Intermittent Expulsion of Warm Methane Fluid from Mud Volcano in the Canadian Beaufort Sea

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Abstracts

The Canadian Beaufort Sea is one of the most prominent areas to study geologic features related to gas hydrate in association with permafrost environment because the continental shelf experienced subaerial cold conditions during the Last Glacial Maximum (LGM) and long-term warming occurred since then. Expedition ARA04C using IBRV Araon was carried out in the Canadian Beaufort Sea during September 6-24, 2013 as part of a Korea/Canada/USA international cooperative research program. During the expedition several attempts to measure geothermal gradients using a 5-m-long heat probe were made at a total of eight sites: 1) the inside/outside of a flat-topped mud volcano where fluid expulsion was observed by echosounder, 2) along the eastern slope of the Mackenzie Trough where permafrost below the seafloor degrades basin-ward, and 3) at a background location close to sites of IODP pre-proposal #753 on the continental slope, where no permafrost below the seafloor is expected and also no vertical fluid expulsion features occur. Results from our measurements on the flat top of the mud volcano seem to support the evidence that warm methane-rich fluid has intermittently been emitted through sediments into the ocean. For instance, we find: 1) a much higher geothermal gradient than that from the outside of the mud volcano as well as the background value from the regular seafloor, 2) a much higher seafloor temperature compared with bottom water temperature, and 3) a significantly high methane concentration from the water samples. On the other hand, both substantial variability in the geothermal gradients and seafloor temperatures equilibrated with surrounding water from the eastern slope of the Mackenzie Trough area indicate a possible geothermal perturbation by permafrost. Unfortunately, in-situ thermal conductivity was not measured due to instrument malfunction. Further detailed heat flow analysis together with sediment core analysis may improve our understanding of the nature of methane expulsion emitted from marine sediments in connection with the degradation of permafrost over the arctic shelf.

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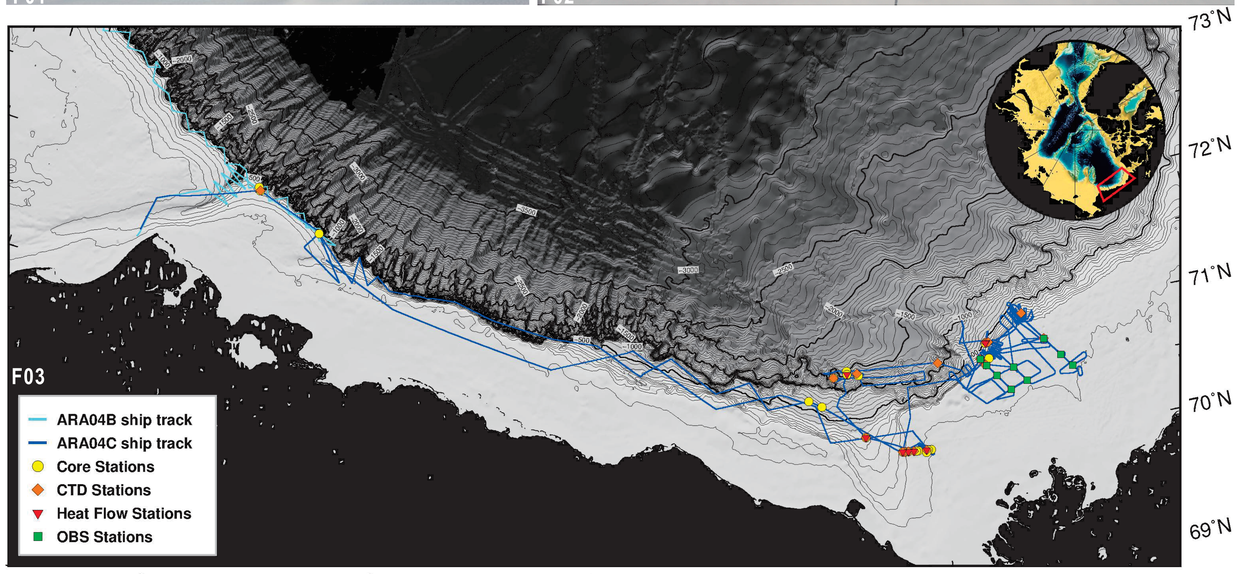
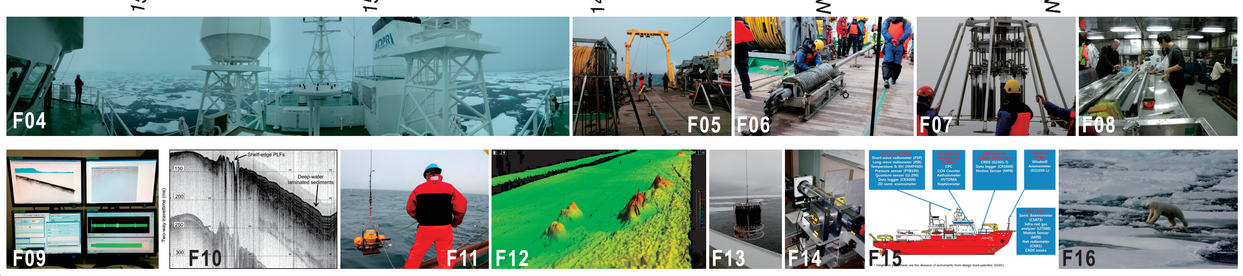
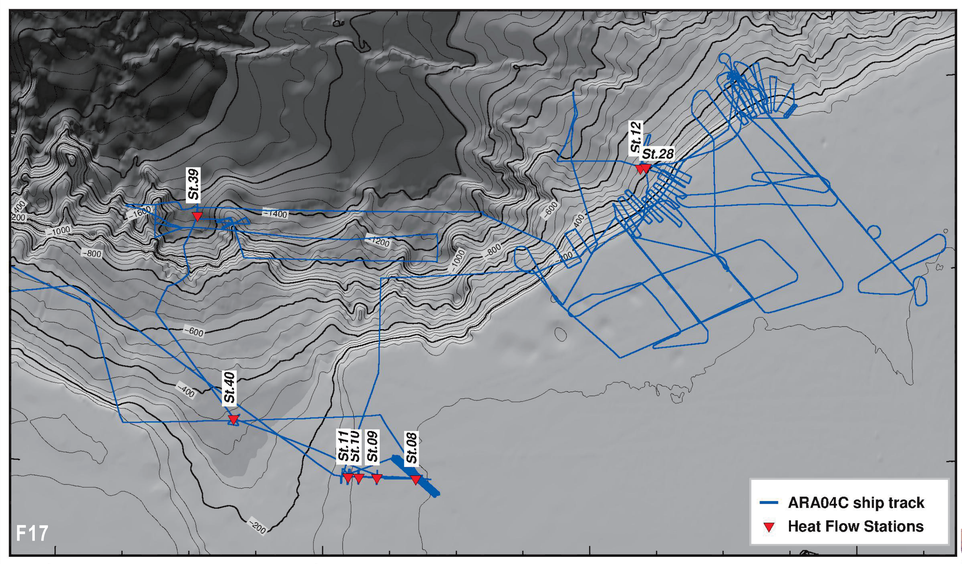
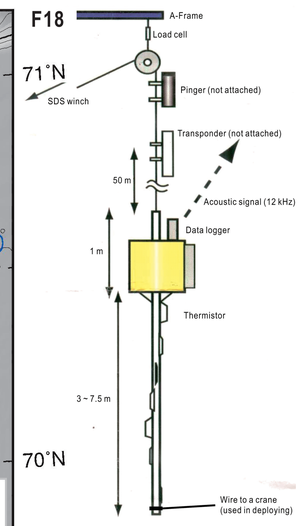
1. Expedition ARA04C (Arctic Araon Exp. 04 Leg C)

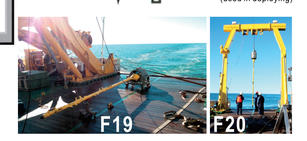




2. Marine Heat Flow Measurements

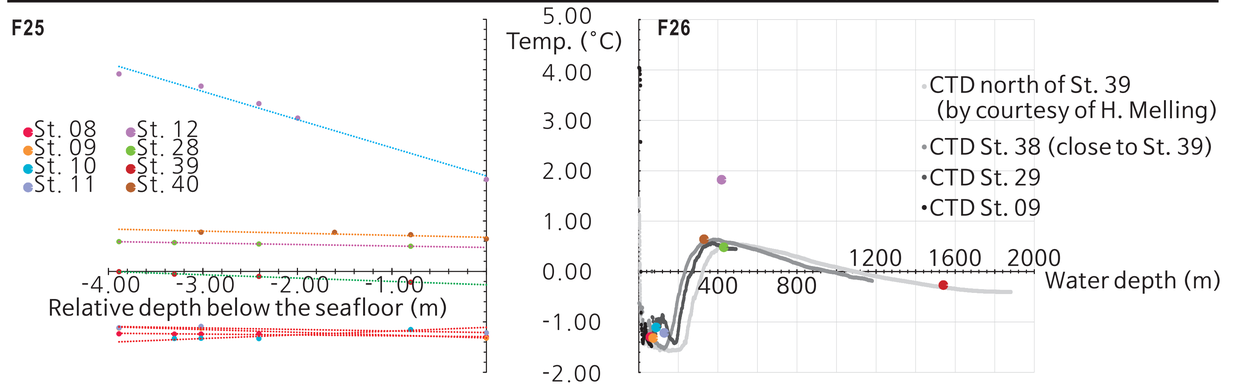


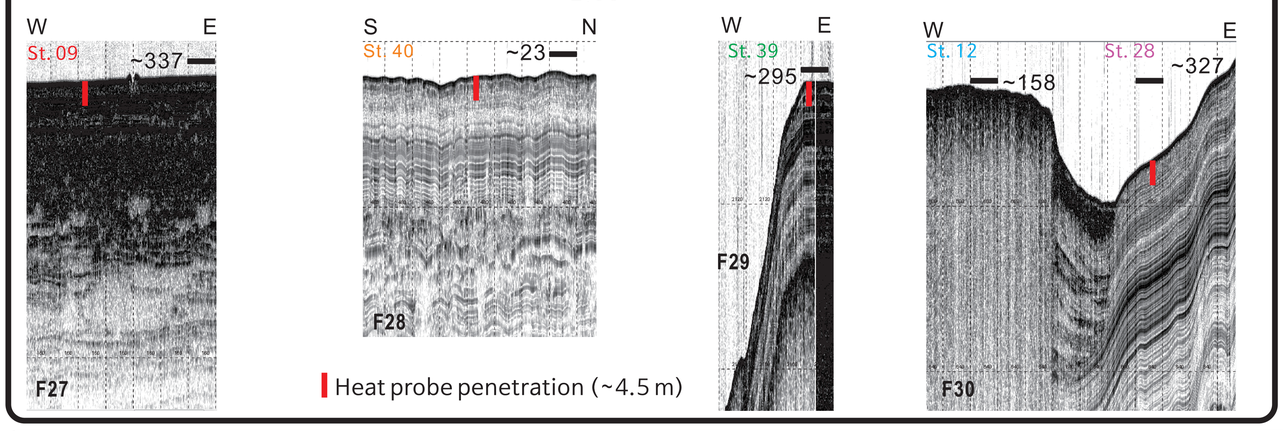




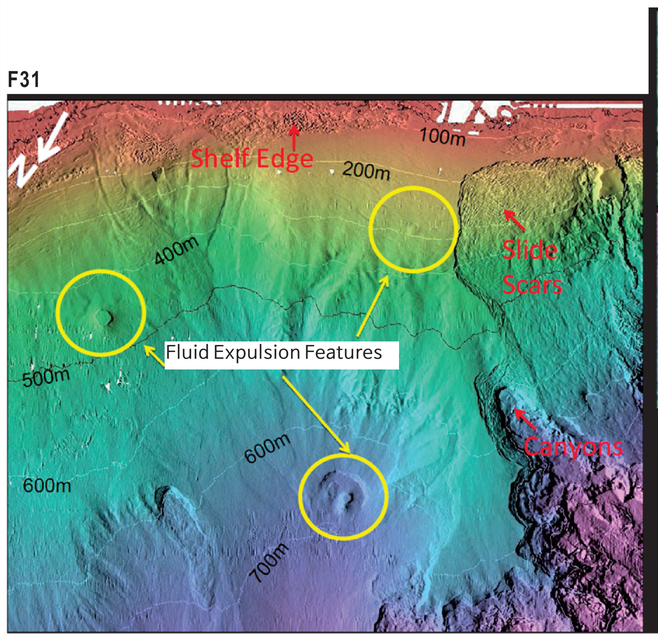
3. Observed Geothermal Gradient & Seafloor Temperature

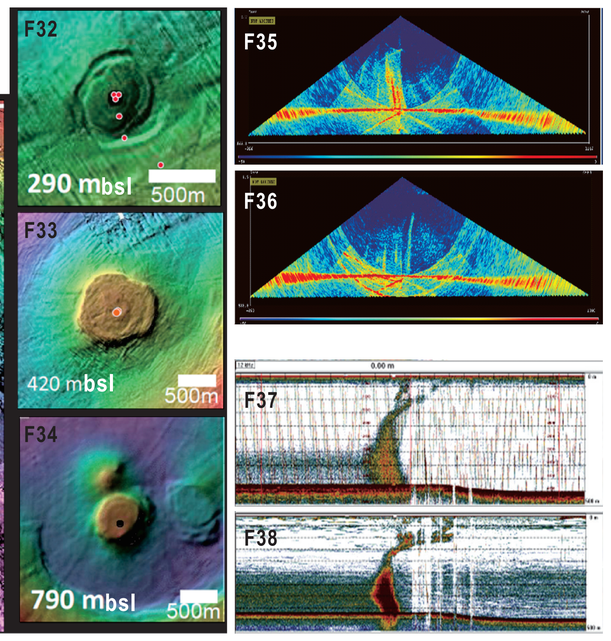
T01	St. 08	St. 09	St. 10	St. 11	St. 40	St. 39	**St. 12**	St. 28
Seafloor temp. (°C)	-1.30	-1.32	(-1.11)	(-1.22)	0.64	(-0.27)	**1.82**	(0.48)
Geothermal gradient (mK/m)	16.8	55.3	-73.9	30.1	41.5	66.1	**557.9**	28.9
Water depth (m)	59	73	88	129	330	1540	**419**	430
Site description	Eastern slope of the Mackenzie Trough (EMT); permafrost below the seafloor				EMT; No permafrost	Around IODP pre-proposal #753	Top of mud volcano	Outside of mud volcano

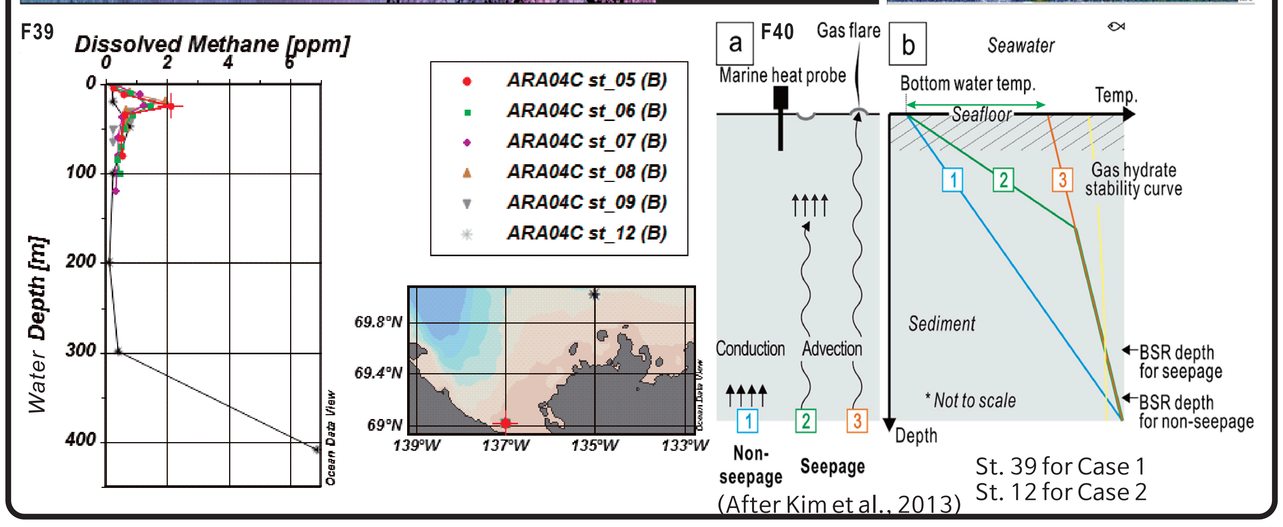




4. Intermittent Methane Fluid Expulsion from Mud Volcano at 420 mbsl







5. Conclusions & Future Plan

- Marine heat flow in the Arctic Sea is observable with the current marine heat probe but it is necessary to modify for better results.
- In the research area, geothermal gradient is observed as a range between -73.9 mK/m and 557.9 mK. Linear temperature profile together with seafloor temperature equilibrated to the surrounding water except at Station 12 (top of mud volcano) indicates the steady state in conductive heat transfer mode within sediments. Wide range from the Eastern Mackenzie Trough seems to stem from effect of permafrost (ice).
- At Station 12, warm methane-rich fluid is intermittently emitted from sediments into the water column. Further, origin depth and flux of the fluid will be analyzed with utilizing porewater chemistry and physical properties of sediment cores.
- Background geothermal gradient seems to be measured from Station 39, the deepest site, but we need check out during the upcoming cruise in this summer. At this stage, we may consider using Tishchenko et al. (2005)'s equation that the top of gas hydrate stability zone locates ~320 mbsl.
- In-sith thermal conductivity is not measured due to instrument problem. In the upcoming cruise, additional thermal conductivity meter (TK04 with a need probe) will be prepared to measure laboratory thermal conductivity of sediment cores on board.

6. Acknowledgments & Notice

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- The contents in this poster was previously presented at the European Geosciences Union General Assembly 2014 (EGU2014-4814) held in Vienna, Austria, from 27 April to 02 May 2014.

7. References

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