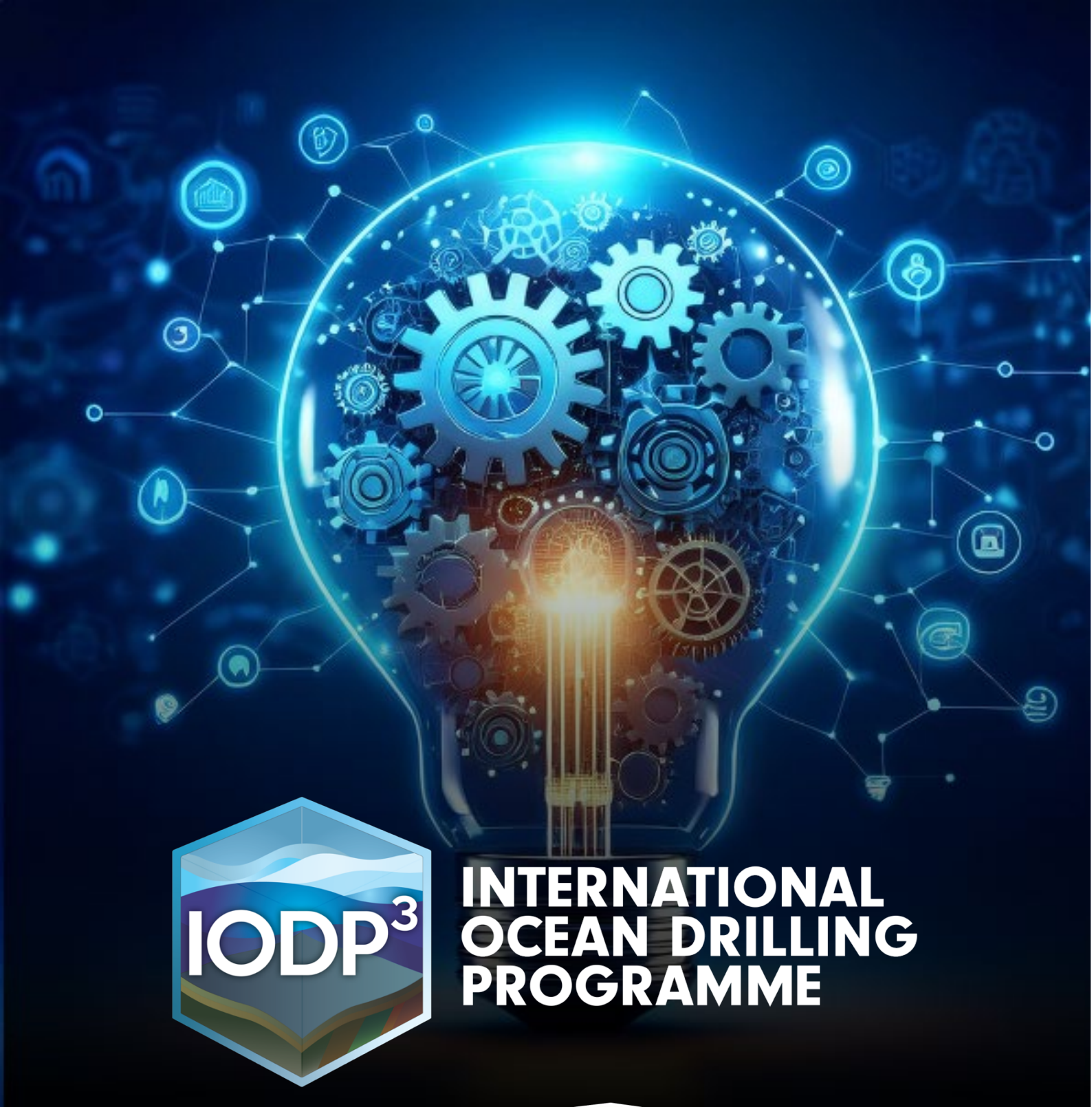

INTERNATIONAL OCEAN DRILLING PROGRAMME

# PROPOSAL 1114-FULL

# Rhythms of Volcanic Ash and Impacts on Subseafloor Diagenesis, Microbiology, and Land-Sea Ecosystems

# IODP$^3$ Proposal Cover Sheet

## Proposal Title:

Rhythms of Volcanic Ash and Impacts on Subseafloor Diagenesis, Microbiology, and Land-Sea Ecosystems

## Broad Geographic Area of the Proposal

Pacific Ocean, near Southern Mexico and Central America

## Project Abstract

Explosive volcanic ash erupted at convergent plate boundaries is a driver of Earth-system processes, linking deep-Earth dynamics to climate, biogeochemical cycles, and ecosystems across the land-sea continuum. Forecasting volcanic geohazards is essential for protecting society, but the drivers and rhythms of eruptions are not well understood and limit predictive models. Alteration of volcanogenic material in marine sediment play an important role in the subseafloor biosphere and carbon cycling/storage with consequences that may impact climate, but the mechanisms driving these reactions are unclear. Furthermore, volcanic ash can disrupt or fertilize terrestrial and marine ecosystems, but its role in past ecosystem upheavals is not well constrained. Despite its importance, there is still much to be understood about the rhythms and impacts of volcanic ash in each of these Earth systems.

This proposal aims to core Quaternary-age marine sediment from the Pacific Ocean offshore the volcanic arcs of Southern Mexico and Northern Central America and adjacent to the Middle America Trench – one of the most dynamic convergent margins on Earth. On land, the terrestrial ecosystem is the Nearctive-Neotropical Transition Zone, a unique region where flora and fauna from North America and South America converge. Lacustrine sediment archives preserve shorter-term Holocene records, with a few extending back 400 ka. But, marine sediment cores are necessary for older, continuous archives of ash deposition, turbiditic events, and sedimentary biogeochemical alteration. The ash-rich marine sediment in the Pacific Ocean integrates signals from explosive volcanism, tectonic coupling, climate variability, and diverse ecosystems from land and sea environments.

The proposed drilling program aims to test nine hypotheses grouped into three themes unified by volcanic ash: (1) Diverse pathways for ash alteration and the deep biosphere, (2) Rhythms, magnitude, and mechanisms of tectonics and explosive volcanism, and (3) Bridging land and sea – biogeographic evolution of Nearctic-Neotropical Transition Zone. By combining sedimentology, tephrochronology, geochemistry, microbiology, and paleoecology, the proposal spans from deep-Earth processes to surface environments and life, advancing all seven strategic objectives of the Science Ocean Drilling 2050 Science Framework related to geohazards, global cycles of matter, habitability, and Earth-system feedbacks. The resulting research will reveal the rhythms of volcanic activity, role of volcanic ash in deep sea carbon preservation, impacts on microbial communities of the deep biosphere, and decipher the influence of external factors modulating volcanic hazards, improving predictions of future explosive volcanic hazards and their terrestrial and marine ecological impacts.

## Scientific Objectives

The proposed work will recover marine sediment to test the following hypotheses:
H1a: The presence of reactive silicates in volcanogenic material and the diagenetic environment in the host sediment determine whether CO2 is released or sequestered as an authigenic carbonate.
H1b: Microbial abundance, composition, and activity are controlled by the presence of volcanogenic material and its degree of alteration and/or diagenesis.
H1c: Enhanced reactive silicate and organic carbon input shapes distinct microbial communities and activities in the trench.
H2a: The rhythms of volcanic activity from the Mexican and Northern Central American volcanic arcs are correlated with glacial-interglacial cycles and/or tectonic events.
H2b: Paleoseismicity along the Middle America Trench, recorded by turbiditic event layers in offshore sediments, exhibits patterns that reflect variations in subduction coupling and may correlate with volcanic activity cycles.
H2c: The occurrence of highly explosive (Plinian) mafic eruptions is controlled by plate margin settings (e.g. slab dip, incoming plate structure and composition) rather than by internal processes (ascent rate, crystallization, gas content) alone.
H3a: During the Quaternary, glacial-interglacial cycles drove latitudinal range shifts of Nearctic and Neotropical plant taxa in the tropical Americas that resulted in structural and compositional changes of vegetation.
H3b: Tephra-forming events are followed by an initial decline in vegetation productivity associated with atmospheric perturbations, and a subsequent increase in biomass driven by large-scale fertilization.

H3c: Volcanic ash deposition, modifies seafloor habitats, causing declines in benthic abundance, shifts in community composition, and delayed recolonization that scale with ash thickness and sediment properties.

## Science Communication Plain Language Summary

Volcanic ash plays a key role in interconnected Earth systems including the biosphere, atmosphere, tectonics, climate, and society. Despite its importance, fundamental questions remain regarding the production, reactivity, and long-term fate of volcanic ash in marine environments. Given the significant societal impacts of hazardous eruptions and the role of ash alteration in global elemental cycles, understanding the biological, chemical, and physical processes that control eruption frequency, size, and downstream impacts is a pressing scientific challenge.

The Mexican and Central American Volcanic Arcs are amongst the most active volcanic and seismic margins on Earth. Winds from the east blow erupted materials from volcanoes into the Pacific Ocean. The ash deposited in marine sediments become archives of the area’ s eruption and climatic history; host diverse microbial and geochemical environments; and record the impacts of volcanic events on both land-based and marine biological communities.

We propose to collect marine sediment from the Pacific Ocean offshore the tectonically complex Southern Mexico and Central America and address four research goals: 1a) examine how volcanic ash alteration and the subseafloor environment contributes to carbon storage in marine sediments; 1b) evaluate subseafloor biosphere and microbial activity amidst buried volcanic ash to better understand life on our planet; 2) construct records of volcanic events for the last millions of years as well as the abundance of earthquakes for the last hundred thousands of years to identify common controlling mechanisms and improve forecasting of geohazards; and 3) explore ecosystem response to climate, tectonics, and volcanism across land and sea environments.

Offshore of Southern Mexico and Central America is an ideal natural laboratory to test the impacts of different ash types and subseafloor chemical environments on carbon storage and the biosphere as well as the rhythms of volcanic and seismic activity.  will be recovered by The array of sites proposed to be cored will recover different ash composition (north-south) and geochemical gradients (east-west), allowing constraints on the impact of these variations on microbial communities and the carbon cycle. Simultaneously, these cores provide records of hazard-relevant volcanic and seismic  activity along Mexico and Central America as well as ecosystem changes on the continent. The diverse range of ash characteristics, depositional environments, and geochemical settings in our target area will advance understanding of geohazards, limits of life, volcano-tectonic processes, and climatic changes both on land and at sea and tie together the deep biosphere, volcanic activity, and tectonic rhythms.