IODP³

INTERNATIONAL OCEAN DRILLING PROGRAMME

PROPOSAL 1105-FULL

Drilling and monitoring in Hyuga-Nada: Unveiling effects of seamount subduction on slow earthquakes

IODP^3 Proposal Cover Sheet

Proposal Title:

Drilling and monitoring in Hyuga-Nada: Unveiling effects of seamount subduction on slow earthquakes

Broad Geographic Area of the Proposal

NW Pacific

Project Abstract

Shallow slow earthquakes, which last minutes to years, are important indicators of subduction megathrust slip behavior and future seismic and tsunami potential. Subducting plate roughness and seamounts have been proposed to promote slow earthquakes by inducing local hydrologic and geomechanical heterogeneity. The Hyuga-Nada region offshore Kyushu, Japan is an outstanding locale for drilling and observatory experiments to investigate these effects. Slow earthquakes are repeatedly observed on and near the subducting Kyushu-Palau-Ridge, a chain of seamounts, thus providing excellent opportunities to explore the effects of seamount subduction on geomechanical/hydrologic/thermal properties, and ultimately tremor, earthquake and slow slip generation. Long-term monitoring enabled by a planned permanent network (N-net) will allow subsurface processes during frequent (~1 year) episodic slow earthquakes and ~M7 earthquakes (~20-30 year interval) to be captured with high fidelity. Drilling, logging, and coring will provide key constraints on the stress state, hydrologic processes, and sediment physical properties in the region above the ridge.

We propose to drill and install observatories at three primary locations in Hyuga-Nada to address two hypotheses: 1) Seamount subduction creates spatially variable stress and consolidation states and creates substantial deformation within the upper plate leading to complex plate boundary slip behavior; 2) The majority of plate motion at Hyuga-Nada is accommodated by episodic slow slip events, very low-frequency earthquakes and tremors, whose spatiotemporal distribution is strongly influenced by seamount subduction. We will drill primary holes at three distinct sites relative to the subducting seamount, to characterize subsurface properties and conditions through core analysis, LWD and APCT-3. These sites and analysis will characterize the in-situ thermal, hydrologic, and stress state, fracture density and subsurface fluid flow. Spatial variations in the upper plate deformation caused by seamount subduction will be revealed by comparing results from holes in the leading and lateral edges, and above the currently subducting seamount; these observations are important for constraining geomechanical, hydrological, and thermal models. At two of the sites, we will install a "Fiber-CORK" observatory equipped with conventional pressure and temperature sensors and cutting-edge fiber-optic sensors. One site will be connected to the N-net node for real-time data streaming. The combination will fill observational gaps in a spectrum of slip behavior, a small portion of which is observable with current seismic and geodetic instrumentation. Fully characterizing slow earthquakes will reveal the degree to which they accommodate plate motion, and whether strain is accumulated for past and future earthquakes.

Scientific Objectives

Objective 1: Characterize the stress regime, temperature, rock properties, shallow sedimentary strata that are potentially deformed by the seamount subduction

Question 1-1: What is the stress and consolidation state? Do they differ between the leading side, the lateral side and the top of the seamount? Do they azimuthally vary around the subducting Toi Seamount?

Question 1-2: How is the seamount disrupting the upper plate?

Question 1-3: Can we resolve progressive deformation induced by multiple episodes of seamount subduction?

Question 1-4: How does the shallow state relate to the state of the upper plate at deeper depth?

Question 1-5: Is temperature on the plate interface anomalously lower or higher where the KPR subducts?

Question 1-6: What is the hydrological state of the slow earthquake region, and how is it impacted by seamount subduction? Do seamounts enhance permeability, and thereby drive increased fluid flux from deeper sources, affecting the pore fluid chemistry and thermal state?

Objective 2: Monitor slow earthquake activities and subsurface changes by installing cutting-edge observatories equipped with conventional and advanced sensors

Question 2-1: What is the spatiotemporal relationship between SSE, tremors and VLFEs? Do SSEs collocate and migrate in the same manner as tremors/VLFEs?

Question 2-2: Do subsurface elastic structures change over time associated with slow earthquake activities?

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Science Communication Plain Language Summary

Shallow slow earthquakes, which last minutes to years, are important indicators of subduction megathrust slip behavior and future seismic and tsunami potential. Subducting plate roughness and seamounts have been proposed to promote slow earthquakes by inducing local hydrologic and geomechanical heterogeneity. The Hyuga-Nada region offshore Kyushu, Japan is an outstanding locale for drilling and observatory experiments to

investigate these effects. In this region, slow earthquakes are repeatedly observed on and near the subducting Kyushu-Palau-Ridge (KPR), a chain of seamounts, thus providing excellent opportunities to explore the effects of seamount subduction on geomechanical/hydrologic/thermal properties, and ultimately tremor, earthquake and slow slip generation. Long-term monitoring enabled by a planned permanent network (N-net) will allow subsurface processes during frequent (~1 year) episodic slow earthquakes and ~M7 earthquakes (~20-30 year interval) to be captured with high fidelity. Drilling, logging, and coring will provide key constraints on the stress state, hydrologic processes, and sediment physical properties in the region above the ridge.
We propose to drill and install observatories at three primary locations in Hyuga-Nada to address two hypotheses: 1) Seamount subduction creates spatially highly variable stress and consolidation states and creates substantial deformation within the upper plate leading to complex plate interface slip behavior; 2) The majority of plate motion at Hyuga-Nada is accommodated by occasional large earthquakes and a variety of slow earthquakes that includes episodic slow slip events lasting days to years, very-low-frequency earthquakes lasting 10-100 seconds, and tremors lasting 0.1-10 seconds. The spatiotemporal distribution of slow earthquakes is strongly influenced by seamount subduction. We will drill primary holes at three distinct sites relative to the subducting seamount to characterize subsurface properties and conditions through core analysis, physical parameters measurement while drilling and temperature sensing. These sites and analysis tools are of particular interest for characterizing the in-situ thermal, hydrologic, and stress state, fracture density and other indicators of deformation, and subsurface fluid flow. These observations are important for constraining geomechanical, hydrological, and thermal models. At two of the sites, we will install a “Fiber-CORK” observatory equipped with conventional and cutting-edge fiber-optic sensors in order to monitor temperature and strain changes andll fill the observational gap in a spectrum of megathrust slip behavior. Fully characterizing slow earthquakes will reveal the degree to which they accommodate plate motion, and whether strain is accumulated for past and future earthquakes.