



# INTERNATIONAL OCEAN DRILLING PROGRAMME

**PROPOSAL 1113-PRE**

**Zero Age drilling of the Ocean Crust**

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

## Proposal Title:

Zero Age drilling of the Ocean Crust

## Broad Geographic Area of the Proposal

Eastern Pacific

## Project Abstract

The formation of ocean crust at mid-ocean ridges (MOR) is the foundational step in the plate tectonic cycle and is responsible for repaving the Earth's surface every ~200 million years. Newly formed ocean crust hosts unique vent systems driven by circulating hydrothermal fluids. Hydrothermal systems are pivotal to microbial life, enabling diverse ecosystems to thrive in these deep-sea environments. Life is only possible in these environments because of the intersection of magmatic, tectonic and hydrothermal processes that shape the crust, not only as it forms but crucially as it ages and evolves. Our observations at the ridge axis based on geophysical surveys and surface samples demonstrate that even at fast spreading rates, axial processes are spatially and temporally complex. Previous drilling targeting ocean crust millions to tens of millions of years off axis indicate that important changes occur in very young crust from immediately after the initial cooling and crystallisation of magma at the ridge axis (e.g hydrothermal circulation, seismic velocity, magnetic properties). Crucially, no successful drilling has taken place at the ridge axis itself, or in crust <100 kyr. This represents a critical knowledge gap: only by understanding the initial processes that shape our seafloor at mid-ocean ridges can we (1) understand how our ocean crust forms and (2) interrogate the longer term changes that take place over the life cycle of a tectonic plate, whether that be contributions to global biogeochemical cycles, the initiation of microbial activity or the evolution of geophysical characteristics of the oceanic lithosphere, such as seismic velocity or magnetism. We propose to drill, using seabed rock drills, a transect of holes along zero age crust (ridge parallel) and a second transect slightly off-axis (ridge perpendicular, up to ~1 Ma) at the East Pacific Rise 9°50' N, our natural laboratory for fast spread ocean crust. We will be able to advance our transdisciplinary understanding of mid-ocean ridges and provide essential benchmarks to compare with the rich legacy of basement sampling achieved by scientific ocean drilling

## Scientific Objectives

Objective 1: Determine the nature of axial hydrothermal recharge.

Objective 2: Evaluate whether early hydrothermal alteration controls the evolution of the physical and magnetic properties of the ocean crust.

Objective 3: Reconstruct spatial and temporal records of volcanism to investigate the links between eruptions and the link to underlying magmatic plumbing system.

Objective 4: Determine who, where, when and how microbial colonisation begins at mid-ocean ridges.

## Science Communication Plain Language Summary

Our seafloor is made of volcanic rocks that are formed by an underwater chain of volcanoes (called mid-ocean ridges) that encircle the Earth like the seams of a baseball. These volcanic rocks erupt under water and cool very rapidly, creating lots of fractures in the rocks. These fractures allow seawater to enter the rocks, and because this is a volcanic system associated with lots of heat, this seawater becomes heated as it circulates through the rocks. This heated seawater reacts with the volcanic rocks and changes the chemistry of the seawater and transforms it into a hydrothermal fluid that is typically metal-rich and acidic. These hot, metal rich hydrothermal fluids then exit the seafloor forming hydrothermal vents, often called black smokers. Hydrothermal vents host unique ecosystems, existing in an environment that is too harsh for most life on Earth, but may well be where life began. These ecosystems are underpinned by microbial life that draws energy from chemical exchange that allow them to become rich oases of fauna. Seawater circulation is therefore a key part of the formation of our ocean crust it allows these unique hydrothermal vent communities to exist and plays an important role in the cooling of the ocean crust. Despite decades of research into these fascinating systems, a number of questions about how this hydrothermal system really works and importantly how it is influenced by the volcanic construction of the crust and how it changes the physical and magnetic properties of the volcanic rocks of the ocean crust remain unanswered. To further our understanding on how our mid-ocean ridges work, we need to 'see inside them' by looking at the rocks that have formed. Seafloor drilling allows us to recover rocks from beneath the surface in order to make observations on the sequence of lavas that have formed. Using the sequence of lava flows we can construct an eruption history (including some known eruptions) that forms the basis for us to investigate the hydrothermal system in terms of changes to the rock by fluid/rock reactions, their physical and magnetic properties, as well as understanding what microbial life is present and how it is living beneath the seafloor. Crucially our mid-ocean ridges represent 3D systems, with changes in all directions (along the baseball seams,

across them, and beneath them), therefore we need to sample the sub-surface using a transect approach to cover all these dimensions.