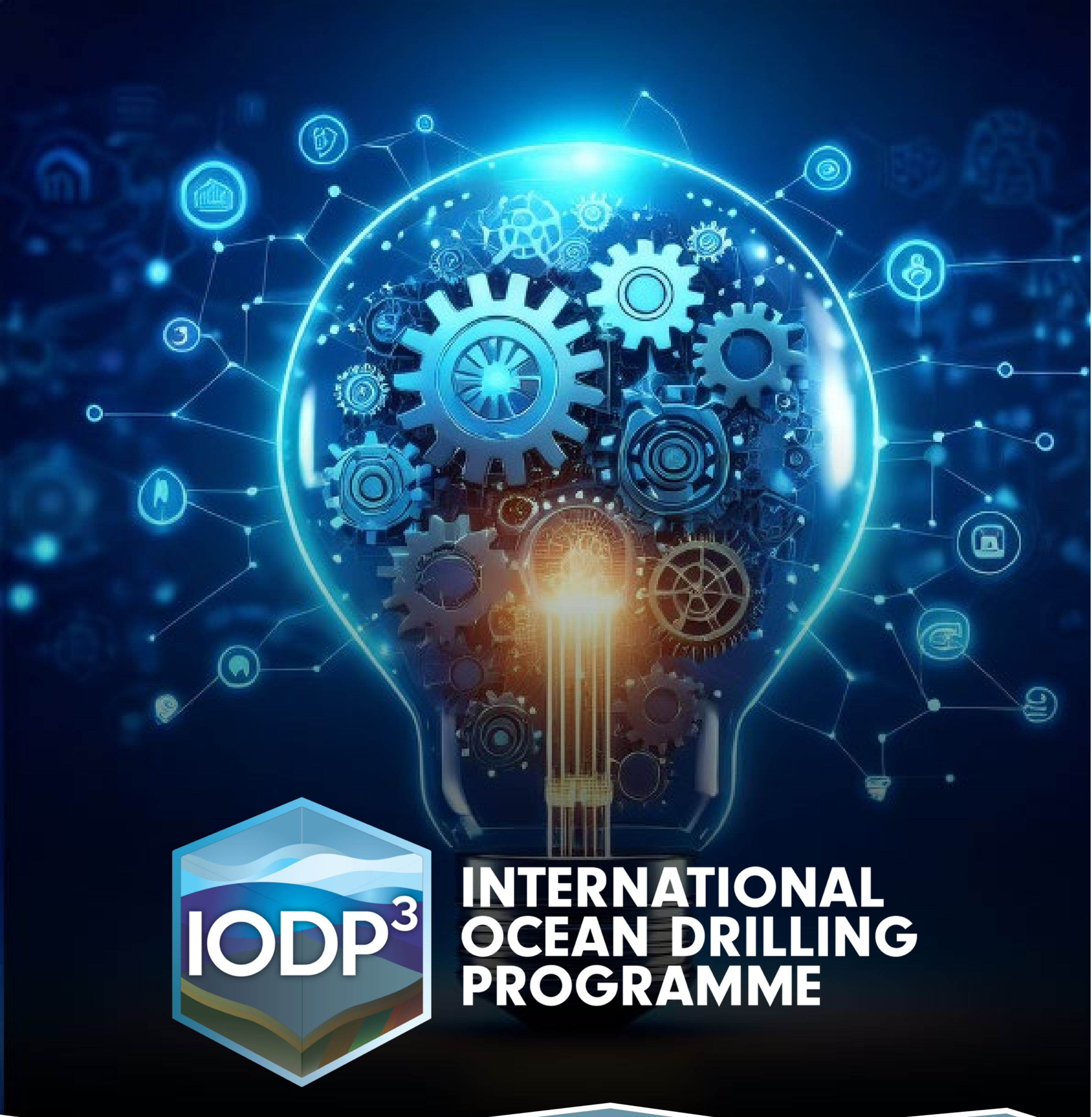

IODP³ INTERNATIONAL OCEAN DRILLING PROGRAMME

PROPOSAL 1107-PRE

Northern Cascadia Borehole Observatories – A Plate-Scale Observatory Network to Study Inter- and Intra-Plate Motion and How Plate Boundaries Communicate

IODP^3 Proposal Cover Sheet

Proposal Title:

Northern Cascadia Borehole Observatories – A Plate-Scale Observatory Network to Study Inter- and Intra-Plate Motion and How Plate Boundaries Communicate

Broad Geographic Area of the Proposal

Northern Cascadia, Northeast Pacific Ocean

Project Abstract

Building upon several existing borehole observatories, we propose to install up to six deep-sea borehole observatories, to establish an observatory network across the northern Cascadia Subduction Zone (CSZ) and the incoming Juan de Fuca (JdF) plate, to address fundamental questions on tectonic plate motion (The *2050 Science Framework Strategic Objective* #2) and earthquake and tsunami hazards (*Strategic Objective* #7). The CSZ has hosted large subduction earthquakes with large tsunamis. Onshore geodetic observations suggest present-day megathrust locking but offer no constraints on locking or creep near the trench. Together with the ongoing seafloor GNSS-A experiments and other geophysical monitoring efforts, our proposed observatory network can better define offshore locking state of the subduction megathrust. Outboard of the trench, the young and warm incoming JdF plate (<5 Ma) is bounded to the west by the nearby JdF mid-ocean ridge and to the north by the Nootka transform fault. Our proposed plate-scale network will elucidate the geodynamic interplay between these active plate boundaries and the CSZ, as governed by the rheology of the lithosphere-asthenosphere system. Outstanding questions to address include (1) whether the seismologically imaged and presumably melt-rich Lithosphere-Asthenosphere Boundary (LAB) along the base of the JdF plate enables effective (viscoelastic) stress transfer between the plate boundaries, (2) whether strain perturbations originated from offshore plate-boundary faults can cause impulsive loading on the megathrust, and (3) whether and over what breadth the northern Cascadia megathrust is fully locked or can exhibit creep with or without triggering. We propose to install borehole observatories in the Advanced CORK or LTBMS format, with two permeable screens outside the casing to monitor formation fluid pressures as a sensitive proxy for volumetric strain changes. Other geophysical instruments (e.g., fiber-optic strain meters, broadband seismometers, and tiltmeters) will be hosted inside CORK casing or outside an LTBMS configuration. We target the fine-grain low-permeability sediment section several hundred meters below the seafloor to ensure good hydrological isolation from both the ocean above and the highly fractured and permeable basaltic basement below. Most of the proposed observatories will have potential access to Ocean Networks Canada’s NEPTUNE cable for power supply and real-time data transmission. Together with companion observatories proposed for other locations along Cascadia (offshore Oregon), our collective efforts will yield insights into along-strike variations in Cascadia megathrust mechanics and behaviour.

Scientific Objectives

We propose to use D/V Chikyu or another suitable drilling platform to establish up to six deep-sea borehole observatories, for pressure and strain monitoring at the northern Cascadia subduction zone, with the following objectives:

- Determine whether this part of the megathrust is fully or partially locked.
- Constrain the pattern of strain (energy) buildup above the locked subduction fault at the late interseismic stage of the earthquake cycle.
- Determine the presence or absence of various modes of seismic or aseismic slip. Provide constraints on the portions of the megathrust that can host seismic slip, be involved in tsunamigenesis, or only creep.
- Monitor any short- to long-term temporal variations in the locking/creeping state of the subduction fault, similar to the shallow slow slip events observed at Nankai and the decadal deep megathrust creep observed before the 2011 Mw=9 Tohoku-oki earthquake.
- Observe strain perturbations originating from other neighbouring plate-boundary boundaries (i.e., Juan de Fuca Ridge, Nootka fault) to constrain the mechanism of lithospheric stress transfer and effects on megathrust loading.
- Determine whether the Lithosphere-Asthenosphere Boundary, with seismologically inferred ponded partial melts, is rheologically weak and can affect tectonic plate motion, subduction, and transient deformation.
- Establish a real-time monitoring system, with the capacity of cable connection (ONC’s NEPTUNE), to enhance regional hazard early warning.

Science Communication Plain Language Summary

We propose to install up to six new deep-sea borehole observatories off the coast of northern Cascadia to study earthquake and tsunami hazards, and to examine how tectonic plates move. The Cascadia Subduction Zone has a history of producing large earthquakes and tsunamis, but we do not fully understand how the shallow offshore portion of the fault behaves. By placing these observatories beneath the seafloor, we aim to study whether parts of the subduction fault are locked or slowly slipping, how stress transfer influences inter- and intra-plate motion, and how the different tectonic plate boundaries interact via the stress transfer. These borehole observatories will be equipped with sensitive instruments to measure changes in fluid pressure in the formation that reflect deformation and strain beneath the ocean floor. The observations will be used to study a variety of fault activities, including earthquakes, less-energetic slower fault slip, and the gentle buildup of strain (energy) surrounding the subduction fault. They will also help us understand how the stress loading on the Cascadia subduction fault is influenced by other seismically active plate-boundary faults bounding the young, warm and small Juan de Fuca plate. Over the coming years, data will be stored and recovered periodically at some of the sites. For most sites, connection to the Ocean Networks Canada’s underwater NEPTUNE cable system will allow real-time monitoring and data transmission. Our proposed effort will provide new insights into the fundamental processes of tectonic plate motion and will help us better assess future earthquake and tsunami hazards for North America’s west coast.