IODP³ INTERNATIONAL OCEAN DRILLING PROGRAMME

PROPOSAL 1111-PRE

Tracing climate-driven Interactions of Microbes and Organic carbon in Records of carbonate sediments (TIMOR)

IODP^3 Proposal Cover Sheet

Proposal Title:

Tracing climate-driven Interactions of Microbes and Organic carbon in Records of carbonate sediments (TIMOR)

Broad Geographic Area of the Proposal

North Australian (Sahul) shelf

Project Abstract

This proposal aims to investigate how climate variability influences microbially mediated carbon burial and diagenetic alteration of palaeoenvironmental signals in carbonate shelf sediments. Microbial redox zones in the upper sediment column act as diagenetic filters, regulating carbon flux and reshaping the fidelity of ecological and climatic proxies. These zones respond dynamically to organic carbon input and sedimentation rates, both of which are modulated by climate. Following the Early–Mid Pleistocene Transition (EMPT; 700–1250 ka), amplified climate variability and sea-level fluctuations likely reorganized diagenetic processes, altering carbon burial efficiency and proxy preservation.

TIMOR targets the Sahul Shelf in the Timor Sea–a carbonate platform uniquely suited for studying these interactions due to its extensive spatial coverage, well-documented palaeoenvironmental history, and sensitivity to glacial–interglacial sea-level changes. By recovering a continuous two-million-year sedimentary archive spanning the EMPT, we aim to (1) characterize microbial ecosystem dynamics within redox zones, (2) determine how microbially driven changes in alkalinity and pH influence carbonate dissolution and cementation, (3) assess the impact of these processes on carbon burial under Quaternary climate variability, and (4) assess spatio-temporal patterns of palaeoenvironmental signal loss during diagenesis across glacial cycles and burial depths.

Our approach integrates microbiology, sedimentology, and geochemistry through scientific ocean drilling using a Mission Specific Platform equipped with advanced coring technology to recover early diagenetic features. This strategy enables direct sampling of microbial communities and diagenetic transitions, overcoming limitations of previous expeditions. Insights from TIMOR will refine models of carbon cycle feedbacks during major climate transitions, improve interpretations of palaeoclimate records, and inform projections of future carbon burial dynamics on marine shelves–critical $CaCO_3$ depocenters and long-term carbon reservoirs.

By elucidating the interplay between microbial processes, carbonate diagenesis, and climate variability, TIMOR addresses fundamental questions about the completeness of the geological record and the resilience of carbon storage in shallow marine environments under changing climate regimes.

Scientific Objectives

(1) Identify microbial ecosystem dynamics and their influence on carbon burial within sediment redox zones.
(2) Determine how microbially driven changes in alkalinity and pH alter carbonate sediments and filter ecological and climatic signals.
(3) Assess the impact of objectives (1) and (2) on carbon burial under Quaternary climate and sea-level variability.
(4) Assess spatio-temporal patterns of palaeoenvironmental signal loss during diagenesis across glacial cycles and burial depth.

Science Communication Plain Language Summary

The TIMOR proposal will set out to answer an important question: how does climate change affect the way carbon is stored beneath the ocean floor? Carbon storage in marine sediments is a key part of Earth’s long-term climate system because it helps regulate the amount of carbon dioxide in the atmosphere. However, the processes that impact this carbon dioxide sink are still poorly understood, especially in the shallow seas of the tropics.

When sediments are deposited on the seafloor, microbes living on and below the seafloor break down organic matter. This activity changes the chemistry of the sediment, sometimes dissolving carbonate minerals in the sediment and sometimes causing new minerals to form. These changes can “rewrite” the original environmental signals recorded in the sediments, making it harder for scientists to reconstruct past climates. Understanding these processes is critical because they influence both the stability of carbon in sediments and the palaeo-environmental information stored in the geologic record.

TIMOR focuses on the Sahul Shelf in the Timor Sea, off northwestern Australia. This region is ideal to study these processes because it has a long history of strong climate variability and sea-level changes, especially over the last 2 million years in the Pleistocene epoch. A major shift called the Early–Mid Pleistocene Transition (EMPT) occurred about 700,000 to 1.2 million years ago, when cyclic climate changes became more extreme. We think this transition changed how carbon was buried and how sediments were altered by microbes.

To test this idea, TIMOR aims to drill deep into the seafloor to recover sediment cores spanning two million years. These cores will allow scientists to study microbial communities, chemical changes, and physical features of the sediments. By combining microbiology, geochemistry, sedimentology, and climate science, the project will reveal how microbial processes interact with climate-driven changes in sedimentation and carbon flux.

The results will help us understand how carbon burial on continental shelves responds to climate change – knowledge that is vital for predicting future carbon cycle feedbacks. It will also improve the accuracy of climate reconstructions, which depend on signals preserved in marine sediments. Ultimately, TIMOR will shed light on the resilience of Earth’s carbon storage systems and their role in shaping global climate over long timescales.