IODP Proposal Cover Sheet

992 - Full

Prince William Sound Subduction and Climate

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Title	Understanding megathrust earthquake hazards and post-LGM climate change along the southern Alaska margin through scientific drilling
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Keywords	Alaska, megathrust, paleoseismology, climate, landslides
Area	Prince William Sound, Alaska

Proponent Information

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Abstract

Southern Alaska is a preeminent location to address central IODP challenges, with sedimentation rates providing exceptional temporal resolution of time-varying processes. The Prince William Sound region of Alaska experienced a Mw 9.2 great earthquake in 1964 and is the best modern example of a glaciated subduction margin. We aim to develop a paleoseismic and paleoclimate record from pre-Last Glacial Maximum (LGM) time to the present to address: 1) megathrust earthquake recurrence and variability, the completeness of marine paleoseismic records, mechanical conditions governing tsunamigenic splay faulting, and submarine landsliding; 2) distal-proximal timing, synchroneity, and abruptness of Cordilleran Ice Sheet dynamics during the the last deglaciation, linking to nearby IODP Exp. 341 drilling. Seismic data indicate likelihood of collecting good stratigraphic sequences through Marine Isotope Stage 3 to test emerging hypotheses about abrupt climate and ice sheet change, and we may recover Last InterGlacial (LIG) and older sediments.

We propose drilling four areas:

(1) Port Valdez - Develop: a) a history and understanding of the mechanics of large submarine landslides, compare the timing to terrestrial paleoseismic records, and test relationships between frequency and/or volume of landslides during neoglacial times (last 3-4 kya) relative to earlier Holocene; b) a Holocene climate record to examine the potential causes and impacts of hypothesized changes in Holocene climate states at high resolution.

(2) Central Prince William Sound Basin - a) Collect a late Pleistocene climate and sedimentary record and establish timing of major ice stream deglaciation; b) develop a potential 10,000-year record of megathrust earthquakes; c) examine a high-latitude record of abrupt MIS3 climate changes in an ice-proximal setting; d) establish slip rate and variability of a megasplay fault.

(3) Junken Trough - Constrain: a) rates and progression of megathrust splay (out of sequence) faulting that ruptured during the 1964 event, b) evaluate mechanical properties and fault zone structure by drilling through a splay fault; c) develop climate record through three glacial cycles.

992 - Full

Scientific Objectives

We will develop a high-resolution paleoseismic and paleoclimate record from the last glacial cycle. We will evaluate marine paleoseismic techniques by comparison to terrestrial records, and establish the timing of deglaciation from distal to proximal sites. We will examine megathrust earthquake variability, the mechanical conditions governing the role of potentially-tsunamigenic splay faulting, and submarine landsliding, and the relationships between climate change, glacial behavior, and sea level rise after the LGM. We expect to sample MIS 3 to 6 sediments, developing a poorly resolved climate history for the subarctic Pacific ocean in that time period and testing hypotheses on the role of North Pacific climate and Cordilleran Ice in the global climate system to test if late Pleistocene ice retreat was catastrophic or gradual, and synchronous or diachronous compared to previous findings from SE Alaska and elsewhere. We propose drilling multiple holes in four locations.
(1) Port Valdez - mechanics and frequency of submarine landslides; proximal Holocene climate; relationship between climate state and large landslide frequency and volume.
(2) Central Prince William Sound Basin - post-LGM climate and earthquake record, with additional constraints on pre-LGM climate and megasplay faulting slip rates.
(3) Junken Trough - rates and progression of megathrust splay faulting; mechanical properties of fault zones; development of an ice-proximal record of high-latitude climate and marine-terminating ice streams through multiple glacial cycles.
(4) Junken Slope- a) continental slope record of deglaciation and climate change, age constraints of regional reflectors, b) water mass dynamics and relation to climate, sea ice, regional productivity, and subsurface ventilation.

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

Have you contacted the appropriate IODP Science Operator about this proposal to discuss drilling platform capabilities, the feasibility of your proposed drilling plan and strategies, and the required overall timetable for transiting, drilling, coring, logging, and other downhole measurements?

yes

Science Communications Plain Language Summary

Using simple terms, describe in 500 words or less your proposed research and its broader impacts in a way that can be understood by a general audience.

The region of Prince William Sound, Alaska, USA, is home to dynamic glacial processes and great earthquakes that generate landslides and tsunamis, and serves as a natural laboratory to understand these systems based on their past behavior, now recorded in layered sediments that can be recovered by drilling. The sedimentary record here has exceptional time resolution due to high rates of glacier-produced sediment delivery into the Sound and neighboring continental shelf and slope. This finely resolved sedimentary record documents past events in the region, and in a relatively compact and cost-effective program will improve understanding of advances and retreats of marine-terminating glaciers, faulting and earthquakes, and other natural hazards, testing specific hypotheses that will be applicable to global systems. We propose four scientific drilling sites to capture these sedimentary records. (1) Port Valdez - mechanics and frequency of submarine landslides; proximal Holocene climate; relationship between climate state and large landslide frequency and volume. (2) Central Prince William Sound Basin - post-ice age climate and earthquake record, with additional constraints on pre-ice age climate and earthquakes. (3) Junken Trough - rates and progression of shallow faulting; mechanical properties of fault zones; development of an ice-proximal record of high-latitude climate and ice streams through multiple glacial cycles. (4) Juken Slope- continental slope record of deglaciation and climate change, age constraints of regional reflectors. This proposed expedition builds off the results and experience from IODP Expedition 341 (tectonics climate and sedimentation in the Gulf of Alaska) located to the east, an extensive onland earthquake record, and offshore seismic images of active thrust faults that moved in the 1964 M9.2 great earthquake. The science proposed is of extremely high interest to the public, addressing themes of natural hazards in the Pacific Rim, rates of abrupt climate changes, and impacts of warming. The location and time interval to be studied are key to issues of climate and sea level influences on early human migration from Asia to North America, especially via the proposed “kelp highway” marine route, which is the only viable route for peopling of the Americas during the Last Glacial Maximum, a topic that attracts broad public interest in new scientific findings.

Proposal History

Submission Type: Resubmission from previously submitted proposal

Review Response

First submission of full proposal

992 - Full

Proposed Sites (Total proposed sites: 18; pri: 9; alt: 9; N/S: 0)

Site Name	Position (Lat, Lon)	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
PWSPV-01B (Primary)	61.10790 -146.46833	242	403	0	403	The Port Valdez sediments will contain a proximal record of post-LGM climate change and submarine landslides. With drilling, we will develop a history and an understanding of the mechanics of submarine landsliding, compare this record to the terrestrial paleoseismic history, and evaluate the completeness of the record and the frequency of landslides. We will develop a unique proximal climate record after deglaciation, albeit punctuated by submarine landslide debris, to be compared to more distal sites to understand the timing and rates of deglaciation around the northern Pacific.
PWSPV-02A (Alternate)	61.10764 -146.49375	245	403	0	403	The Port Valdez sediments will contain a proximal record of post-LGM climate change and submarine landslides. With drilling, we will develop a history and an understanding of the mechanics of submarine landsliding, compare this record to the terrestrial paleoseismic history, and evaluate the completeness of the record and the frequency of landslides. We will develop a unique proximal climate record after deglaciation, albeit punctuated by submarine landslide debris, to be compared to more distal sites to understand the timing and rates of deglaciation around the northern Pacific.
PWSPV-03A (Primary)	61.09381 -146.60730	251	391	0	391	The Port Valdez sediments will contain a proximal record of post-LGM climate change and submarine landslides. With drilling, we will develop a history and an understanding of the mechanics of submarine landsliding, compare this record to the terrestrial paleoseismic history, and evaluate the completeness of the record and the frequency of landslides. We will develop a unique proximal climate record after deglaciation, albeit punctuated by submarine landslide debris, to be compared to more distal sites to understand the timing and rates of deglaciation around the northern Pacific.
VAL-01A (Alternate)	61.1147 -146.4419	237	293	0	293	The Port Valdez sediments will contain a proximal record of post-LGM climate change and submarine landslides. With drilling, we will develop a history and an understanding of the mechanics of submarine landsliding, compare this record to the terrestrial paleoseismic history, and evaluate the completeness of the record and the frequency of landslides. We will develop a unique proximal climate record after deglaciation, albeit punctuated by submarine landslide debris, to be compared to more distal sites to understand the timing and rates of deglaciation around the northern Pacific.
VAL-02A (Alternate)	61.1124 -146.4608	238	308	0	308	The Port Valdez sediments will contain a proximal record of post-LGM climate change and submarine landslides. With drilling, we will develop a history and an understanding of the mechanics of submarine landsliding, compare this record to the terrestrial paleoseismic history, and evaluate the completeness of the record and the frequency of landslides. We will develop a unique proximal climate record after deglaciation, albeit punctuated by submarine landslide debris, to be compared to more distal sites to understand the timing and rates of deglaciation around the northern Pacific.
VAL-03A (Primary)	61.0967 -146.5447	246	308	0	308	The Port Valdez sediments will contain a proximal record of post-LGM climate change and submarine landslides. With drilling, we will develop a history and an understanding of the mechanics of submarine landsliding, compare this record to the terrestrial paleoseismic history, and evaluate the completeness of the record and the frequency of landslides. We will develop a unique proximal climate record after deglaciation, albeit punctuated by submarine landslide debris, to be compared to more distal sites to understand the timing and rates of deglaciation around the northern Pacific.
PWSCB-01B (Primary)	60.52442 -146.875115	332	327	0	327	The Central Prince William Sound basin sediments will contain a complete record of post-LGM climate change. This site will also help us test rates and timing of deglaciation in the north Pacific, and sample possible MIS 3 and older interglacial sediments. Preliminary work indicates there is also a high-resolution paleoseimic record, which has the potential of giving us a record of megathrust earthquakes spanning the entire Holocene, and further developing the field of marine paleoseismology.
PWSCB-02A (Alternate)	60.515234 -146.868815	330	306	0	306	The Central Prince William Sound basin sediments will contain a complete record of post-LGM climate change. This site will also help us test rates and timing of deglaciation in the north Pacific, and sample possible MIS 3 and older interglacial sediments. Preliminary work indicates there is also a high-resolution paleoseimic record, which has the potential of giving us a record of megathrust earthquakes spanning the entire Holocene, and further developing the field of marine paleoseismology.

Proposed Sites (Continued; total proposed sites: 18; pri: 9; alt: 9; N/S: 0)

Site Name	Position (Lat, Lon)	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
PWSCB-03A (Primary)	60.652097 -146.936269	335	306	0	306	The Central Prince William Sound basin sediments will contain a complete record of post-LGM climate change. This site will also help us test rates and timing of deglaciation in the north Pacific, and sample possible MIS 3 and older interglacial sediments. Preliminary work indicates there is also a high-resolution paleoseimic record, which has the potential of giving us a record of megathrust earthquakes spanning the entire Holocene, and further developing the field of marine paleoseismology.
PWSCB-04A (Alternate)	60.612348 -146.91828	333	306	0	306	The Central Prince William Sound basin sediments will contain a complete record of post-LGM climate change. This site will also help us test rates and timing of deglaciation in the north Pacific, and sample possible MIS 3 and older interglacial sediments. Preliminary work indicates there is also a high-resolution paleoseimic record, which has the potential of giving us a record of megathrust earthquakes spanning the entire Holocene, and further developing the field of marine paleoseismology.
PWSJT-01B (Primary)	59.54248272 -148.1841377	209	274	0	274	This site should penetrate three glacial cycles, which would lead to the development of a high latitude glacial and interglacial climate record. Moreover, timing of LGM deglaciation at this site is critical to understanding of LGM ice sheet collapse was catastrophic or gradual. A chronology here should help to evaluate rates and progression of megathrust splay faulting.
PWSJT-02A (Alternate)	59.53480124 -148.2078545	205	216	0	216	This site should penetrate three glacial cycles, which would lead to the development of a high latitude glacial and interglacial climate record. Moreover, timing of LGM deglaciation at this site is critical to understanding of LGM ice sheet collapse was catastrophic or gradual. A chronology here should help to evaluate rates and progression of megathrust splay faulting.
PWSJT-03A (Primary)	59.62613972 -148.3429446	195	283	0	283	A chronology at this site should help to evaluate rates and progression of megathrust splay faulting on the time span of 10s to 100s of thousands of years. This site should penetrate three glacial cycles, which would lead to the development of a high latitude glacial and interglacial climate record. Moreover, timing of LGM deglaciation at this site is critical to understanding of LGM ice sheet collapse was catastrophic or gradual.
PWSJT-04A (Alternate)	59.62043641 -148.3532876	194	295	0	295	A chronology at this site should help to evaluate rates and progression of megathrust splay faulting on the time span of 10s to 100s of thousands of years. This site should penetrate three glacial cycles, which would lead to the development of a high latitude glacial and interglacial climate record. Moreover, timing of LGM deglaciation at this site is critical to understanding of LGM ice sheet collapse was catastrophic or gradual.
PWSJT-05A (Primary)	59.56385014 -148.214661	203	86	1025	1111	The purpose of this site is to collect samples across a megathrust splay fault with known historical rupture in order to evaluate mechanical properties of the fault zone.
PWSJT-06A (Alternate)	59.6292841 -148.3010139	197	132	628	760	The purpose of this site is to collect samples across a megathrust splay fault with known historical rupture in order to evaluate mechanical properties of the fault zone.
PWSJS-01A (Primary)	59.0566182 -147.4855221	908	1187	0	1187	This slope site is outboard of the LGM ice margin in a region of a former ice stream emanating from Prince William Sound. Relatively complete records collected here will address the dynamics of trough-bound paleo-ice streams and their role in draining the Cordilleran ice sheet. These records are instructive for understanding processes of current and future retreat dynamics of large outlet glacier systems, such as controls of grounding zone stability via ocean or atmospheric forcing, or feedbacks involving ice-proximal sedimentation or glacial isostatic rebound, which may serve to stabilize or destabilize grounding zones faced with warming ocean or atmosphere.
PWSJS-02A (Alternate)	59.03292781 -147.4238198	1106	1187	0	1187	This slope site is outboard of the LGM ice margin in a region of a former ice stream emanating from Prince William Sound. Relatively complete records collected here will address the dynamics of trough-bound paleo-ice streams and their role in draining the Cordilleran ice sheet. These records are instructive for understanding processes of current and future retreat dynamics of large outlet glacier systems, such as controls of grounding zone stability via ocean or atmospheric forcing, or feedbacks involving ice-proximal sedimentation or glacial isostatic rebound, which may serve to stabilize or destabilize grounding zones faced with warming ocean or atmosphere.