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IODP Proposal Cover Sheet

806-Pre

☒ **New** ☐ **Revised** ☐ **Addendum**

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Title:	Methane release and geologic processes associated with warming permafrost and gas hydrate deposits beneath the Beaufort Sea Shelf and upper Slope		
Proponent(s):	Charles Paull, Scott Dallimore, Timothy Collett, Young Keun Jin, Jurgen Mienert, Kai Mangelsdorf , and Michael Riedel		
Keywords: *(5 or less)*	climate change, offshore permafrost, gas hydrates, geohazard, glacial history Arctic shelves	Area:	Beaufort Sea/ Arctic Ocean

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Permission to post abstract on IODP Web site: ■ Yes ☐ No

Abstract: (*400 words or less)*

A comprehensive scientific drilling program to investigate the warming of permafrost and gas hydrates occurring beneath the Arctic shelf is proposed for consideration by both the Integrated Ocean Drilling Program (IODP) and International Continental Scientific Drilling Program (ICDP) simultaneously. An overarching research goal will be to assess geologic processes caused by marine transgression, determine the cause of observed seabed release of methane and to estimate the sensitivity of this environment to climate change in the Arctic. A dill transect with target depths of ≥300 m for all the holes on the shelf edge to upper slope transect is being proposed with continuous coring to the full depth to capture a record of the variation in geology and pore water / gas chemistry /microbiology. Biostratigraphic studies of sediment cores and geothermal modeling of observed ground temperatures will also assist to constrain the Quaternary history of the Arctic shelf with emphasis on determining the offshore glacial limits, the history of transgression/regression, evidence for Younger Dryas glacial outburst flooding as well as periods of permafrost and gas hydrate formation/degradation. Geochemical and microbiological studies will quantify the abundance of greenhouse gases present within ice bonded permafrost, provide an estimate of the flux of methane to the seabed, and determine the biogeochemical dynamics. Detailed geocryologic logging of core samples will investigate the mode and occurrence of ground ice and gas hydrate within the cored sediments.

Drill sites will be chosen on the outer Beaufort shelf and slope to the east of the Mackenzie Delta in areas with varied geologic/permafrost/gas hydrate settings and transgression histories. The technical requirements to accomplish the proposed drilling and monitoring program are challenging as the water depths are shallow (50-400m) and sea ice can encroach on the study area, even during the short open water operational season (generally August to October). Efforts to minimize disturbance of permafrost and gas hydrate present in cored sediments may require consideration of advanced drilling/coring technologies. Measurements of downhole formation temperatures and pressures are a high priority.

This program will benefit from the lessons learned from the 2002 Mallik International Continental Scientific Drilling Program (ICDP), which completed three 1150 m deep instrumented research wells (one coring well and two observation wells) at a coastal site in the Mackenzie Delta. These wells provide a terrestrial analogue for comparison with the offshore. This program also established protocols for preservation and analyses of permafrost and gas hydrate-bearing core samples, and deployment of DTS temperature cables in an Arctic setting.

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Scientific Objectives: (*250 words or less*)

We propose to drill a transect of research wells to document the rapidly changing transitional geologic environments of the southern Beaufort Sea from the mid shelf to upper slope. Conventional stratigraphic, biostratigraphic core studies, newly developed geocryologic determinations of ground ice fabric and structure, and high resolution dating methods (including 14C and optical dating) will provide a basis to reconstruct the Quaternary transgression-regression history of the shelf including sea level fluctuations and evidence of glacial ice cover, ice shelves and a Younger Dryas outburst flood. These studies, when combined with measurements of the in situ temperature and pressure regime at four contrasting sites will allow development and verification of a geothermal model which can then be used to estimate the sensitivity of this setting to future climate warming linkages. We also seek to elucidate the interconnections between deep-seated processes (including ground water flow, sediment movement, gas release, microbial communities) associated with permafrost and gas hydrate warming and degradation and shallow sea bed processes including formation of pingo-like features, pock mark formation and large-scale slope instability. One research well will be sited in the upper shelf (~300m water depth) to study the stability marine gas hydrate in this setting and geologic processes responsible for the formation of large-scale sea floor expulsion features.

Please describe below any non-standard measurements technology needed to achieve the proposed scientific objectives.

The target depth of ≥300 m TD for all the holes on the shelf edge to upper slope transect is being proposed with continuous coring to the full depth to capture a record of the variation in geology and pore water / gas chemistry /microbiology. The exact total depths will be adjusted based on the site survey information that is ultimately available. Because we anticipate that the shelf research wells will encounter thaw-sensitive permafrost (Ruffel et al., 1992) and others may contain *in situ* gas hydrate, it will be necessary to minimize thermal and mechanical disturbance of core samples and to take measures to limit post-coring sample degradation. In addition to a conventional suite of open hole wireline logs, it would be very desirable to include advanced tools such as the NMR log to quantify variability in *in situ* water/ice/gas hydrate content (Kleinberg and Griffin, 2005). Pressure cores will be critical for quantifying the volumes of dissolved gas, free-gas and gas hydrate. A central goal of the research wells will also be to characterize the *in situ* pressure and temperature regime. There are several ways that this could be achieved including periodic probe type tests ahead of the bit as each hole is advanced, deployment of active borehole logging tools after drilling like the Schlumberger MDT and XPT tools, or the placement of instrumentation within the well such as fibre optics cables or discrete pressure/temperature sensors.

Proposed Sites:

Site Name	Position	Water Depth (m)	Penetration (m)			Brief Site-specific Objectives
			Sed	Bsm	Total	
BS001A	Approx 70°28.9'N 135° 26.5'W	50	≥300 m		≥300 m	Near a mid-shelf PLF to document conditions at the top of gas hydrate stability zone where gas believed to be from gas hydrate decomposition (Paull et al., 2007) is known to be venting. This research well will establishthe ground temperature (T) and pressure (P) regime of offshore permafrost. Core studieswill document for the first time porous media properties of this unstable zone including the biogeochemistry, permeability and seal potential and abundance of trapped gases that may be released upon warming including.
BS001B	Approx 70°28.9'N 135° 26.5'W	60	≥100 m		≥100 m	Mid-shelf PLFs commonly have well developed moats that are tens of meters deeper than the surrounding shelf and thus form mini-basins, which are very effective sediment traps. This well with ≥100 m penetration will be sited within a moat surrounding one of the PLFs where we anticipate up to 60 m thickness of stratified post-transgression Holocene sediments that have not been disturbed by ice scour. Recovering a shallow stratigraphic core from one of these mini-basins offers an unprecedented opportunity to carry out high-resolution paleoenvironmental and sea level studies of this region.
BS002A	Approx 70°32.5'N 135° 46'W	80	≥300 m		≥300 m	Geothermal modeling suggests that a near isothermal permafrost and permafrost gas hydrate interval extends far offshore and pinches out in the outer shelf area between 80-100m water depth. This is an area where there is a widespread evidence of sea bed

						instability which includes PLFs, pock marks and sea bed active gas release. This research well will establish the in situ P-T regime of most thermally disturbed offshore permafrost. Core studies will confirm the physical properties of this unique setting.
BS003A	Approx 70°33.5'N 135° 55.2W	125	≥300 m		≥300 m	Geothermal modeling suggests that neither permafrost nor marine gas hydrate is stable is the upper slope with water depths between 100-250 m. This is an area where there is considerable evidence of sediment instability with several large landslide features, some of which are releasing gas. A research well in this setting will confirm the absence of permafrost and also quantify unique subsurface processes such as lateral discharge of shelf ground water/ gases from thawing permafrost affecting the strength of near surface sediments.
BS004A	Approx 70°38.9'N 135° 58.0'W	300	≥300 m		≥300 m	The proposed shelf to upper slope transect (Fig. 6) will be anchored on the seaward side by a ≥300 m deep borehole on the upper most slope in ~290 m water depths. This borehole will document the geology and porous media setting near the uppermost boundary of gas hydrate stability (e.g., ~270 m below sea level), enabled by the unique hydrographic conditions in this section of the Arctic Ocean.