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IN THIS ISSUE

A CANADIAN RESEARCH ICEBREAKER TO STUDY THE CHANGING ARCTIC OCEAN

Louis Fortier

Climate warming will be particularly intense over the Arctic and several observations tend to confirm that the arctic ice cover has already started to melt. The consequences of an ice-free Arctic Ocean will be far-reaching. They include potential extinction of unique arctic fauna, disruption of oceanic circulation, accelerated climate warming, the opening of a new ocean to resource exploitation and navigation, and major socio-economic and geo-political perturbations that will impact the entire Northern Hemisphere.

The international scientific community unanimously recognizes the acute need for direct observation and measurement of oceanographic conditions and processes in the Arctic Ocean to improve the climate models that attempt to predict the rate and extent of global warming. This has led arctic states and several non-arctic countries of the G7 to accelerate their national efforts in arctic oceanography. Germany is leading a comprehensive international program organized around its research icebreaker *Polarstern.* The US program in arctic oceanography has received a formidable boost with the launch of the research icebreaker *Healy.* Japan has increased efforts in the Arctic with support from the ice-reinforced research ship *Mirai.* The icebreaker *Oden* supports Sweden's program. Even China is now deploying a 150-m icebreaker, the *Xuelong*, to sustain a fast-growing program in arctic oceanography.

Despite obvious arctic responsibilities, Canada has been slow to join in leadership of the international effort to study the Arctic Ocean's response to climate warming; Canada's northern research efforts have consistently dwindled over the last 20 years. The recent Report of the Task Force on Northern Research appointed by the Natural Sciences and Engineering Research Council (NSERC) and the Social Sciences and Humanities Research Council (SSHRC) makes a clear case for renewing the historic Canadian leadership in arctic science (Hutchinson *et al.*, 2000, *From Crisis to Opportunity: Rebuilding Canada's Role in Northern Research*). The report identified the present weakness of logistical support as one of the

The CCGS *Pierre Radisson,* sister ship of the CCGS *Sir John Franklin.* Photo: Martin Fortier

main reasons for the decline of the Canadian research presence in the Arctic. The Report concludes, “If action is not taken, Canada will not be able to meet its international science and research obligations, or contribute to issues of global importance. Nor will we be able to meet basic national obligations to monitor, manage, and safeguard the northern environment ...”.

A SIGNIFICANT STEP TOWARDS THE REVITALIZATION OF CANADIAN ARCTIC SCIENCE

There are signs that this grim situation is changing, and that a revitalization of Canadian Arctic research is under way. In particular, a consortium of Canadian universities and federal agencies submitted a proposal to the International Fund of the Canada Foundation for Innovation to transform the 98-m icebreaker Sir John Franklin into a state-of-the-art research vessel to study the Arctic Ocean. Last June, the Board of Directors of the CFI selected this proposal to proceed to the next phase of review (see www.innovation.ca/media/index.cfm?websiteid=227). The proposed infrastructure also includes the specialized equipment necessary for the ship’s scientific mission, and partial operating funds for the first five years. The icebreaker is the key to jump-starting an urgently needed international program – led by Canada – that will study the changing Arctic Ocean over the next 15 to 20 years.

With the expected success of this proposal, the research icebreaker will become an important catalyst for the re-energizing of Canadian Arctic science by giving researchers unprecedented access to the Arctic Ocean. The infrastructure will also substantially strengthen Canada’s position in international arctic programs. Over the next ten years, the vessel will support several major multidisciplinary programs of international stature to advance our understanding of climate, oceanic circulation, sea-ice dynamics, biology, biogeochemistry, sedimentology, paleoceanography, and geology in the Canadian sector of the Arctic Ocean. The infrastructure will also support ship-based studies of the response of the coastal inland zone of the Canadian Arctic to climate forcing, and epidemiologic studies of the impact of climate change on the health of Northerners. Planned programs include:

Canadian Arctic Shelf Exchange Study (CASES, 2002–2007). The objective of CASES, which is fully funded, is to understand and model the response of biogeochemical and ecological cycles to atmospheric, oceanic and continental forcing of sea-ice cover variability on the Mackenzie Shelf.

International Monitoring Program of Arctic Canadian Seas (IMPACS, starting in 2004–2005). The lack of long-term data impedes our understanding of current changes in the arctic. IMPACS will begin gathering a long-term series of physical, biological and biogeochemical variables within the Arctic Basin (Mackenzie Shelf) and in the Canadian outflow of the Arctic Ocean (North Water).

Ice Information and Navigation Experiment (I^2NE, starting in 2003). A climate-induced extension of the ice-free season could open the Northwest Passage to intercontinental navigation as early as 2015–2025. I^2NE will build predictive ice dynamics and distribution models to develop management strategies for decreasing the risk of marine disasters while maximizing the potential shipping season.

Northern Regional Sensitivity to Climate Change (Northern-RiSCC, 2005–2010). This major international initiative focuses on a 55°N (Kuujjuarapik) to 80°N (Ellesmere Island) transect analysis of Canadian coastal land, lake and wetland environments to determine the potential response of terrestrial northern ecosystems to a northward shift of isotherms as the Northern Hemisphere warms. The research icebreaker will serve as a moving base, with access to coastal sites by launch and helicopter.

Role of Ice in the Morphodynamics of Arctic Coasts (RIMAC-ACD). RIMAC will anticipate the response of the Arctic Coast to climate-induced changes in ice cover, wave generation and storm surge. This information is critical for developing global sediment and carbon budgets and for predicting the impacts of changing climate on high-latitude coasts, infrastructure, habitats, cultural resources and communities.

Climate Change and Public Health in the Canadian Arctic (2003–2008). This program will examine the influence of climate on human health in the Arctic and will develop strategies for adapting to potential impacts of climate change in northern communities. The icebreaker will provide access to communities for collecting biological samples and facilities for interviewing and medical examination.

The comprehensiveness of the transformations and the diversity of the equipment pool attached to the ship will make it a versatile research platform able to provide support not only in the field of oceanography but also in several other fields of arctic science. For example, the ship will be equipped with the most sophisticated systems for ocean-floor mapping and, thanks to the moon pool and dynamic positioning system, will accommodate drilling operations in shallow waters – thus providing geologists and paleoceanographers with an exceptional tool for exploring arctic shelves and coasts. State-of-the-art reception stations and meteorological instruments will enable atmospheric specialists to calibrate satellite images with direct observations along the ship's path, and to further the study of atmosphere-ocean exchanges in the Arctic. The helicopter, launch and landing barge will provide access to the coastal zone of the Canadian Archipelago to terrestrial ecologists. The transformed clinic will facilitate epidemiological research in northern communities.

A VERSATILE RESEARCH INFRASTRUCTURE

For its new role as a research vessel the icebreaker will be modified to include:

- An internal moon pool. Thick sea ice and sub-zero atmospheric temperatures are major obstacles to the safe deployment of delicate instruments. The internal moon pool solves these difficulties by providing an opening to the sea from inside the ship.
- A dynamic positioning system including the addition of stern and mid-ship thrusters. The DPS allows the vessssel to maintain a precise position despite tides, currents, winds and drifting ice, essential for operations such as coring, drilling, the precise mooring and recovery of instruments, the deployment of remotely operated vehicles, etc.
- Fully-equipped wet and dry laboratories, including temperature-controlled units, and microscopy and instrumentation rooms for a total of nearly 400m^2 of working space.
- A fast-launch davit for deployment and recovery of a 7-m survey boat while the ship is steaming at up to 6 knots. This system provides substantial savings of time (and research funds) by reducing the interference between survey operations and ship-based operations.
- An acoustic well which permits changing acoustic transducers (to modify frequency or for maintenance) without dry-docking the ship. The acoustic well is needed for comprehensive studies of the distribution and abundance of zooplankton and fish, and for other studies using acoustic transducers.
- A scientific landing barge.
- Six container-laboratories.
- A state-of-the-art data logging and communication network.

The icebreaker's scientific equipment pool will include:

- Two CTD-rosette systems. The conductivity-temperature-depth-rosette sampler or CTD-rosette system is the workhorse that enables oceanographers to quickly obtain multiple water samples from different depths and continuous profiles of key physical, biological and chemical variables.
- Twelve ADCPs. Moored on the sea bottom, Acoustic Doppler Current Profilers use the reflection of sound on planktonic organisms to measure current speed and direction simultaneously at several depths.
- Twenty-four environment probes (CTD, oxygen, fluorescence, acoustic current-meter).
- Twenty-four sediment traps.
- Twenty-four acoustic releases and flotation for 12 moorings.
- A pinger system for localizing deployed instruments.
- A towed undulating probe carrier vehicle. Depth rudder and a computer-controlled winch determine the trajectory of this underwater fin towed by the ship. The fin carries an array of instruments that provide high-resolution vertical sections of oceanographic conditions.
- A remotely operated vehicle (ROV).
- Inboard ADCPs and ship-track water monitoring systems for continuous monitoring of currents and ocean surface conditions along the path of the icebreaker.
- Optical and near-infrared spectrometers.
- 19-, 37- and 85-ghz radiometers.
- A radiosonde to study the atmospheric forcing of sea ice variability. The temperature, humidity and pressure signals transmitted by a small balloon-borne expandable radio provide a vertical profile of the atmospheric conditions.
- A multi-channel satellite receiver.
- An open path infrared gas analyser.
- Parcol arctic shelters, heavy-duty snowmobiles, standard snowmobiles.
- A scientific echo sounder.
- 0.5- and 1.0-m multinet zooplankton samplers.
- A rectangular midwater trawl and experimental trawls.
- A multibeam echo sounding system.
- A shallow water sweep bathymetry system.
- Corers and a core splitter.
- A shipborne x-ray system for sediment cores.
- A seismic reflection system.
- A liquid chromatography mass spectrometer.

THE ICEBREAKER: A KEY TO A CROSS-SECTORIAL APPROACH TO CLIMATE CHANGE IMPACT RESEARCH IN THE ARCTIC

International efforts to stabilize greenhouse gases emissions, such as proposed by the Kyoto protocol, can only marginally curb the present rate of atmospheric warming. Strategies to adapt northern and southern societies to the full impact of anthropogenic climate warming must therefore be envisaged and developed. The ecosystem-level questions and challenges raised by a warming arctic can only be addressed though a cross-sectorial approach involving specialists from the natural, social and medical sciences. To further promote this cross-sectorial approach, the proponents of the icebreaker project have proposed a Network of Centres of Excellence that will bring together the best arctic specialists in Canada and their collaborators from abroad. ArcticNet will build synergy among existing arctic centres of excellence in the natural, medical and social sciences. The objective of the Network is to translate our growing understanding of the changing arctic into impact assessments, national policies and adaptation strategies. The direct involvement of northerners in the scientific process is a primary goal of the Network that will be fulfilled through bilateral exchange of knowledge, training and technology.

As mentioned earlier, scientists agree that direct observations and measurements are needed to address the ecosystem-level questions raised by climate change in the Arctic. The proposed Network is built around the research icebreaker that will provide oceanographers, terrestrial ecologists, geologists, epidemiologists and other specialists with unprecedented access to the Arctic. If funded, ArcticNet will become a unique supplier of expertise to inform Northerners of the potential impacts and opportunities that climate change will bring to the North, and to help decision-makers and industry cope with a changing Arctic.

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RESPIRATORY TRACT INFECTIONS IN INUIT CHILDREN

Anna Banerji

Anyone who spends time in the North will soon realize how pervasive respiratory illness is. While northerners accept the high rates of respiratory infection as a fact of life, southerners regard them with disbelief.

I first came to Baffin Regional Hospital in Iqaluit, Nunavut, in 1995, during my training in children's infectious disease. I was disconcerted by the severe cases of bronchiolitis, a respiratory syndrome in young children thought to be caused by viruses, that I saw. All too frequently Inuit babies were intubated and evacuated by air to the South for life-support. I was perplexed by children aged 3 or 4 appearing to have *bronchiectasis,* a condition usually associated with long-term smokers in their 60s or 70s.

In an attempt to understand if what I was witnessing was a real phenomenon, I spent the summer scouring the medical records. I wanted to understand first the extent of the problem, and then what factors were creating it. Thus began a serendipitous cascade of events that led to some answers – and more questions.

I soon discovered that the medical literature on lung infections in Inuit children, especially in Canada, was practically nonexistent. I examined the medical charts of all children under four years of age admitted to Baffin Regional Hospital and discovered that the problem was likely even worse than I had imagined: bronchiolitis was responsible for about 50% of all the hospital admissions of children under four. In fact, most of the Baffin hospital's expenditures for children related to bronchiolitis.

Kimberly Tikivik, shown here with her mother Malaya, undergoing treatment for infectious lung disease at the Baffin hospital. Photo: Douglas Sage

I calculated that the rate of admission for bronchiolitis was 306 per 1,000 children less than one year of age. That is approximately 30 times the rate in the South. Almost 13% of the children hospitalized during this year had been intubated. When assessing possible risk factors, about a quarter of the children were born prematurely, five percent had congenital heart disease, and half had their first admission before three months of age – all of which are known risk factors for severe bronchiolitis. When looking at the infections identified in these cases of bronchiolitis, *Respiratory Syncytial Virus* (RSV), thought to be the most common cause of bronchiolitis, was under-represented.

What interested me was that 12% of the children were found to have *Chlamydia trachomatis* in their eyes or nasal secretions. *Chlamydia trachomatis* is a known pathogen that causes bronchiolitis-like illness in infants and is transmitted to the child at birth. I wondered if undetected Chlamydia infection might be an important cause of lower respiratory tract infections, in Inuit children.

In 1997 I began a prospective study searching for the infectious and environmental factors contributing to lower respiratory tract infections in children younger than six months of age admitted to Baffin Regional Hospital, specifically trying to understand the role of Chlamydia. This study showed a rate of admission for lower respiratory tract infection of 484 per 1,000 in children less than six months of age – one of the highest rates ever reported. In other words, a Baffin infant less than six months old has about a one in two chance of being admitted to hospital with a lower respiratory tract infection.

We were surprised to find that all the children admitted were exposed to cigarette smoke during pregnancy, and to second-hand smoke in their homes. In general, these children lived in overcrowded conditions compared to other Canadians. Forty percent of the children were adopted to a female relative.

The Baffin Regional Hospital receives patients from Iqaluit and the eleven smaller communities of the Qikiqtaaluk (Baffin) region. Photo: Douglas Sage

We identified infectious organisms in 18/27 (66%) of the admissions in the study, but were not able to identify Chlamydia in any of the children. During the period of the study, major improvements occurred in the awareness, diagnosis and treatment of Chlamydia in pregnancy. Detection of Chlamydia increased by 60%.

There were many limitations to the study including the lack of health controls, and a small number of cases. We encountered numerous obstacles, such as a limited budget ($8,000), and logistical problems with specimen transport. One of our greatest challenges was the perception that research in Inuit communities did not directly benefit the community being studied. With the encouragement of those who understood the impact of respiratory illness in the north, we perservered.

But serendipity was soon at play again. Quality control testing for *Chlamydia trachomatis* failed to identify the pathogen. Instead, another chlamydia-like organism now called *Simkania negevensis* (SN) occurred in 14/22 (64%) of the specimens tested. SN was first identified in Israel, where studies showed it to be present in a number of children with bronchiolitis but absent in controls. Unlike Chlamydia, which is a sexually transmitted disease, SN appears primarily to cause respiratory infections. Previously, bronchiolitis was considered a viral disease. If SN is a common cause of bronchiolitis in young Inuit children, it could potentially be treated with an antibiotic. This, I felt, could not be ignored.

Many children in Iqaluit and elsewhere in the region live in overcrowded and poorly ventilated homes. Photo: Douglas Sage

As we searched for support for further research we found that the study didn't fit the mandates of most funding agencies. To the credit of the newest and one of the smallest governments in Canada, the Nunavut Department of Health and Social Services considered respiratory infections in children a high priority, and readily agreed to support further research..

In January 2002 we initiated the next phase. A case-control study, it includes all children under the age of five admitted to Baffin Regional Hospital, again looking at the environmental and infectious factors in lower respiratory tract infection in this population, and specifically exploring the role of SN.

Once we understand the cause of respiratory infections in the Baffin region we can make a real impact. And, one can only hope that the probable contributing factors – smoking, overcrowding and poverty – will be addressed, and the unacceptable rate of respiratory infection in Baffin will become a thing of the past.

Anna Banerji, MD, is a pediatrician and infectious disease specialist in the Department of Pediatrics at the University of British Columbia.

CANADA CLOSING ARCTIC OZONE OBSERVATORY

Kimberly Strong

Located high in the Canadian Arctic, less than 1,000 km from the North Pole, Environment Canada's Arctic Stratospheric Ozone Observatory (ASTRO) has been in operation since 1993, providing us with valuable insight into the state of the ozone layer over northern Canada. Unfortunately, it looks like ASTRO will not be celebrating its tenth anniversary as the facility is being mothballed, saving the federal government about $300,000 a year in basic operating costs. This may sound like a large amount, but for comparison, the cost of hosting the 30-hour Kananaskis G8 Summit is equivalent to running ASTRO for 1,000 years!

ASTRO sits on a mountain ridge near Slidre Fjord on Ellesmere Island, about 15km from the Eureka weather station (80°N, 86°W) in Nunavut. It is ideally located for atmospheric measurements, as the high-latitude high-altitude site offers clear skies through most of the year. In addition, the Arctic vortex, a cold isolated mass of air that acts as a container for the chemical reactions that lead to ozone destruction, regularly passes overhead, allowing observations both inside and outside this chemically perturbed region. This is very useful in helping us unravel the chemical and physical processes that control the stratospheric ozone budget.

The Arctic Stratospheric Ozone Observatory. Photo: M.R. Bassford, University of Toronto

The state-of-the-art ASTRO facility was established by Environment Canada in response to concerns about the future of the thinning ozone layer above the Canadian Arctic. It contains a suite of scientific instruments that measure stratospheric ozone and various trace gases involved in ozone chemistry, as well as atmospheric temperature and aerosol profiles. These instruments (several built by Canadian companies) are operated by scientists from the Meteorological Service of Canada (MSC) and by research partners from several Canadian universities, Japan, and the USA. The Japanese have been particularly active participants, with a number of the instruments having been developed and used by scientists from the Meteorological Research Institute, the Communications Research Laboratory, and Fukuoka and Nagoya Universities.

The importance of ASTRO to global atmospheric measurements was quickly recognized, as it was designated as part of the Arctic primary station of the international Network for the Detection of Stratospheric Change (NDSC), which is co-ordinated by the World Meteorological Organization. The closing of ASTRO thus eliminates a key site in the global effort to monitor the recovery (or not) of the ozone layer after the signing of the Montreal Protocol and its subsequent amendments that regulate the production of ozone-destroying chlorofluorocarbons (CFCs). It also means that Canada, with its huge landmass, including about 30% of the Arctic (above 60°N), regrettably no longer has any fully active sites in the NDSC.

My own connection with ASTRO began in 1999, when we first deployed our new grating spectrometer there as polar night was ending in late February. Students and post-doctoral fellows from my research group continued to take it back to the Arctic for each of the following three winters. Equipping the system to operate in the frigid temperatures at Eureka (often dipping to −50°C) was a challenge, which we met by housing it in a thermostatically controlled weatherproof case that sat on the roof of the ASTRO building. We also automated the operation of the spectrometer, so that we could leave it to make unattended measurements for several months, interactively monitoring it from Toronto, with on-site assistance from the MSC's Eureka station manager as needed.

Our goal has been to make measurements through polar spring, the period when the perturbed stratospheric conditions necessary for ozone destruction occur. The instrument records UV-visible absorption spectra of scattered sunlight at sunrise and sunset, from which concentrations of ozone, NO_2, BrO, and OClO can be derived. It complemented the measurements that were being made at ASTRO by the lidars, infrared and millimetre-wave spectrometers, and Brewer ozone spectrophotometers already installed there.

By combining the high-quality observations made by such a suite of instruments, it is possible to obtain a comprehensive data set that can be used to address outstanding questions regarding the current state and future evolution of the ozone layer. Stratospheric ozone is crucial to the Earth's climate. Its best known role is as a highly effective absorber of harmful UV-B solar radiation that protects the biosphere from radiation which can cause skin cancer and eye damage in humans, harm vegetation and marine organisms, and degrade materials such as plastics and paper. However, the absorption of radiation by ozone is also the dominant source of heating in the stratosphere, influencing stratospheric winds. Decreasing stratospheric ozone concentrations are thus likely to increase the amount of UV-B radiation reaching the ground, to enhance UV-dependent photochemical reactions in the troposphere, to reduce stratospheric temperatures, and to possibly change the dynamics of the stratosphere. In fact, measurements made with Environment Canada's Brewer ozone spectrophotometer have provided evidence for the link between ozone depletion and UV increases.

Stratospheric ozone concentrations have declined significantly since about 1980 in response to enhanced levels of chlorine resulting from anthropogenic emissions of CFCs. This is particularly true in the polar regions, with dramatic declines in ozone observed over Antarctica in late winter and early spring. During the 1990s, springtime losses in lower stratospheric ozone have frequently been observed over Arctic regions, with very low ozone column amounts recorded in several recent years, including cumulative ozone losses of 60% at 18km seen in early 2000. Over the Canadian high Arctic, there has been an average decline of about 12% over the past two decades.

Polar ozone depletion is a seasonal effect, which begins with the formation of polar stratospheric clouds (PSCs) in the vortex during the cold polar winter. Heterogeneous reactions on the surfaces of these clouds convert chemically inactive chlorine into a more reactive form, and when sunlight returns in the spring it releases chlorine

Installing our spectrometer on the roof of ASTRO in spring 2001. Shown in photo are Dr. Stella Melo and Elham Farahani from the University of Toronto, and Vivek Voora, Dr. Richard Mittermeier, and Dr. Hans Fast from the Meteorological Service of Canada. Photo: Y. Makino, Japan Meteorological Agency atoms which destroy ozone in a catalytic cycle. This continues until the Sun causes a dynamical breakdown of the winter vortex and PSCs evaporate.

To date, springtime ozone loss has been less severe over the Arctic than over Antarctica because Arctic stratospheric temperatures are generally higher, resulting in less frequent formation of PSCs, which are necessary for the chemistry that leads to ozone destruction. However, concern over Arctic ozone is growing, as models suggest that increasing greenhouse gas concentrations may lead to a colder Arctic stratosphere. (While greenhouse gases warm the lower atmosphere, this trapping of heat near the surface actually cools the stratosphere.) This in turn is predicted to cause further Arctic ozone depletion that will peak during the next 10 to 20 years, with a possible reduction of up to 2/3 in the total ozone column. It was ASTRO measurements that provided the first evidence that global warming was increasing ozone loss in the high Arctic.

The need for the kind of observations that are possible at ASTRO is thus greater than ever. Will the mitigating effects of the Montreal Protocol and its amendments for the reduction of CFCs be counteracted by rising greenhouse gas concentrations and an associated decrease in stratospheric temperatures? What will be the impact of the changing concentrations of other constituents, such as methane, nitrous oxide, water vapour, and sulphate aerosols? Without long-term monitoring of ozone, CFCs, aerosols, temperature, and the chlorine, bromine, and nitrogen compounds that all play a part in ozone chemistry, we can only guess. It is critical that Canada continue to make such long-term measurements if we are to have a role in the international effort to understand climate change. Such data is also important for the validation of satellite measurements, such as those that will be made by Canada's SCISAT-1 mission when it is launched in 2003.

View from ASTRO. Photo: M.R. Bassford, University of Toronto

The closing of ASTRO is symptomatic of Canada's declining commitment to northern research. That this is in "deep crisis" was recognized in the National Task Force Report, "*From Crisis to Opportunity: Rebuilding Canada's Role in Northern Research*", released in 2000. Increasingly, studies in the Canadian Arctic are being undertaken by scientists from other nations, who realize the importance of this region as an early warning system for global change (see "Tundra Northwest 99", *Meridian,* Fall/Winter, 2001). Canadian government cutbacks over the past decade have had a severe impact on our research capability, particularly with regard to northern science and environmental monitoring. For example, Environment Canada's budget was cut from $800 million in 1988 to $550 million in 1998, making it the smallest federal government department. Although it has since been increased to about $650 million, this reduction has had a direct impact on the research budget of Environment Canada scientists. Some have departed in frustration, while those remaining are left with such difficult decisions as whether to close ASTRO, cut other equally important research projects, or delay repairs to the aging infrastructure of meteorological stations.

What of the future? Next year, we may deploy our spectrometer at Resolute Bay, where there is an observatory managed by SRI International on behalf of the US National Science Foundation. However, the measurements being done there are of the upper atmosphere, not the stratosphere, so it will no longer be possible to combine our measurements with those of complementary instruments, as we have been doing at ASTRO. Unfortunately, this will limit the scientific value of the data we collect.

In the longer term, we hope that funds to reopen ASTRO can be found, given its importance to Canadian and international Arctic science. Ideally, this would continue to be the responsibility of Environment Canada, as the federal government has an important role in long-term monitoring of the atmosphere. It is more difficult for such a facility to be operated by universities, for example, given the relatively short-term nature of graduate student and post-doctoral positions. However, many scientists, both in Canada and abroad, are sufficiently shocked and dismayed by the recent mothballing of ASTRO that we are trying to assemble a consortium of university and government partners to save it. To really operate the facility at full capacity, at least $1 million per year would be needed. This undertaking, being led by my colleague Professor Jim Drummond of the University of Toronto, is still in the early stages and will require significant effort and resources if it is to be successful, but we are convinced that it is vital that ASTRO be kept open. Canada has an obligation to its own population and to the global community to do its part in monitoring the Arctic stratosphere in the years ahead, as we try to unravel the complex climate system processes that result in feedbacks between stratospheric ozone and climate change.

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Further Information
For more details on atmospheric research at the University of Toronto, visit atmosp.physics.utoronto.ca.

For information about ASTRO, visit the Environment Canada web site http://exp-studies.tor.ec.gc.ca/e/eureka/eureka.htm.

The National Task Force Report, "*From Crisis to Opportunity: Rebuilding Canada's Role in Northern Research*", is at ftp://ftp.nserc.ca/pub/nserc_pdf/nor/crisis.pdf.

The Network for the Detection of Stratospheric Change web site is ndsc.ncep.noaa.gov/.

EXPLORING FOR GAS HYDRATE IN THE ARCTIC

Adrienne Ethier

Canadians are continually searching for new energy sources to replace depleting and increasingly expensive conventional fossil fuels. One potential new fuel could come from gas hydrate reservoirs found deep below the ocean floor on the continental shelf.

The existence of methane hydrate was first recognized over seventy years ago as an icy sludge that fouled natural gas pipelines. It was dismissed as a nuisance until 1964, when a Russian drilling crew discovered naturally occurring methane hydrate in a Siberian gas field and recognized its possibilities as a resource. Interest in this source of natural gas has since expanded, and gas hydrate is now regarded as holding enormous potential.

Gas hydrate is a crystalline solid that consists of gas molecules trapped within a cage of water molecules, a structure known as a clathrate (Figure 1). Although many gases such as carbon dioxide and hydrogen sulfide can form gas hydrate, methane forms most marine gas hydrate, making it an abundant source of natural gas.

Hydrate can store immense amounts of methane. One volume of water can bind 207 equivalent volumes of methane at atmospheric pressure. A gas hydrate reservoir may contain 170 times more gas than a conventional high pressure natural gas reservoir of equal volume.

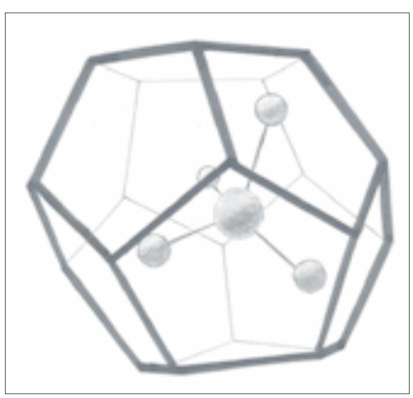


Figure 1

Figure 2

The major factors controlling gas hydrate formation and stability are pressure, temperature, gas chemistry, the salt content of the pore waters, the porosity of the enclosing formation sediments, and the free gas availability and abundance. Gas hydrate exists in nature at high pressure and temperatures near 0°C. Hydrate in sediment dissociates quickly when brought to the surface because of decreased pressure and increased temperature. Sediment will actually pop and fizzle at the surface, as the hydrate decomposes and the highly concentrated methane escapes into the atmosphere.

The sediment can even be set aflame when methane hydrate concentrations are high enough (Figure 2). This phenomenon has led to the term "flammable ice" since the dissociation of gas hydrate freezes the sedi-

Figure 3

ment that contains it when it is brought to surface pressures.

Hydrate occurs within the pore spaces of ocean sediments, 130 to 2,000 metres beneath the sea floor along the margins of most continents. There are large deposits in the Nankai Trough off the coast of Japan, along the west coast of Vancouver Island, and in Blake Ridge, off South Carolina. Hydrate also occurs deep within the sands of the Mackenzie Delta along Canada's arctic coast.

Conservative estimates place the world-wide amount of total carbon bound in gas hydrate at approximately 2,800 to 7,600,000 trillion cubic metres of gas, twice the amount in all known reserves of oil, natural gas and coal. Gas hydrate exploration and production testing is already under way in Canada with collaboration from other countries including Japan, Germany, the United States, and India.

One of the largest known gas hydrate reservoirs in the world lies in the Mackenzie Delta/Beaufort Sea region of northern Canada (Figure 3). In 1979 Shell Oil drilled several exploration wells on the Mackenzie Delta. The Mallik L-38 drill site and the other exploration wells confirmed a thick (~200m) layer of gas hydrate in the area.

In 1998, a team led by the Geological Survey of Canada drilled a dedicated research well near Mallik L-38 to sample and test the gas hydrate resource. The new well, Mallik 2L-38, brought scientists from Canada, the United States and Japan together to examine the vertical profile of gas hydrate in the sediment in an effort to learn more about the geologic controls on their growth and distribution. A key component of the project, cutting a core of gas hydrate-bearing sediments, provided scientists with samples for testing. The results led to planning of a second and more ambitious program. After two years of preparation, including an early staging of equipment to the site by barge prior to freeze-up, drilling began in December 2001 (Figure 4).

At the Inuvik Research Institute in Inuvik, NWT in late February of this year, I was among the numerous project researchers collecting samples from the cores as they arrived from the rig site. I collected some 1,300 samples, and over the next few years these will be analyzed at the University of Ottawa in order to learn more about the geochemistry of gas hydrate in its natural environment. Isotope geochemistry will allow us to identify the detailed history of gas hydrate formation and dissociation in the sediment. This information will help other researchers involved with the project to better understand how gas hydrate behaves in the environment and will hopefully help with production method development and estimations of the potential for contamination. Information on the research and production tests will be posted on the Mallik web site at http://icdp.gfz-potsdam.de/html/sites/mallik/index/.

Methane gas is around 20 times more effective as a greenhouse gas than carbon dioxide. Since hydrates release methane at surface temperature and pressure, concerns have been expressed that developing this resource could accelerate global warming, but developing the resource isn't a problem if it is just replacing conventional gas. The connection with global warning is a positive one: the research from Mallik will increase and improve data on which global climate models are based, as methane is a relatively "clean" fuel.

Research on the Mallik methane hydrate deposits will provide hard data for climate change models. The potential contribution of methane gas to global warming is controversial. Methane is an important trace component of the atmosphere with a wide variety of sources and sinks, including methane hydrate. Although a sudden release of methane could affect atmospheric composition and contribute to global warming (see G.R. Dickens, 1999, "The blast in the past", *Nature* 401: 752–755 and M.E. Katz, D.K. Pak, *et al.,* 1999, "The source and fate of massive carbon input during the latest paleocene thermal maximum", *Science* 286: 1531–1533), the methane released from gas hydrate will more likely vent slowly over time, allowing microbial and chemical processes to oxidize it into carbon dioxide which would then be absorbed by the oceans. Any methane that does reach the atmosphere would likely react with hydroxyl radicals and disappear over the course of about ten years.

The other main concern with gas hydrates is the drilling and production hazard from blowouts and casing failures. The drilling mud used in both the 1998 and 2002 exploration wells has proved successful in sequestering dissociation of gas hydrate as it is removed from the core, decreasing the likelihood of potential methane blowouts. The process of extracting hydrates in commercial quantities only exposes the sediments of interest to changes in temperature and pressure to initiate the dissociation of gas from hydrate. An uncontrolled release of methane would therefore be highly unlikely, and if so, very localized.

Finally, removing gas hydrates may affect sea floor stability. Frozen gas hydrate fills sediment pore spaces, acting like cement. Removing hydrates could weaken sediments and cause submarine landslides, which could affect any nearby structures (like conventional gas wells or submarine cables).

There is a growing consumer demand for natural gas. As present reservoirs become depleted there will be a need to develop cost-effective methane supplies. Gas hydrates could play a major role in moderating price increases and assuring long-term availability of reliable, affordable fuel. In time, as researchers find answers to the remaining environmental and other questions surrounding gas hydrates, as production techniques are developed – and as gas prices rise – fuel production from gas hydrates will become viable. It is likely that within the next 20 years we will be using this fuel source in our everyday lives.

With the Mallik project, Canada is taking a leading role in gas hydrate exploration and development. As a result natural gas from "flammable ice" could eventually become one of Canada's major energy resources.

Adrienne Ethier is a Ph.D. student in Earth Sciences at the University of Ottawa.

Figure 4

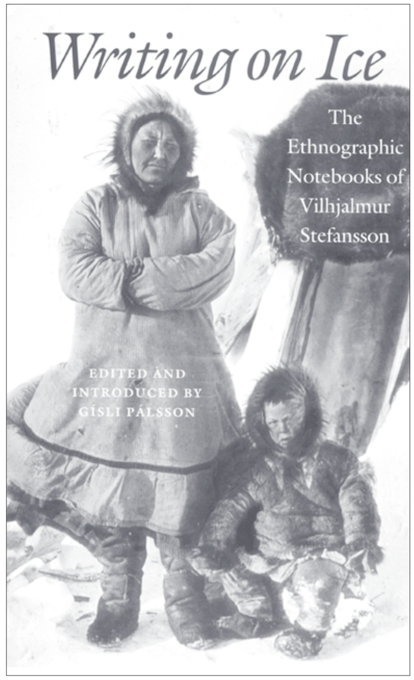
BOOK REVIEW: WRITING ON ICE

Graham W. Rowley

Writing on Ice. The Ethnographic Notebooks of Vilhjalmur Stefansson, edited and introduced by Gisli Palsson, 2001. University Press of New England, Hanover and London, xiv + 351 pages.

Vilhjalmur Stefansson spent most of the years 1906–1918 on three expeditions to the Arctic Regions of Canada and Alaska. He went on the first two as an ethnographer, and *Writing on Ice* gives extracts from his diaries of the ethnographical observations he wrote at the time. He was in command of his third, longest, and best-known expedition and considered himself more as a geographer and explorer. One member of his expedition was Dr. Diamond Jenness, later the very eminent Canadian anthropologist, and Stefansson left ethnography to him.

Palsson points out that the anthropological extracts from Stefansson's diaries have already been published by Clark Wissler, Curator of Anthropology at the American Museum of Natural History, in Volume 14 of their Anthropological Papers entitled "Stefansson-Anderson Arctic Expedition". Part I gives Stefansson's own "Preliminary Ethnological Report" followed by the Wissler extracts intended as "useful anthropological data not included in Stefansson's *My Life with the Eskimo*" and recorded in chronological order. Part II is by Clark Wissler on "Harpoons and Darts in the Stefansson Collection" and the last section includes "Corrections and Comments" by Stefansson on a number of points as he was in the field and could not see proofs.



The extracts edited by Palsson were very carefully compiled by five Icelandic students in anthropology from microfilms of the diaries which are in the Special Collections of Dartmouth College. The extracts could therefore be used as material by researchers, however, they do not include the archaeological or geographical information given by Wissler and are not easy to follow as the two maps provided are too small and difficult to read. Clear maps, published in *My Life with the Eskimo,* were reprinted in the Museum's Report. Moreover the corrections given by Stefansson in the Museum's report are not included or acknowledged. Some parts of the diaries were written in Icelandic, presumably because Stefansson considered them confidential, and these are translated into English by the Editor, who is Professor of Anthropology at the University of Iceland, and published here I believe for the first time.

In the introductory "Historical Background" the Editor seems to be specially interested in trying to throw new light on aspects of Stefansson's career. One is his relationship to Fannie Pannigabluk, the expert seamstress on his second expedition. Her son, Alex, and his children use the name Stefansson and the relationship has been widely accepted, but was never publicly acknowledged by Stefansson. Another aspect is the leadership of the third expedition which was commanded by Stefansson, and was divided into two sections, a Northern Party and a Southern Party. The Northern Party was concerned mainly with exploration and Stefansson was in every way its leader. The Southern Party, which included most of the scientists of the expedition, was directed by Dr. R.M. Anderson, who had been with Stefansson on his second expedition, and relations between them had sometimes been strained. Most of the Southern Party members considered it independent of Stefansson, who would not accept a written statement to this effect, but again this is not new material.

Another point of interest to the Editor is Stefansson's "Blond Eskimos". On his scond expedition Stefansson was the first ethnographer to encounter the Copper Inuit of Victoria Island. In his view they were different in several ways from the other Copper Eskimos on the mainland and had fairer skin. Stefansson considered these differences might have resulted from a relationship with the Vikings who had colonized part of Greenland several hundred years earlier, and whose subsequent history is little known. This speculation aroused great interest, but Diamond Jenness did not accept it and did not confirm that Stefansson's "Blond Eskimos" differed significantly from other Inuit in the comprehensive reports he wrote on the Copper Eskimos, and Stefansson's anthropological credibility suffered from this controversy.

In this scholarly book, Professor Palsson is trying to show how the diaries support Stefansson's solid contributions to arctic ethnography, and "rescue Stefansson the anthropologist from the showmanship of early twentieth-century exploration". As one who benefitted greatly from Stef's encyclopedic knowledge and generosity in assisting with arctic information, I can sympathize with Professor Palsson's aims.

Graham Rowley is a retired explorer, archaeologist, and public servant living in Ottawa.

WHAT'S NEW

NEW BOARD MEMBERS AT THE POLAR COMMISSION

The Canadian Polar Commission welcomes the following new members to the Board: Jocelyn Barrett (Kuujjuaq), Gordon Miles (Iqaluit) and Leah Otak (Igloolik). We thank outgoing Board members Julie Cruikshank, Jean Dupuis and Wayne Adams for their work on behalf of the Commission.

Peter Johnson, formerly Vice-Chairperson, replaces Michael Robinson as Chairperson. Mr. Robinson and Piers McDonald continue as Members, and Richard Binder is the new Vice-Chairperson.

POLAR COMMISSION SCHOLARSHIP WINNER

Julie Ross, a University of Toronto Ph.D. student, has won the 2002–2003 Canadian Northern Studies Polar Commission Scholarship, worth $10,000. Ms. Ross is using archaeological data as well as diatom and pollen remains from the Cambridge Bay area of Nunavut to study the relationship of environmental change to past human migration and regional cultural development. We congratulate her on her achievement and wish her well in her research.

NORTHERN RESEARCH FORUM COMING TO CANADA IN 2004

The Northern Research Forum brings together scientists, politicians, community leaders, students, academics, bureaucrats, and business people to discuss northern issues in an atmosphere of open exchange (see *Meridian,* Spring/Summer, 2001). Delegates to the second Forum, held in September 2002 in Veliky Novgorod, Russia, voted to bring the third meeting, to be held in 2004, to northern Canada. The exact location will be chosen in the coming months.

AN ANTARCTIC SCIENCE STRATEGY FOR CANADA

The Polar Commission and the Canadian Committee for Antarctic Research have released *Antarctic Science and Bipolar Linkages: A Strategy for Canada.* This document is available in print from the Commission or online at polarcom.gc.ca.

FUNDING OPPORTUNITY: CHURCHILL NORTHERN STUDIES CENTRE

The Churchill Northern Studies Centre is pleased to announce this year's CNSC Northern Research Fund (NRF) competition for the 2003/04 field season. The NRF is a matching-funds grant program providing cash, accommodations, and equipment rental to qualified individuals conducting research from the Churchill Northern Studies Centre in Churchill, Manitoba. All disciplines, including the social sciences, are eligible for support at any level, from B.Sc./B.A. to Ph.D. and beyond.

Applicants may request assistance from a pool of $7,000 direct monetary support, 250 user-days (accommodations and meals), 100 vehicle-days (vehicles and/or equipment excluding fuel), or a number of complimentary air and rail passes, as available. The application deadline for this year's competition is **December 6, 2002.** For more information, please visit the website at cancom.net/~cnsc or e-mail cnsc@cancom.net.

The CNSC Northern Research Fund is supported by Manitoba Conservation, Calm Air International Ltd., Via Rail Canada, and member donations.

Michael Goodyear
Executive Director
Churchill Northern Studies Centre
Box 610, Churchill, MB
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Tel.: (204) 675-2307
Fax: (204) 675-2139

H O R I Z O N

2002 5th International Workshop "Land-Ocean Interactions in the Russian Arctic" (LOIRA)

12–15 November 2002
P.P. Shirshov Institute of Oceanology
RAS, Moscow, Russia

Contact: Dr. Vyacheslav Gordeev
P.P. Shirshov Institute of Oceanology
RAS
36 Nakchimovsky Prospect
Moscow 117997, Russia
Fax: 7-095/124-5983
Tel.: 7-095/124-7737

7th International Symposium on Mining in the Arctic

30 March – 1 April 2003
Iqaluit, Nunavut, Canada
nunanet.com/~cngo/isma.html

Contact: Dr. John E. Udd
Principal Scientist
Mining and Mineral Sciences
Laboratories
Natural resources Canada
555 Booth Street
Ottawa, Ontario, Canada
K1A 0G1
Tel.: 1-613-947-8383
Fax: 1-613-996-2597

3rd International Mammoth Conference

24–29 May 2003
Dawson City, Yukon Territory, Canada

The International Mammoth Conference covers research on mammoths, their environment and associated fauna. For more information please see our website at yukon museums.ca/ mammoth/index.htm.

Contact: John Storer
Yukon Palaeontologist
Fax: (867) 667-8007
Email: John.Storer@gov.yk.ca

Fourth International Conference on Arctic Margins (ICAM IV)

30 September – 3 October 2003
Halifax, Nova Scotia, Canada
icamiv.org/

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We are updating our database of Canadian polar researchers and specialists. If you are an arctic researcher, kindly take a few minutes to fill in the questionnaire below, or complete it electronically on the Polar Commission web site: www.polarcom.gc.ca.

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Please list your most recent publications

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