



# INTERNATIONAL OCEAN DRILLING PROGRAMME

## PROPOSAL 1108-S

ENIGMA: Exploration Into a Global early  
Miocene Anomaly

# IODP<sup>3</sup> Proposal Cover Sheet

## Proposal Title:

ENIGMA: ExploratioN Into a Global early Miocene Anomaly

## Project Abstract

The Miocene Epoch (23.03–5.33 Ma) was a pivotal period of climate and biosphere evolution, yet the early Miocene (23–17 Ma) remains poorly understood due to a scarcity of high-resolution records. Recent studies suggest that around 19 Ma, a major but enigmatic biotic and environmental shift occurred, marked by significant declines in shark diversity, restructuring of marine vertebrate communities, and widespread planktonic and benthic ecosystem changes across trophic levels. These shifts coincided with geochemical anomalies, including a contraction of tropical oxygen-deficient zones, disruptions in primary productivity, and isotopic signals indicative of climate perturbations. The underlying mechanisms driving these changes remain unclear, as do their broader implications for oceanic ecosystem evolution as a whole. The ENIGMA project aims to resolve the causes and consequences of this early Miocene anomaly by analyzing comprehensive marine sediment records. By integrating micropaleontological, geochemical, and sedimentological data from legacy scientific ocean drilling cores, we will assess how paleoceanographic changes influenced primary productivity, nutrient cycling, and marine biodiversity. A focus on complete early Miocene sequences, particularly in the Atlantic sector, will provide a basin-wide perspective on these transformations. Our findings will enhance understanding of the early Miocene's role in shaping the modern ocean system and contribute critical insights into ecosystem resilience and climate change dynamics over geological timescales.

## Scientific Objectives

- Scientific Objective 1: Refine chronostratigraphic age models of all studied records to assess synchronicity of oceanographic and biotic changes during the early Miocene.
- Scientific Objective 2: Generate and synthesize records of early Miocene environmental change in the Atlantic Ocean
- Scientific Objective 3: Collate and create records of early Miocene biotic change
- Scientific Objective 4: Assess the collective response of marine organisms to environmental changes using ecologically-motivated statistical and mechanistic models

As we pursue each of these scientific objectives, we will leverage the diverse expertise within our proponent and collaborator team and provide training to the next generation of scientific ocean drilling scientists.. We will also pay special attention to the inclusion of scientists with historically excluded identities in STEM.

## Science Communication Plain Language Summary

Earth's climate has changed dramatically through geological time, shaping marine ecosystems and influencing biodiversity as we see it today. One of the most mysterious periods of change may have occurred around 19 million years ago, during the early Miocene Epoch, when ocean life experienced a sudden shift. It is suspected that changes in climate, ocean circulation, or nutrient cycling may have triggered this event, but the exact causes remain unknown.

The ENIGMA project seeks to uncover what happened by analyzing ancient seafloor sediments. These sediments contain a comprehensive archive of fossils and geochemical clues that can help us reconstruct past ocean conditions. By studying these records, we can understand how marine ecosystems responded to past climatic changes and use that knowledge to improve predictions of future ocean conditions and ecological resilience. Understanding how modern marine biodiversity came to be, and what causes it to change is critical for refining climate models. This will inform conservation efforts and ensure the sustainability of vital ocean resources like fisheries for future generations.

Beyond scientific discovery, ENIGMA is committed to training the next generation of ocean scientists. Team members will gain hands-on experience in data management, analysis, and international collaboration. The project will also promote diversity and inclusion by actively involving researchers from historically underrepresented backgrounds and ensuring accessibility for scientists who may have been excluded from traditional ocean drilling expeditions.

Public engagement is also a key part of ENIGMA. The team will share findings through social media, blogs, museum exhibits, and educational activities designed for students and teachers. Partnerships with outreach organizations, such as Time Scavengers, will help make climate and ocean science more accessible to global audiences. Additionally, team members will work with policymakers to guarantee that research findings contribute to informed decision-making about climate change and ocean conservation. By investigating an ancient climate mystery, training future scientists, and engaging the public, ENIGMA aims to expand our understanding of Earth's past while helping to safeguard its future.