IODP Proposal Cover Sheet

947B - Pre

Cascadia Borehole Observatories: Oregon

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Title	Cabled Borehole Observatories to Investigate Plate Boundary Mechanics of the Cascadia Subduction Zone - Oregon Transect
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Area	Northeast Pacific Ocean - Offshore Cascadia (the Pacific Northwest)

Proponent Information

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Abstract

In multiple settings, scientific drilling and the installation of borehole hydrological and geophysical observatories have, in conjunction with seafloor observations, transformed our scientific understanding of plate boundary mechanics and the hazards posed by subduction zones. The Cascadia subduction zone is a warm endmember among global subduction systems that hosts a relatively narrow locked zone, features a well-developed accretionary prism and serpentinized mantle wedge, receives abundant sediment input, exhibits minimal seismicity on the plate interface, and represents a significant tsunami and ground shaking hazard. Land-based geodetic observations suggest that the megathrust is largely locked at the coast and immediately offshore, but they provide no constraints on strain accumulation and release near the trench. There is abundant evidence for segmentation of the Cascadia subduction zone but its origins and its implications for along strike variations in megathrust locking offshore are not well understood. The central section of the Cascadia subduction zone off central Oregon, is a particularly alluring target for detailed study because many observations suggest that it exhibits different behavior than regions to the north or south that may be fully locked. The primary attributes of this section include: (1) geodetic evidence for partial megathrust locking, suggestive of some combination of kinematic locking and creeping behavior; (2) seismological evidence for distinct clusters of earthquake activity on the megathrust, including repeating earthquakes, which are generally interpreted to indicate local asperities on a creeping fault; and (3) access to seafloor power and real time telemetry afforded by the Ocean Observatories Initiative Cabled Array. This proposal seeks to install a transect of real time borehole observatories off central Oregon to detect the subtle geodetic and seismic signals of secular and episodic creep. Each borehole observatory is positioned to be connected to the OOI Cabled Array and will monitor formation fluid pressures at two depths and host geophysical instrument packages comprising a seismometer, tiltmeters, and in at least one hole, a fiberoptic strain meter. To characterize the patterns of strain accumulation and release in the subduction zone, the three highest priority sites are on the incoming plate near the deformation front and two sites on the overriding plate successively farther away from the deformation front. A fourth site near the OOI node in the middle of the Juan de Fuca plate will contribute to studies that seek to understand how strains are transmitted across the plate from mid-ocean ridge spreading events and transform fault motions.

947B - Pre

Scientific Objectives

The principal scientific objective of this proposal is to install a transect of hydrological and geophysical borehole observatories across the central Oregon margin that can discriminate between three endmember hypotheses that each explain the land-based geodetic and seismic observations that suggest partial megathrust locking offshore:

1. The partial locking is spatially uniform across the megathrust. Some small level of aseismic creep should be occurring across the entire zone and could be characterized by either continuous or transient slip.
2. The partial locking is spatially heterogeneous with distinct asperities that are locked surrounded by aseismic zones that are dynamically restrained. This predicts that aseismic creep, either continuous or transient, should surround zones of clustered microseismicity.
3. The partial locking is accommodated by a narrow, fully locked zone extending along strike. Aseismic creep would be expected to have a strong down-dip dependence. This outcome would have major implications for tsunamigensis if the locked zone is near the trench.

A second objective is to install a borehole observatory in the middle of the Juan de Fuca plate that in conjunction with borehole observatories installed or planned elsewhere, will constrain the transfer of strain from spreading events on the Juan de Fuca Ridge and transcurrent motions on the Blanco, Nootka and Sovanco transform faults to test a fourth hypothesis:

4. Tectonic stress is efficiently transferred across the Juan de Fuca plate such that tectonic activity at the nearby mid-ocean ridge and transform faults incrementally perturb and load the Cascadia megathrust.

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

947B - Pre

Proposed Sites (Total proposed sites: 6; pri: 4; alt: 2; N/S: 0)

Site Name	Position (Lat, Lon)	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
CASOR-01B (Primary)	44.4901 -125.4430	2910	500	0	500	Core and log upper portion of incoming plate sedimentary section for lithology and physical properties. Establish an ACORK borehole observatory to measure time series of pore fluid pressure, temperature and seismic/geodetic signal
CASOR-03B (Alternate)	44.4759 -125.2640	1912	500	0	500	The primary objectives are to drill, core, and LWD a site to ~500 meters bsf into the main frontal anticlinal ridge inland of the frontal thrust, and install a CORK borehole observatory to measure time series of pore fluid pressure, temperature, and seismic/geodetic strain signals. This site would monitor transient deformation, fluid pressure, and temperature, testing hypotheses on the locking vs. transient activity (or lack) of the outermost upper plate accretionary wedge.
CASOR-04A (Primary)	44.4644 -125.1178	1315	500	0	500	The primary objectives are to drill, core, and LWD a site to ~500 meters bsf into a sedimentary basin 15 km east of the deformation front, and install a CORK borehole observatory to measure time series of pore fluid pressure, temperature, and seismic/geodetic strain signals. This site would monitor transient deformation, fluid pressure, and temperature, testing hypotheses on the locking vs. transient activity (or lack) of the outer upper plate accretionary wedge.
CASOR-05A (Primary)	44.3740 -124.9440	562	500	0	500	The primary objectives are to drill, core, and LWD a site to ~500 meters bsf into site on the upper continental slop 30 km east of the deformation front, and install a CORK borehole observatory to measure time series of pore fluid pressure, temperature, and seismic/geodetic strain signals. This site would monitor transient deformation, fluid pressure, and temperature, testing hypotheses on the locking vs. transient activity (or lack) of in the middle of the accretionary wedge.
CASOR-06A (Alternate)	44.6810 -124.4570	105	100	0	100	The primary objectives are to drill a cased hole to ~100 meters at a site that lies close to the epicenter of an earthquake cluster on megathrust at 15 km depth so support borehole instrumentation to measure seismic and geodetic signals.
CASOR-07A (Primary)	45.7460 -127.3128	2825	400	0	400	Core and log upper portion of incoming plate sedimentary section in the middle of the Cascadia Basin (Juan de Fuca Plate). Install CORK borehole observatory. Long-term measurements will include pore fluid pressure, temperature and seismic/geodetic strain signals to understand the transfer of strains from spreading episodes on the Juan de Fuca Ridge, transcurrent motions on the Blanco, Nootka and Sovanco transform faults, and any motion on the megathrust across a tectonic plate.