IODP Proposal Cover Sheet

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Ulleung Basin Landslides

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Title	Ulleung Basin gas hydrates and submarine landslides: climate-driven hazards?
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Abstract

Submarine slope failure and derived sediment gravity flows are recognized as a major sedimentary process in basins worldwide. Their large failure volumes and long-runout distances pose significant tsunami hazard for offshore and coastal facilities, and thus it is important to understand the mechanisms and processes involved in the initiation of slope failure. One hypothesis currently being debated is that sea level fluctuations and ocean bottom temperature changes can cause gas hydrate dissociation and/or dissolution and/or gas exsolution and expansion leading to submarine slope failure. However, evidence that propagation in seafloor sediments of pressure and thermal perturbations associated with climate change induce slope instability is lacking, and more importantly there has not been a dedicated study to investigate these feedbacks. To move forward in our understanding of the roles of climate, sedimentation patterns, geomechanical properties of gas-hydrate bearing sediments and slope stability, we propose to acquire an expanded Quaternary record of mass-wasting activity, gas emissions, climatic/paeloceanographic proxies and physical properties to better constrain the gas hydrate-slope failure system. The Ulleung Basin, situated between the Korean peninsula and the Japanese archipelago, is an optimal study region because: (1) the high abundance of gas hydrates, particularly at the southern end of the basin (2) more than 50% of the >1000 m thick Plio-Quaternary succession is comprised of Mass Transport Deposits (MTDs), (3) high susceptibility of background sedimentary cycles to climate changes, and (4) extensive Site Survey Data has already been collected in this region which ensures proper site selection. The fundamental science objective of this proposal will not only improve our understanding of the hydrate-slope failure link in relation to climate induced perturbations, but will enhance our understanding of dynamic behavior of the MTDs and further help to address societally relevant problems related to assessing geohazards to adjacent land-masses.

Scientific Objectives

This proposed drilling program addresses the following scientific interrelated hypotheses that are related to the pre-failure, failure and post-failure stages and the hazard from offshore slope failures:
H1) Climate-modulated sedimentary cyclicity and margin architecture precondition the slope for failure and control its size and style.
H2) Climate-induced stress and temperature variations drive perturbation of gas hydrate systems which trigger submarine landslides.
H3) Magnitude, timing, frequency and clustering of submarine landslides determine the hazard from submarine slope failures and derived tsunami.

To test these hypotheses, we propose the following scientific objectives that can only be achieved by drilling:
O1) Investigate how climate-modulated sedimentation, stratigraphy and fluid flow control slope failure.
O2) Understand the development of weak layers.
O3) Constrain the influence of past sea level and temperature changes on perturbations to the gas hydrate system.
O4) Test whether dissociation or dissolution is the preferential way by which gas hydrates originate slope failure.
O5) Constrain timing and frequency of submarine landslides and potential clustering in relation to major climatic changes.
O6) Assess the hazard from submarine slope failures and derived tsunamis.

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

LWD logging to collect near-seafloor data in sediments after minimal drilling disturbance.*
SET-P, T2P pressure probes to estimate pore pressure.*
Pressure core sampler (PCS) to determine gas hydrate saturation and physical properties of the cores at in situ pressures

*We are working to secure funding for additional costs related to the use of these tools.

Proposal History

Submission Type: Resubmission from previously submitted proposal

Review Response

Major changes of the revised 885-Full proposal, reflecting SEP comments, are the following:
1. Supplements for “the climatic information”: 1) We described the oceanography and paleoceanography background more explicitly in a separate section, referring to the recent results from Exp. 346, which demonstrated that conventional proxies were successful in reconstructing orbital-scale climate cyclicity. 2) In point B of methodologies and proxies related to “Testing hypothesis 2”, we suggested how planktonic/benthic foraminiferal oxygen isotopic and alkenone temperature data can provide local sea level history, in addition to the eustatic sea level changes provided by correlation to the LR04 stacks. 3) In point C of the methodologies and proxies related to “Testing hypothesis 2”, we reviewed problems in using foraminiferal Mg/Ca ratio and suggested four different approaches for reconstruction of deep and intermediate water temperature changes.
2. Differences between proposal 885-Full and proposal 811-Full / Expedition 372: We emphasize that the aims of 885-Full encompass a wider perspective on the relationship between submarine landslides and climate change (e.g., GH dissolution (not only dissociation), climate-modulated weak layers, landslide dynamics) that were not dealt with in the previous drillings.
3. Site Survey Data: 1) We modified the drilling site names according to the IODP’s site naming rule. 2) We added two primary sites (UBSL-08A, UBSL-09A) to ensure achievements of objectives 3 and 4. 3) We provided alternate sites for all the primary sites. 4) Other comments for Site Survey Data will be faithfully reflected in the next data upload.
4. Operations: We made more clear operation plans, including LWD or WL logging at each site. We currently have no plan to use 3rd party PCS.
5. We accepted the recommendations for the usage of geographic names.
6. Other improvements: 1) We more explicitly suggested possible roles of diatom-rich layers as weak layers for submarine landsides in section “4. Quaternary sedimentation and submarine landslides”. 2) Two new figures were added.

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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	
UBSL-01A (Primary)	36.277664 130.035543	1313	500	0	500	Expanded, mostly biogenic, in-situ sequence on the western slope. This site will provide climatic, oceanographic and age constraints for MTDs in the basin. It will also provide mechanical characteristics of sediments on the western slope that contain weak layers correlated to adjacent gliding planes. Presence of gas hydrates will allow testing the role of dissociation and dissolution in triggering slope failure (Objectives 1, 2, 3, 4, 5).
UBSL-02A (Primary)	35.702560 130.338706	977	250	0	250	Expanded, mostly terrigenous, in-situ sequence on the southern slope but close to large slope failures. This site will provide climatic, oceanographic and age constraints for MTDs in the western slope and basin. It will also provide mechanical characteristics of sediments on the southern slope. Presence of gas hydrates will allow testing the role of dissociation and dissolution in triggering slope failure (Objectives 1, 2, 3, 4, 5).
UBSL-03A (Primary)	35.599585 130.182136	425	400	0	400	In-situ sequence adjacent to submarine slope failure scars. BSR or enhanced reflection intersects the slope nearby recent submarine landslides. This location will reveal past and recent gas hydrate phase changes, likely related to dissociation, and define the geothermal gradient and current state of stress thanks to pore pressure measurements (objectives 3, 4).
UBSL-04A (Primary)	35.802003 130.326836	1276	280	0	280	Sequence of stacked MTDs near landslide evacuation area. BSR present in the sedimentary column. This site will address past gas hydrate phase changes and define the geothermal gradient and current state of stress. It will also help constrain landslide stages, emplacement style and rheology in a proximal setting (Objectives 3, 4, 6).
UBSL-05A (Primary)	36.144712 130.335383	1652	400	0	400	Sequence of stacked MTDs in proximal setting. This site will constrain landslide stages, emplacement style and rheology in a proximal setting (Objective 6).
UBSL-06A (Primary)	36.478230 130.335378	2067	400	0	400	Sequence of stacked MTDs. This site will provide material for direct dating of slope failure events and will help constrain landslide stages, emplacement style and rheology (Objectives 5, 6).
UBSL-07A (Primary)	36.794749 130.235734	2213	640	0	640	Sequence of stacked MTDs in distal setting. This site will provide material for direct dating of slope failure events in a distal setting and will help constrain landslide stages, emplacement style and rheology (Objectives 5, 6).
UBSL-08A (Primary)	36.254876 129.964135	1190	600	0	600	In-situ sequence adjacent to submarine slope failure scars. BSR or enhanced reflection intersects the slope nearby recent submarine landslides. This location will reveal past and recent gas hydrate phase changes, likely related to dissociation, and define the geothermal gradient and current state of stress thanks to pore pressure measurements (objectives 3, 4).
UBSL-09A (Primary)	36.128979 129.836497	800	500	0	500	In-situ sequence adjacent to submarine slope failure scars. BSR or enhanced reflection intersects the slope nearby recent submarine landslides. This location will reveal past and recent gas hydrate phase changes, likely related to dissociation, and define the geothermal gradient and current state of stress thanks to pore pressure measurements (objectives 3, 4).
UBSL-10A (Alternate)	36.322852 130.097291	1506	490	0	490	Expanded, mostly biogenic, in-situ sequence on the western slope. This site will provide climatic, oceanographic and age constraints for MTDs in the basin. It will also provide mechanical characteristics of sediments on the western slope that contain weak layers correlated to adjacent gliding planes. Presence of gas hydrates will allow testing the role of dissociation and dissolution in triggering slope failure (Objectives 1, 2, 3, 4, 5).
UBSL-11A (Alternate)	35.740250 130.354242	1090	255	0	255	Expanded, mostly terrigenous, in-situ sequence on the southern slope but close to large slope failures. This site will provide climatic, oceanographic and age constraints for MTDs in the western slope and basin. It will also provide mechanical characteristics of sediments on the southern slope. Presence of gas hydrates will allow testing the role of dissociation and dissolution in triggering slope failure (Objectives 1, 2, 3, 4, 5).

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	
UBSL-12A (Alternate)	35.617444 130.182214	530	400	0	400	In-situ sequence adjacent to submarine slope failure scars. BSR or enhanced reflection intersects the slope nearby recent submarine landslides. This location will reveal past and recent gas hydrate phase changes, likely related to dissociation, and define the geothermal gradient and current state of stress thanks to pore pressure measurements (objectives 3, 4).
UBSL-13A (Alternate)	35.823598 130.324915	1305	300	0	300	Sequence of stacked MTDs near landslide evacuation area. BSR present in the sedimentary column. This site will address past gas hydrate phase changes and define the geothermal gradient and current state of stress. It will also help constrain landslide stages, emplacement style and rheology in a proximal setting (Objectives 3, 4, 6).
UBSL-14A (Alternate)	36.187613 130.335762	1688	400	0	400	Sequence of stacked MTDs in proximal setting. This site will constrain landslide stages, emplacement style and rheology in a proximal setting (Objective 6).
UBSL-15A (Alternate)	36.490183 130.334891	2076	400	0	400	Sequence of stacked MTDs. This site will provide material for direct dating of slope failure events and will help constrain landslide stages, emplacement style and rheology (Objectives 5, 6).
UBSL-16A (Alternate)	36.776659 130.235866	2210	640	0	640	Sequence of stacked MTDs in distal setting. This site will provide material for direct dating of slope failure events in a distal setting and will help constrain landslide stages, emplacement style and rheology (Objectives 5, 6).
UBSL-17A (Alternate)	36.277447 129.963800	1057	700	0	700	In-situ sequence adjacent to submarine slope failure scars. BSR or enhanced reflection intersects the slope nearby recent submarine landslides. This location will reveal past and recent gas hydrate phase changes, likely related to dissociation, and define the geothermal gradient and current state of stress thanks to pore pressure measurements (objectives 3, 4).
UBSL-18A (Alternate)	36.133571 129.836516	780	520	0	520	In-situ sequence adjacent to submarine slope failure scars. BSR or enhanced reflection intersects the slope nearby recent submarine landslides. This location will reveal past and recent gas hydrate phase changes, likely related to dissociation, and define the geothermal gradient and current state of stress thanks to pore pressure measurements (objectives 3, 4).