies for paleoclimate reconstructions</i>
Marco TAVIANI	<i>Marine Geology and the Biosphere</i>
Luca LANCI	<i>From Rocks to Rotation Poles: Insights from Paleomagnetism</i>
Lisa MCNEIL	<i>Deep sea hazards</i>
Marzia ROVERE	<i>Deep sea resources</i>

## PRACTICAL EXERCISES – SEAFLOOR DYNAMICS: INSIGHTS FROM GEOPHYSICAL DATA

Fabiano GAMBERI/Federica FOGLINI/Giovanni DE ALTERIIS/Gemma AIELLO

## PRACTICAL EXERCISES – GROUND TRUTHING: ANALYSIS OF DEEP-SEA CORES

Hernández MOLINA/Fabiano GAMBERI/Alina POLONIA/Alessandra ASIOLI

## PRACTICAL EXERCISES – ROCK GEOCHEMISTRY & GEODYNAMICS

Alessio SANFILIPPO/Daniele BRUNELLI/Luca LANCI/Marco LIGI

## FEATURED LESSON - TYRRHENIAN SEA IODP LEG 402 – PRELIMINARY RESULTS

Nevio ZITELLINI

## FEATURED LESSON – NORTH ATLANTIC IODP LEG 403 – PRELIMINARY RESULTS

Renata Lucchi

# CHALLENGES IN MARINE GEOLOGY

Marine geology, the study of the Earth's oceanic crust and sediments, presents several challenges due to the harsh and inaccessible nature of the marine environment. Some of the key challenges in marine geology include:

1. **Inaccessibility and Depth:**

The majority of the Earth's surface is covered by oceans, and much of it is deep and difficult to access. Conducting research and collecting samples at extreme depths poses logistical and technological challenges.

2. **Extreme Pressure:**

The pressure in deep-sea environments increases with depth, creating challenges for equipment design and durability. Instruments and sampling devices must withstand high pressures without compromising data accuracy.

3. **Remote Sensing:**

Large portions of the seafloor remain unexplored or are difficult to access. Remote sensing technologies, such as sonar and satellite imagery, are essential for mapping and studying the ocean floor, but limitations still exist in resolution and coverage.

4. **Sample Collection:**

Collecting samples from the seafloor is challenging due to the depth, pressure, and complex geologic features. Specialized equipment, such as remotely operated vehicles (ROVs) and autonomous underwater vehicles (AUVs), is required to gather sediment cores, rocks, and other geological samples.

5. **Corrosive Environment:**

The marine environment can be corrosive, affecting the durability of equipment and instruments. Researchers must use materials that can withstand the corrosive effects of seawater.

6. **Limited Direct Observation:**

Unlike terrestrial geology, where researchers can directly observe and study rock formations, marine geologists often rely on indirect methods. Interpretation of seismic data, sediment cores, and other proxies are used to reconstruct geological processes.

7. **Data Integration:**

Data collection in marine geology involves a variety of techniques, such as seismic surveys, sediment coring, and bathymetric mapping. Integrating data from different sources and disciplines can be challenging but is crucial for a comprehensive understanding of marine geological processes.

8. **Environmental Impact:**

Conducting research in the marine environment can have environmental impacts. Care must be taken to minimize disturbance to ecosystems, and ethical considerations must be addressed, especially in sensitive areas.

9. **Tectonic Plate Boundaries:**

Many key geological processes, such as plate tectonics and subduction, occur beneath the ocean. Accessing and studying tectonic plate boundaries, where these processes are most active, is challenging due to their depth and the dynamic nature of these regions.

10. **Climate Change Impacts:**

Understanding the impact of climate change on marine geology requires data collection for a long-term monitoring (paleoceanography). Changes in sea level, ocean temperature, and sedimentation patterns must be studied to assess the effects on the marine environment.

Despite these challenges, advancements in technology and ongoing research efforts continue to expand our understanding of marine geology, contributing to our knowledge of Earth's dynamic processes.

# PROGRAM

## Day 1: INTRODUCTION TO MARINE GEOLOGY

- **Morning: registration, introduction to the school**  
08:00–09:00 Welcome and Registration  
09:00–09:30 Introduction to the School and Agenda

## METHODOLOGIES FOR THE EXPLORATION OF THE DEEP-SEA

- **Morning: Exploring the Seafloor**  
10:00–11:30 Age Determinations: Rock and sediment dating techniques  
11:30–13:00 Biostratigraphy
- **Afternoon: Exploring the Seafloor**  
14:00–16:00 Seismic Reflection and Refraction: Data acquisition & processing  
16:30–18:00 Heat Flow, Gravity and Magnetics: Data acquisition & processing  
18:00–20:00 Icebreaker Activities

## Day 2: METHODOLOGIES FOR THE EXPLORATION OF THE DEEP-SEA (CONTINUED)

- **Morning: Exploring the Seafloor**  
08:30–10:30 Seafloor Mapping: Data acquisition & processing  
11:00–13:00 ROVs, AUVs, and Manned Submersibles
- **Afternoon: Deep Sea Exploration in Practice**  
14:00–14:30 A Gateway to Ocean Exploration: ECORD/IODP-Italia  
14:30–15:15 Featured Lesson: Tyrrhenian Sea IODP Leg 402 - Preliminary Results  
15:15–16:00 Featured Lesson: Eastern Fram Strait IODP Leg 403- Preliminary Results  
16:30–18:30 Seafloor Dynamics: Insights from Multibeam & Seismic Data Analysis

## Day 3: GEOLOGY OF THE DEEP SEA

- **Morning: Plate Tectonics: How the Earth Works**  
08:30–10:30 Plate Tectonics and Seafloor Spreading  
11:00–13:00 Mid-ocean ridges, Faulting, Detachment faults & Hydrothermal activity
- **Afternoon: Transfer and Storage of Matter, Chemicals and Energy**  
14:00–16:00 Deep-Marine Sedimentary Processes & Systems  
16:30–18:30 Ground Truthing: Analysis & Interpretation of Deep-sea Cores

## Day 4: GEOLOGY OF THE DEEP SEA (CONTINUED)

- **Morning: Geochemical Processes in Seafloor Environments**  
08:30–10:30 Major, Trace and Isotopes Geochemistry of Oceanic Lithosphere  
11:00–13:00 Geochemistry of Sediments
- **Afternoon: Geochemical Processes in Seafloor Environments**  
14:00–16:00 Fluid Circulation: Seawater Interactions with Rocks and Sediments  
16:30–18:30 Geochemistry & Geodynamics in Practice: Implications in Reconstructions

## Day 5: IMPORTANCE & INTERDISCIPLINARY CONNECTIONS OF MARINE GEOLOGY

- **Morning: Marine Geology and Life**  
08:30–09:30 Sapropels: Climate, Oceanography and Paleoenvironment  
09:30–10:30 Geochemical Proxies for Paleoclimate Reconstructions  
11:00–12:00 Marine Geology and Biosphere  
12:00–13:00 From Rocks to Rotation Poles: Insights from Paleomagnetism
- **Afternoon: Hazards and Resources**  
14:00–15:30 Geological Hazards in the Deep Sea  
16:00–17:00 Deep Sea Resources  
17:00–17:30 Closing Remarks

## ICEBREAKER ACTIVITIES (DAY 1, 18:00–20:00)

The proposed activities include a mini conference for the participants, where students present very short talks (max 3 min) on their recent activities or illustrate their posters. This allows the sharing of the students' backgrounds and areas of interest or research, and it also helps the lecturers to evaluate students' level and focus.

## REGISTRATION

Candidates must fill in the application form and send it with all supporting documents in digital form, including the relevant certificates and transcripts of previous studies, to xxx@cnr.it, from September 1<sup>st</sup>, 2024 and no later than October 13<sup>th</sup>, 2024. Only complete applications will be assessed. Incomplete applications may be rejected without further notification. A complete application consists of:

1. Personal information about the applicant (family name, name, date of birth, place of birth, nationality, address) as reported in the registration form.
2. Diploma and transcripts (diploma supplement or list of the subjects taken during the study and correspondent marks).
3. Motivation letter (in English) – the letter should present the applicant's motivation to enroll the School, including the competencies and skills he/she would like to achieve, future perspectives and aspirations.
4. An extended abstract of their research activity also in the context of their Master's or Doctoral thesis to be shown as poster in a dedicated space within the School.
5. Curriculum Vitae (CV) with information about relevant experience and professional training (relevant courses, workshops, seminars, etc. can also be included).
6. Up to a maximum of 30 participants will be admitted to the course. Registrations beyond this maximum will be placed on a waiting list.
7. The course fee is €350 including daily lunches, coffee-breaks and social dinner.. Travel, accommodation and other meals must be covered by the participants. Confirmation of Registration will be sent once the registration fee has been paid via the appropriate link (communicated via email) starting from October 14<sup>th</sup> to October 27<sup>th</sup>, 2024.
8. Up to a maximum of 5 scholarships covering school fee, travel and accommodation will be awarded to the most deserving Masters and PhD students. The members of the Steering Committee will be part of the Commission for the assignment of scholarships, basing the evaluation on the CV and motivation letter of the applicants, with priority for Master's students. The registration fee will be refunded to the scholarship winners.