# IODP Proposal Cover Sheet

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Cascadia Borehole Observatories

Received for: 2018-10-01

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| Title | Cabled Borehole Observatories to Investigate Plate Boundary Mechanics of the Cascadia Subduction Zone |
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| Keywords | Subduction Zone, Cascadia, Borehole Observatories, |
| Area | Northeast Pacific - Cascadia Margin |

## Proponent Information


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## Abstract


The Cascadia subduction zone is a warm end-member 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, and exhibits minimal seismicity on the plate interface. The slip behavior, structure of the prism, sediment type, and the dip of the plate interface all vary along-strike, suggestive of segmentation in the mechanical controls of the system. There is abundant geological evidence of repeated, large megathrust events on the plate boundary with accompanying tsunamis. Yet nothing is known about the state of interseismic locking at the trench or the potential for shallow slip transients, and existing terrestrial observations provide only weak constraints on the offshore deformation. Seafloor drilling in Cascadia has the potential to address a variety of important questions related to the mechanics and interseismic locking state of the subduction zone, fluid flow, the potential for tsunamigenesis, and sediment characteristics of the incoming plate. We propose a set of sealed borehole observatories along transects offshore Oregon and Vancouver Island. The holes will be logged and then instrumented to measure pressure at multiple levels, ground motions and tilt and to sample fluids. This plan is informed by community feedback from a 2015 workshop that focused on drilling targets in Cascadia. The proposed borehole locations will leverage existing geophysical surveys for site selection and interpretation and new information can be integrated with data from past drilling targets along the margin. The proximity to seafloor cabled infrastructure provides the opportunity for power and real-time telemetry to borehole sensors. Once instrumented, these borehole observatories will help address many unknowns and can provide a stable setting above the seismogenic zone for sensitive instruments to search for deformation signals of which we are currently unaware. The observations will also complement nascent seafloor geodetic observations. New findings will directly inform on the seismic hazard of the subduction zone and the tsunamigenic potential of the frontal splay faults.

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## Scientific Objectives

In order to address the central questions regarding the mechanisms of fault locking, strain accumulation and release, and interrelationship between faulting and fluid processes, we seek to drill two transects of boreholes off central Oregon and off south-central Vancouver Island near the deformation front to establish cabled borehole observatories for geodynamic studies. Each transect capitalizes on extensive previous drilling during ODP and IODP and is proximal to access points for the US and Canadian seafloor cables. The two transects will each entail 2-3 boreholes extending to 600-1000 meters bsf within (a) the incoming sedimentary section and (b) accretionary wedge, respectively. Sealed borehole instrumentation will be installed to monitor pore fluid pressure, temperature, and seismic/geodetic activity and to sample pore fluids. Allied efforts are being pursued to enable connection of the CORK heads to the existing offshore cable systems so that they are established as the first real-time cabled deep offshore observatories for subduction megathrust processes outside of Japan.

Specific objectives include (1) documenting the lithologies, physical properties, and structural geology at each site, the pore fluid pressure regime; (2) capturing continuous and/or transient strain signals at each site, ranging from seismic events to slow creep and all time scales in between; (3) sampling pore fluids over time for evidence of transient flow along faults or elsewhere; and (4) making along-strike comparisons of strain accumulation and release based in hypotheses about variable degrees of megathrust locking made from inconclusive land-based observations.

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

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

| Site Name | Position (Lat, Lon) | Water Depth (m) | Penetration (m) | | | Brief Site-specific Objectives |
|---|---|---|---|---|---|---|
| | | | Sed | Bsm | Total | |
| CASOR-01A (Primary) | 44.5230 -125.4090 | 2910 | 800 | 0 | 800 | Core and log upper portion of incoming plate sedimentary section for lithology and physical properties. Establish a CORK borehole observatory to measure time series of pore fluid pressure, temperature, seismic/geodetic signal, and sample pore fluids. |
| CASOR-02A (Primary) | 44.5790 -125.1460 | 812 | 600 | 0 | 600 | Drill, core, and log ~600 to 1000 mbsf at location of previous sites 892/1244 and install CORK borehole observatory. Long-term measurements will include pore fluid pressure, temperature, seismic/ geodetic strain signals, and fluid sampling. This site will measure poroelastic and other signals within the upper plate accretionary wedge where it is older and more indurated than the frontal ridge, and where the underlying decollement is hypothesized to be partially to fully locked, testing for presence or absence of transient slip events. |
| CASOR-03A (Primary) | 44.5130 -125.2950 | 2199 | 800 | 0 | 800 | The primary objectives are to drill, core, and LWD a site to 600 to 1000 meters bsf into the main frontal anticlinal ridge and across the frontal thrust, and install a CORK borehole observatory to measure time series of pore fluid pressure (in and outside of the fault zone), temperature, seismic/geodetic strain signals, and to sample fluids from the fault system. 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. Fluid sampling for geochemical tracers of flow up the frontal fault. |
| CASVI-01A (Primary) | 48.5220 -127.1688 | 2570 | 800 | 0 | 800 | Establish borehole observatory for documenting deformation of incoming plate near the deformation front of the Cascadia subduction zone accretionary prism, sufficiently close to seismogenic zone to sense any interseismic transient slip and to detect and quantify secular strain caused by plate motion resisted by a locked fault. Document incoming sediment lithology |
| CASVI-02A (Primary) | 48.7422 -126.7087 | 1185 | 800 | 0 | 800 | Establish borehole observatory for monitoring deformation directly above the seismogenic portion of the Cascadia subduction thrust fault in order to constrain the degree of locking and to detect and quantify any interseismic transient slip. |
| CASVI-03A (Primary) | 48.5901 -127.0276 | 2025 | 800 | 0 | 800 | Establish borehole observatory aimed primarily for fluid sampling where subduction zone frontal thrust is intersected. Geodynamics objectives will also be included, with downhole tilt and seismic instruments and external screens for pressure monitoring. |