IODP Proposal Cover Sheet

Hikurangi: Riser

781B - Full

Title	Unlocking the secrets of slow slip by drilling at the northern Hikurangi subduction margin, New Zealand: Riser drilling to intersect the plate interface
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Abstract

Over the last decade, the discovery of episodic slow slip events (SSEs) at subduction margins around the globe has led to an explosion of new theories about fault rheology and slip behavior along subduction megathrusts. The northern Hikurangi margin is the only place on Earth where well-documented SSEs occur on a subduction interface within range of scientific drilling capabilities. Drilling, down-hole measurements, and sampling of the northern Hikurangi SSE source area provides a unique opportunity to definitively test hypotheses for the physical conditions and rock properties leading to SSE occurrence, and ultimately, to unlock the secrets of slow slip.

This proposal is for the deep, riser drilling component of a recently submitted Multi-phase Drilling Project (781-MDP) proposal for IODP drilling to discern the mechanisms of subduction zone slow slip events (SSEs) by scientific drilling in the region of shallow SSEs at northern Hikurangi. The primary aims of the riser phase are to sample, log, and conduct downhole measurements in the hanging wall and across the plate interface where SSEs occur.

Here, we propose a single riser borehole intersecting the plate interface at 5-6 km bsf, to collect samples, geophysical logs and make downhole measurements at the source of SSEs. The riser borehole is designed to address two fundamental scientific objectives: (1) characterize the composition, mechanical properties, and structural characteristics of the megathrust in the slow slip source area; and (2) characterize hydrological properties, thermal regime, stress, and pore pressure state above and within the SSE source region. Together, these data will test a suite of hypotheses about the fundamental mechanics and behavior of slow slip events, and their relationship to great subduction earthquakes. Without direct sampling of rocks from the SSE source and in situ measurements of physical properties (as proposed here), geoscientists are limited to speculation regarding the mechanisms that lead to SSEs.

We also expect that comparisons between cores and logs from deep, riser drilling of the subduction interfaces at both north Hikurangi and Nankai (the NanTroSEIZE project) will address the mystery of why some subduction zones rupture in Great earthquakes (e.g., Nankai), while others are dominated by aseismic creep (e.g., N. Hikurangi).

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Scientific Objectives

Drilling, coring, geophysical logging, and downhole measurements will resolve competing hypotheses and key questions regarding the generation of slow slip and the mechanics of subduction interface thrusts. Major questions that will be addressed are:

(1) What control does temperature and pressure have on the down-dip limit of the seismogenic zone and the depth of slow slip events? (2) Does high fluid pressure at the plate interface influence the occurrence of SSEs, and what role do mineralogical dehydration transformations play in the supply of fluids to the SSE source area? (3) What are the lithologies hosting slow slip, and do they promote conditional stability? If so, do fast seismic slip and slow aseismic slip occur in the same location on the interface? Do SSEs represent prematurely arrested normal earthquakes, as is suggested from dynamic weakening in laboratory friction tests? (4) Are the structural character and frictional properties of a subduction interface dominated by slow, aseismic slip and moderate subduction thrust earthquakes (i.e., Northern Hikurangi) fundamentally different from that of subduction interface faults characterized by stick-slip behaviour and great megathrust earthquakes (such as Nankai)?

Non-standard measurements technology needed to achieve the proposed scientific objectives.

LWD tools: As complete a suite as is possible and practical for logging-while-drilling LWD) should be employed. At a minimum azimuthal resistivity imaging, sonic velocity, density and neutron porosity, gamma, and annular pressure logging are requested.

In situ pore pressure and stress measurements: a packer-based or similar wireline or LWD tool that can be used to conduct pumping and drawdown tests and mini-frac experiments (one example is the Schlumberger modular dynamic tester, or MDT, tool) is important to measure both stress and hydrogeologic state of the slow slip environment and upper plate.

Proposed Sites

Site Name	Position (Lat, Lon)	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
HSM-01B	-38.727283, 178.614233	994	6000	0	6000	1.Coring and logging to assess physical properties and rock composition within and above the upper plate above SSE source region 2. Case and install temporary SSE observatory hole between drilling phases 3. Case and install long-term borehole observatory when the hole is completed