WHITE PAPER

Developing Long Term International Collaboration on Methane Hydrate Research and Monitoring in the Arctic Region

1. Introduction

1.1. It is acknowledged that climate change is of world wide importance and many nations are involved with assessing the causes and mitigating the consequences. The Arctic Ocean and its surrounding land mass are particularly sensitive to changes in temperature and therefore understanding the environmental processes acting in the Arctic region is crucial.

1.2. Particular aspects of the climatology, oceanography, geology, biology and chemical processes of the Arctic Region are unique and there is a profound need for a long term international research and monitoring program.

1.3. This White Paper sets out to initiate an integrated, international, program to address different national concerns, undertake research, integrate knowledge and scientific expertise, and develop mechanisms for cost sharing. Basic research needs to be coupled with a long term monitoring program to improve the knowledge base and provide the data necessary for ecosystem modeling and model calibration.

1.4. The program will initially focus on methane hydrates as it is considered that their dissociation could be of critical importance to climate change. Furthermore, methane hydrates have not been given sufficient attention by the scientific community, particularly in the Arctic region. Methane hydrates will be considered in terms of their occurrence and flux, in relation to seasonal variations and changes in ocean circulation, as well as possible changes in environmental conditions which may have already been initiated by climate change. The program will consider both the continental slope, as well as permafrost regions surrounding the Arctic Ocean.

2. International Collaboration

2.1. Six nations have territorial interests in the Arctic region and these, as well as other nations, have active research programs in the Arctic. It is fundamental to this research and monitoring program that all interested nations are consulted and strongly encouraged to collaborate. Furthermore, it is important to have knowledge of existing, or planned, national and international programs to seek synergies and opportunities for collaboration and coordination, and the sharing of expertise, facilities and costs.

3. Proposed Workshop and Planned Goals

3.1. In order to initiate this program of work, it is proposed to hold a workshop for interested parties. Detailed presentations and discussions will be held on the objectives and procedures for this research and monitoring program on Methane Hydrates in the Arctic regions and their relevance to climate change. It will also provide the opportunity to review existing and planned programs and to assess the potential for collaboration.

3.2. The goals of this workshop will include:

- Provide the opportunity for national representatives to explain their interests, programs and their objectives.
- Establish a comprehensive Arctic Ocean and Tundra review of existing data and system knowledge.
- Setup an international consortium of participating nations.
- Determine key ocean and tundra regions for future monitoring and experimental operations.
- Plan a long term in situ monitoring program that will be coupled with field calibration and experiments.
- Organize a long term monitoring data acquisition plan that considers parameters, regions and frequency.

4. Background Information

4.1. The Arctic region has unique physical, oceanographic, bathymetric and sedimentological conditions, all of which may impact on the occurrence and dissociation of the Methane Hydrates, which are known to exist in this region. The Arctic continental slopes and rises contain thick organic-rich sediment successions which, through biogenic processes, lead to the formation of Methane. Unlike that for the formation of hydrates in deep water, where hydrostatic pressure is the controlling mechanism, low temperatures permit the formation of Methane Hydrates in both shallow water and on land in the permafrost. Temperature variations are critical to their stability. It is considered that the extent and variability of ice cover and the stability of the permafrost may have significant impact on hydrate dissociation, its subsequent escape into the atmosphere and thereby impact on climate change.

4.2. An additional unknown is the role of meta-stable hydrates; that is deposits that are on the physical boundaries of hydrate stability, but are dissociating only very slowly because of the low temperatures in the permafrost. They would be expected to dissociate almost instantaneously once the permafrost “insulator” starts melting. Meta-stable hydrates may be responsible for some gas blowouts in Siberia both on- and offshore. The time gas hydrates can “survive” under meta-stable conditions is still speculative.

4.3. The Arctic Ocean is almost completely enclosed by continental land masses and these are interrupted by eight marginal seas (the Barents, Kara, Laptev, East Siberian, Chukchi, Beaufort, Lincoln Seas and Greenland Seas). In addition, 52.7% of the area is comprised of a shallow continental shelf, which makes the region markedly different from the rest of the world's oceans [1].

4.4. Full-depth ocean circulation occurs through the Molloy Deep between Greenland and NW Svalbard. Otherwise, water circulation with the Atlantic and Pacific Oceans takes place mainly through relatively shallow waters of the Beaufort and Barents seas and through the Davis Strait to the Labrador Sea. The complexity of the circulation and its water properties leads to the establishment of layering, with different layers having residence times varying from seasonal to several hundred years.

4.5. The large variation of seabed morphology through the Arctic Ocean provides a potentially broad range of responses to climate change and resulting ocean circulation, sediment and ocean chemical cycles, and the biological adaptation. Prediction of these changes needs to focus on potential environmental impact and coastal stability, resulting from natural changes, as well as anthropogenic forcing that may occur during increase mineral exploitation, shipping and harbor development.

5. Research and Development Objectives

5.1. The program objectives include the following:

- Integrate national Arctic concerns into a concerted international Arctic research and monitoring plan.
- Combine global expertise in ocean and tundra geophysics, chemistry and biology to plan field monitoring and research.
- Plan long term international funding to support the research and monitoring plan.
- Identify primary locations for a research and monitoring focus.

5.2. Basic science topics to be addressed in the program planning include the following:

- Study the seasonal variability of methane hydrate dissociation and its subsequent absorption in the water column and/or escape into the atmosphere.
- Acquire and integrate seismic, heatflow and geochemical data for the evaluation of hydrate occurrence and distribution within the sediments.
- Estimate the spatial variation in the vertical methane diffusion in comparisons of sediment and water column temperatures, heatflow, seismic profiles, and water column depth.

[1] For the rest of the world oceans, the continental shelves account for less than 17% of the ocean surface area (Menard and Smith, 1966).

- Develop and calibrate models to evaluate sediment hydrate loading, hydrate destabilization through warming, and the fate of methane after hydrate destabilization.
- Develop and calibrate in the laboratory thermodynamic models for dissociation of gas hydrates under meta-stable conditions in sediments.
- Develop and calibrate in the laboratory elastic models of sediments containing ice and gas hydrates, including during dissociation
- Conduct basic sediment and water column research to study microbial methanotrophic activity and its control on methane emissions.
- Determine the relative sediment methane partition between water column and atmosphere.
- Establish the seasonal and spatial variation of methane flux to the atmosphere between the coastal ocean and tundra.

6. Initial Leading Research Participants and Program Coordinators:

Dr. Richard B. Coffin (POC), Section Head Code 6114, Marine Biogeochemistry, Naval Research Laboratory, 4555 Overlook Avenue, SW, Washington DC, 20375, USA richard.coffin@nrl.navy.mil, Phone: 001 202 767 0065

Dr. Jens Greinert, NIOZ Royal Netherlands Institute for Sea Research, Landsdiep 4, 1797 SZ 't Hoorntje Texel, The Netherlands, Greinert@nioz.nl, Phone: +31-222 369 397

Dr. Ingo Pecher, Institute of Petroleum Engineering, Heriot-Watt University, Edinburgh, EH14 4AS, UK, ingo.pecher@pet.hw.ac.uk, Phone: 44 (0) 131 451 3675

Prof. Tina Treude, Leibniz Institute of Marine Sciences (IFM-GEOMAR), Department of Marine Biogeochemistry/Marine Geosystems, Wischhofstr. 1-3, Geb. 4, Raum 207, D-24148 Kiel, Germany, ttreude@ifm-geomar.de, Phone: 49-431-600-2837

Stephen M. Masutani, Ph.D., P.E., Hawaii Natural Energy Institute., School of Ocean and Earth Science and Technology, University of Hawaii 1680 East West Road, POST 109 Honolulu, HI 96822 USA stephenm@hawaii.edu, Phone: 001 808 956 7388

Nicholas Langhorne, Associate Director, US/UK Collaboration, US Office of Naval Research Global, London, UK, Postal Address: 86 - 88 Blenheim Crescent, Building 188, West Ruislip, Middlesex HA4 7HB, nlanghorne@onrglobal.navy.mil, Phone: UK 01895 616 030