

ACD - Arctic Coastal Dynamics

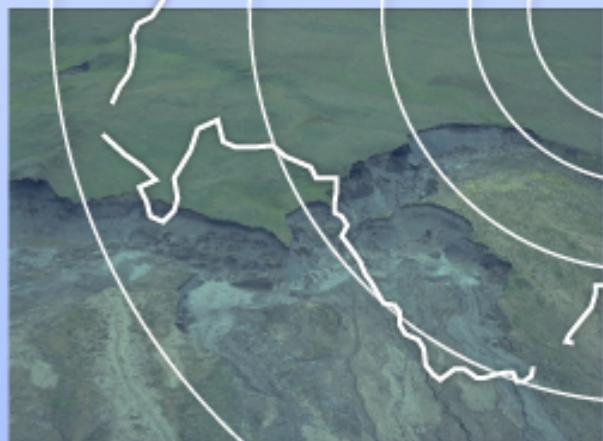
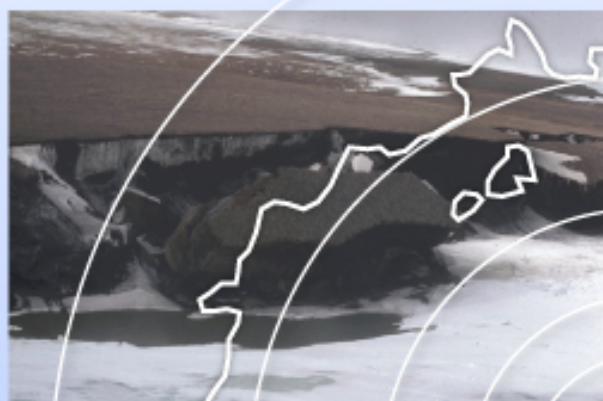


5th International Workshop

Dept. of Geography, McGill University, Montréal, Canada

October 13-16, 2004

PROGRAM AND ABSTRACTS



"Determining sediment sources and transport rates along high latitude coasts in order to interpret their geologic history and to predict their response to climatic and sea level changes"

Organizers:

Volker Rachold (AWI Postdam)

Wayne Pollard (McGill University)

Website: www.acd2004.mcgill.ca

Contact: acd2004@geog.mcgill.ca



WORKSHOP PROGRAM

Tuesday, October 12, 2004

19:00 – 21:00 **Ice-breaker and registration**
Billiard Room of McGill Faculty Club, 3500 McTavish Street

Wednesday, October 13, 2004

Thomson House, 3650 McTavish Street

9:00 – 9:30 **Registration**
9:30 – 10:30 **Official Welcome**, *Alan Shaver, Dean, Faculty of Science*
Introductory Remarks, *Wayne Pollard and Volker Rachold*
10:30 – 11:00 **Coffee break**
11:00 – 12:30 **General outline of workshop program**, *Volker Rachold*
Reports from 2003 ACD working groups (10 minutes each)
- Coastal and Offshore Permafrost, *Hans Hubberten and Michel Allard*
- GIS, *Frits Steenhuisen and Rune Odegard*
- Environmental Forcing, *David Atkinson*
- Biogeochemistry and Biodiversity, *Volker Rachold*
12:30 – 13:30 **Lunch**
13:30 – 15:00 **Plenary presentations** (10 minutes each)
- The Shape of Erosional Arctic Shoreface Profiles, *Feliks Are*
- ACD Key Sites: The Basis for a Coastal Observational Network, *Jerry Brown*
- Establishment of Standardized Stations to Monitor the Response of Permafrost to Climate Change, *Georg Delisle*
- Modeling Block Failure in Vertical Cliffs of Arctic Coasts Underlain by Permafrost, *Azharul Hoque*
- Initiation of a Study on the Flux Transformation of Organic Carbon Across the Eroding Coastline of Northern Alaska, *Torre Jorgenson*
- The Human Dimension of Arctic Coastal Change, *Kathryn Parlee*
15:00 – 15:30 **Coffee break**
15:30 – 17:00 **Plenary presentations** (cont'd):
- Arctic Coastal Dynamics of Eurasia – Results of Two ACD-Related INTAS Projects, *Volker Rachold*
Overview of posters (1 minute each)
18:00 – 20:00 **Reception**
Dept. of Geography, Burnside Hall, 5th floor

Thursday, October 14, 2004

Thomson House, 3650 McTavish Street

- 9:00 – 10:30 **Plenary session: Establishment of working groups and discussion of taskings**, *Volker Rachold*
- WG1: Definition and understanding of the processes involved in the transition from onshore to offshore permafrost
Co-chairs: Hans Hubberten and Michel Allard
Rapporteur: Pavel Rekant
 - WG2: Impact of coastal dynamics on human populations in the Arctic
Co-chairs: Shari Fox Gearhead, Kathryn Parlee. Don Forbes
Rapporteur: Scott Heyes
 - WG3: Analysis of environmental forcing variables
Co-chairs: David Atkinson and Sasha Vasiliev
Rapporteur: Olga Gruzdeva
 - WG4: Compilation of the circum-Arctic coastal GeoInformationSystem
Co-chairs: Frits Steenhuisen and Rune Odegard
Rapporteur: Hugues Lantuit
- 10:30 – 11:00 **Coffee break**
- 11:00 – 13:00 **Working group meetings**
- 13:00 – 14:00 **Lunch**
- 14:00 – 15:30 **Working group meetings (cont'd)**
- 15:30 – 16:00 **Coffee break**
- 16:00 – 17:30 **Working group meetings (cont'd)**
- 17:30 – 18:00 **Recap of working group progress**

Friday, October 15, 2004

Thomson House, 3650 McTavish Street

- 9:00 – 9:30 **Plenary session. Taskings for the day**, *Volker Rachold*
- Presentation:**
- Recent Coastal Dynamics and Sea Level Change on Melville Island, Western Canadian High Arctic, *Patrick Lajeunesse*
- 9:30 – 11:00 **Working group meetings**
- ArcticNet meeting**
Co-chairs: Don Forbes, Wayne Pollard and Michel Allard
- 11:00 – 11:30 **Coffee break**
- 11:30 – 13:00 **Working group meetings**
- ArcticNet meeting**
- 13:00 – 14:00 **Lunch**
- 14:00 – 15:30 **Working group meetings (cont'd)**
- 15:30 – 16:00 **Coffee break**
- 16:00 – 17:00 **Working group meetings (cont'd)**
- 17:30 – 18:00 **Recap of working group progress**
- 19:00 – 22:30 **Banquet**
Main Dining Room, McGill Faculty Club, 3500 McTavish Street

Saturday, October 16, 2004

Peel and De Maisonneuve Rooms, Marriott Residence Inn

- 8:30 – 10:00 **Final plenary session**
 Reports from working group chairs
- 10:00 – 10:30 **Coffee break**
- 10:30 – 12:00 **Discussion about ACD book and recap of workshop, *Volker Rachold***

Free afternoon / ACD Steering Committee Meeting

Sunday, October 17, 2004

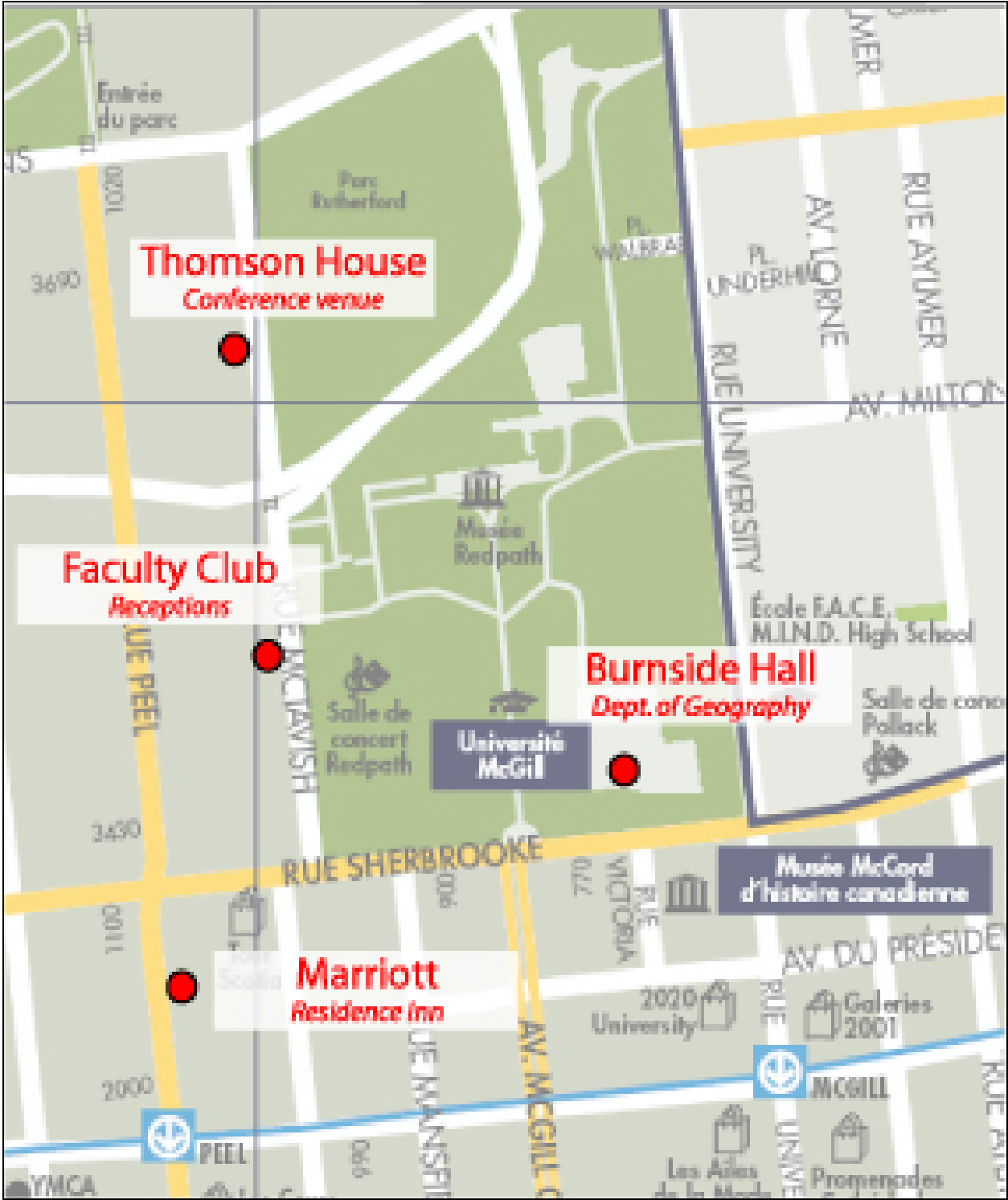
- 9:00 **Departure from Montreal**
- 12:00 **Arrival in Quebec City**
- 12:00 – 12:30 **Lunch**
- 12:30 – 14:30 **Tour of the polar research vessel CCGS Amundsen**
- 14:30 – 17:00 **Free time to visit Old Quebec City or tour of Laval University's Centre
d'études nordiques with M. Allard**
- 17:00 – 19:00 **Dinner at Cochon Dingue restaurant**
- 20:00 **Depart Quebec City**
- 23:00 **Arrival in Montreal**

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* Steering Committee Member, **IASC Young Investigator, *** INTAS Team Leader



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ABSTRACTS

(Alphabetical by lead author)

SNOW REGIME, COASTAL CLIMATE, AND PERMAFROST NEAR UMIUJAO, NUNAVIK, CANADA

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²Bundesanstalt für Geowissenschaften und Rohstoffe (BGR), Hannover, Germany.

A series of daily photographs at the joint BGR-Laval lithalsa study site illustrate the snow regime over discontinuous permafrost terrain from the first snowfall on 19 October until 17 April 2004. The site is located 20 km from the Hudson Bay shoreline. Snow regime on the ground is controlled by snowfall, melt periods and periods of wind erosion. The snow season can be divided into 4 periods: 1- From mid-October to the end of November, the snow cover kept thickening evenly over the mound and depression topography. 2- In December, a cold spell (-19 °C for 3 days between 3 and 6 December) was followed by a milder one with easterly winds until the 25th; snowfalls and wind erosion kept alternating. 3- A cold period from 30 December to 29 March, with a minimum of -44.5 °C on 14 January. The beginning of this cold period coincided with the freeze-up of the sea which turned the climate from an oceanic type to a continental one. The snow cover thickness remained unchanged, with deep snowpacks in depressions and continuing erosion by westerly winds on top of the lithalsa and other mounds. 4- From 29 March to the end of winter, new wet snowfalls alternated with melt periods leaving the general pattern unchanged. The distribution pattern of snow cover over the landscape from January to April corresponds closely with the ground temperature distribution observed in the permafrost.

THE SHAPE OF EROSIONAL ARCTIC SHOREFACE PROFILES

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The shape of 63 shoreface profiles along the erosional Arctic coasts is investigated and compared with the shape of shoreface in temperate environments to identify differences caused by Arctic cryogenic processes. Two mathematical expressions were chosen for description of profiles:

(1) power function suggested by Bruun (1954)

$$h = - A \cdot x^m,$$

where h is water depth, x is offshore distance from the shoreline, A is sediment scale parameter, and m is profile shape factor;

(2) exponential function suggested by Bodge (1992)

$$h = - B(1 - e^{-kx}),$$

where B is an asymptotic depth at a great offshore distance, and k is decay constant.

The distribution of the profile shape factor m on histograms for Arctic profiles is rather far from normal Gaussian distribution. The predominance of average m is poorly expressed if not at all. Processing the data on m and sediment scale parameter A at our disposal revealed an inverse reliance between them. It appears that trying to find any average m value, characterizing shoreface profile shape, is useless. The shoreface profile shape may be determined only by a combination of m and A values. The analytical comparison showed that the shoreface profiles in the Arctic and in the temperate environments have generally the same shape. Cryogenic processes change the shape of the shoreface profile of equilibrium, but these changes are short-lived because the storms restore the equilibrium profile. This is a preliminary conclusion because our database and amount and quality of analytical work carried out until now are insufficient for final conclusions. Investigations of the Arctic shoreface profile have to be continued.

CIRCUM-ARCTIC MELT SEASON TRENDS, 1950 - 2000

D. Atkinson

International Arctic Research Center, Fairbanks, Alaska, USA

An important component of environmental forcing in the cryosphere is the thermal element, especially the magnitude and duration of the melt season. From a coastal context, large seasonal melting degree-day (MDD) totals can result in enhanced erosion due to the combination of sediments weakened from ground ice melt and a long, ice-free season that prolongs wave-attack opportunities. Several melt-season parameters have been calculated, including: melt season start and end dates, melt season length, and annual MDD totals. Individual extreme years are contrasted and simple, long-term linear trends as well as spatial patterns in these parameters are calculated and presented.

Results indicated simple linear trends in MDD as great as ± 20 days/year, however it is unlikely that such rates of change have been maintained over a 50-year period. This suggests greater temporal dynamics, similar to that exhibited by northern hemisphere temperature trends, such that trend periods should be further broken down and greater analysis performed. In terms of specific years, in certain regions of the Arctic the difference between two years can be very large, on the order of hundreds of MDD. This level of interannual variation can be of the same magnitude as MDD seasonal totals, and suggests large interannual cryospheric response to thermal forcing that should be taken into consideration when studying physical response of a cryospheric system. A better understanding of the thermal regime of a given melt-season can help place observed coastal dynamical response into context, e.g., response to a given storm regime.

ACD KEY SITES: THE BASIS FOR A COASTAL OBSERVATIONAL NETWORK

J. Brown

International Permafrost Association, Woods Hole, Massachusetts, USA

Beginning in the mid 1990s the International Permafrost Association stimulated a process of establishing long-term monitoring or observational sites and networks. It began with the Circumpolar Active Layer Monitoring (CALM) as an initial contribution to the International Tundra Experiment. CALM, currently comprises over 125 sites with 15 participating countries, is formally funded by the U.S. National Science Foundation through 2008, and has a number of

international partners. In 1999 the World Meteorological Organization (WMO) and formally recognized the Global Terrestrial Network for Permafrost (GTN-P) as part of the Global Climate Observing System (GCOS). The GTN-P incorporates measurements of both active layer (CALM) and a network of existing boreholes employed for measuring the thermal state of permafrost (TSP). The TSP is being proposed as a basis for a project for the International Polar Year. Other IPA-related networks are in the process of development (carbon, periglacial, biodiversity, and ones in the Antarctic).

The Arctic Coastal Dynamics program has had a highly successful period of development, and it is timely to consider the ACD in light of other existing and future networks. The IPA established a Working Group on Coastal and Offshore Processes with a Subgroup on Coastal Erosion at the 1998 Yellowknife permafrost conference. As a first step in organizing a coastal program, an international workshop was held in November 1999 in Woods Hole sponsored by the US NSF. One recommendation of the workshop was the development of a series of key sites around the circumarctic coast at which periodic measurements including erosion rates are measured. Further planning for the ACD program and funding of subsequent workshops was approved by the International Arctic Science Committee in April 2000. The key sites were included in the ACD Science and Implementation Plan (SIP) that was developed during the Potsdam ACD workshop in 2001. In December 2003, the LOICZ newsletter formally presented ACD as the Arctic component of the IGBP-LOICZ program.

Presently there are a total of 23 key sites in Alaska, Canada, Greenland, Russia, and Svalbard. Metadata are reported on the ACD web. Photographs of the sites are in a photo library on the CAPS CR Rom and available on web sites. Observations at many of these key sites are reported in ACD workshop reports and open literature publications. Now that the ACD is entering a new phase, it is timely to re-assess the scope and role of the key sites in current and future programs. For instance both CALM and ACD share a number of common coastal areas (Arctic Alaska, Mackenzie, Ny Alesund, European Russia, West Siberia, Lena, Kolyma, Chukotka). A proposed soil carbon network would benefit from coordination with the key sites. Now that the first approximation of coastal transfers of sediment and carbon transfers are completed, we should ask questions related to how representative the existing key sites are and how to expand the number of sites into a formal reporting network such as is the case with CALM. Development and further implementation of such a network can be a topic for the McGill workshop and for discussion of the coastal theme during the International Conference on Arctic Planning (ICARP) in November 2005. The ACD key sites could become an integral part for the development of the Circumarctic Environmental Observatories Networks (CEON).

DETECTION AND MAPPING OF PERMAFROST DEGRADATION ON HERSCHEL ISLAND, YUKON, USING RADARSAT-1, SPOT AND IKONOS SATELLITE DATA

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²Department of Geography, McGill University, Montreal, Quebec, Canada

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The stability of many northern landscapes is derived from its frozen ground, thus climatic warming trends at high latitudes is one of the most important environmental issues facing polar regions today. Increases in mean annual ground surface temperatures can eventually cause a shift in the subsurface thermal regime, and lead to increased thawing and terrain instability. To map and monitor thaw-induced terrain changes over vast areas poses considerable challenges. To support these efforts, we investigated the information content available from satellite data.

At Herschel Island, Yukon Territory, we examined several sources of satellite data for providing information on landscape change. Orthorectified high-resolution images provided by panchromatic IKONOS data are at the appropriate scale to compare with older aerial photographs. Recent high-resolution data also complement information collected from detailed field studies where dm-scale GPS surveys were carried out. Cross-validation with ground data enables interpretations from other areas to be made with greater confidence.

With mm to cm scale sensitivity possible from radar, we considered radar coherence images from interferometric processing of RADARSAT-1 data for revealing terrain changes. Although coherence images do provide terrain-related information, the data are at times difficult to interpret. Understanding interferometric SAR information still requires further research in order to fully comprehend its potential information for our application in permafrost studies.

On decadal time scales, optical SPOT data (5-10 m resolution) from archives is capable of detecting retrogressive thaw slumps that have caused erosion or landscape changes with rates on the order of metres per year. An examination of these images revealed that permafrost degradation was not confined to the coastal areas, but has also occurred in land where no previous monitoring have taken place.

Earth observation data sets can be used as a cost-effective tool for providing monitoring information on the effects of climate change, particularly in remote arctic regions where routine access is not always possible.

GEOCHEMISTRY OF EXOGENOUS PROCESSES OF RUSSIAN ARCTIC COAST

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Research Institute for Geology and Mineral Resources of the Ocean (VNIIOkeangeologia), St. Petersburg, Russia

Millions of square meters of land consisted from permafrost rocks are lost every year as a result of global changes, in particular climatic changes in a coastal zone of Arctic seas. Exogenic processes in Arctic basin on which ice melting in permafrost influenced regulate sediment, organic carbon and nutritious balances. A peculiarity of geochemical exogenic processes in Arctic is their

biogeochemical nature to some extent. Oxygen as a product of vital activity of plants has substantial impact on exogenic processes. Despite that oxygen usually is a hard oxidant, pure chemical processes of oxidation have a little effect under low temperatures. But these oxidation processes became substantial if bacteria affected them. Other gases formed under reduction processes of destruction of organic matter: carbon dioxide, hydrogen sulfide, methane and hydrogen have no less significance than oxygen. These two geochemical redox processes determine environmental conditions of formation of authigenic minerals in coastal zone under exogenic processes.

Oxidation of low valency transition elements especially of ferrum resulted absorption of atmospheric oxygen that has a great importance for exogenic processes because auxiliary absorption of oxygen from atmosphere during coastal erosion intensifies unoxidizing processes. The other problem of geochemistry of exogenic processes of permafrost in Arctic coastal zone is focused on composition and volume of gases' bubbles included in tabular ground ice. According to our data the bubbles contain small admixture of gases of halogen-hydrocarbon compound, e.g. natural freons which can destroy the ozone layer.

This study was supported by the INTAS (grant no. 2329)

ESTABLISHMENT OF STANDARDIZED STATIONS TO MONITOR THE RESPONSE OF PERMAFROST TO CLIMATE CHANGE

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² Université Laval, Sainte-Foy, Quebec, Canada

The Université Laval (Quebec) and BGR have monitored since July 2000 the response of permafrost to climatic changes at one site near Umiujaq, eastern Hudson Bay. We plan to expand this cooperation by the put in of standardized permafrost monitoring stations along a south –north trending profile extending from Umiujaq to Salluit. These stations will record in the depth interval of 0 to 20 m standard parameters, (ground temperatures, pore water pressure in partially frozen permafrost and ground movement in active layer in response to the freezing/thawing cycle) and the annual buildup and decay of snow cover (considered is also an integrated technical approach to measure physical snow properties). In addition, already tested geophysical methods such as e.g. GPR transillumination surveys (Vertical ElectroMagnetic Profiling and ElectroMagnetic Tomography) between two boreholes will be applied.

We will introduce a newly developed instrument to drill about 20 m into permafrost at each new monitoring site. Standardized (and low cost) monitoring assemblages will be installed in the bore holes and activated for continuous recording. We hope to establish a recording system that will substantially contribute to a long-time “in depth” monitoring of the permafrost response to climatic changes expected for Northern Quebec.

THE CANADIAN CLIMATE IMPACTS AND ADAPTATION RESEARCH NETWORK (C-CIARN): BUILDING LINKAGES IN A CHANGING WORLD

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The Canadian Climate Impacts and Adaptation Research Network (C-CIARN) consists of six regional offices, and seven sectoral offices. The Regions cover geographically significant issues, while the Sectors focus on areas of broad national interest such as fresh water, the coastal zone, fisheries, landscape hazards, and more. C-CIARN was created in 2001 to develop a network of researchers and stakeholders involved in climate change impacts and adaptation, facilitate research, and provide a voice and visibility to the climate change issue.

A priority and on-going task of C-CIARN is to identify climate change impacts and adaptation research needs and knowledge gaps through consultation with user groups and researchers. Since circumpolar regions are expected to experience the “first and worst” impacts of global warming, and are already seeing changes, many of the identified research needs and knowledge gaps pertain specifically to the North and its vast and sensitive coastal zone.

There is a clear need for those organizations and individuals involved in climate change issues to communicate across the boundaries of geography and discipline and to coordinate their efforts in order to assess what Canada needs to do, and know, to adapt to an ever-varying climate. Both researchers and the users of research are encouraged to join C-CIARN and use its resources to help focus their efforts as efficiently and effectively as possible.

DISTRIBUTION OF ICE-BONDED SEDIMENTS AND MASSIVE GROUND ICE ACROSS THE LAND-WATER INTERFACE IN A TRANSGRESSIVE BARRIER-LAGOON-DELTA SYSTEM, BEAUFORT SEA COAST OF YUKON TERRITORY, CANADA

D.L. Forbes

Geological Survey of Canada, Natural Resources Canada, Bedford Institute of Oceanography, Dartmouth, Nova Scotia, Canada

The lagoon estuary of Babbage River is predominantly less than 1.5 m deep and partially enclosed by a spit. There is a 2 km baymouth entrance opposite the delta front. Relative sea-level rise exceeds the rate of delta-plain sedimentation, resulting in slow inundation and landward migration of the delta front. Boreholes showed ice-bonded sediments beneath high ground, delta plain, tidal flats, and bottomfast ice in the lagoon. In 2 m water depth seaward of the spit, seabed sediments were unfrozen to a depth of 10 m and underlain by ice-bonded mud with ice lenses. In 8 m depth, sediments were unbonded to at least 22 m below seabed. Deposits beneath the spit were ice-bonded to 9 m at one site (11 m at another), below which was a 4 m thick talik of unfrozen silt. The unbonded layer at depth beneath the spit and thicker units of unbonded sediments beneath the lagoon suggest downward refreezing of shallow estuarine sediments as the spit migrates landward. The delta plain is a low-relief surface with shallow ponds and subtle levees. We hypothesize that

anomalous higher surfaces of chaotic microtopography may be elevated in part by massive ice growth fed from taliks beneath adjacent deep channels in which high-salinity water remains throughout winter. These results confirm preservation in shallow coastal waters of massive ice and ice bonding developed below formerly subaerial surfaces which have subsequently been transgressed. Downward thaw of seabed sediments is initiated in the nearshore seaward of the spit as it migrates landward.

INUIT KNOWLEDGE OF ENVIRONMENTAL CHANGE DOCUMENTED AND COMMUNICATED THROUGH MULTIMEDIA TECHNOLOGY: AN INTERACTIVE POSTER

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This poster presents the multimedia, interactive CD-ROM, "When the Weather is Uggianaqtuq: Inuit Observations of Environmental Change." In this CD-ROM, Inuit from two communities in Nunavut (Baker Lake and Clyde River) share their observations and perspectives on recent climate and environmental changes. Topics include weather variability, sea ice, lake levels, snow, animals, glaciers, and icebergs, among others. The integration of interview video clips, maps drawn by Inuit, photos, music, and text, helps to illustrate Inuit observations of changes and the impacts on their livelihoods

"When the Weather is Uggianaqtuq" is a pilot project into using multimedia technology to improve research reporting to communities and designing more creative educational research products. The Inuit involved in this project have approved the CD-ROM as an educational tool for their own communities, as well as for students, researchers, decision-makers, and others in Nunavut and beyond who are interested in issues around Arctic environmental change.

FIELD OBSERVATIONS OF STORM-INDUCED WATER LEVELS FOR ELSON LAGOON, BARROW, ALASKA

O. Francis-Chythlook

Tryck Nyman Hayes, Inc., Anchorage, Alaska, USA.

From August 17-September 29, 2002, a Seabird SBE 39 Temperature/Pressure Recorder gauge was deployed on the sea floor of Elson Lagoon, at Barrow, Alaska (71°18.942'N and 156°26.780'W). It recorded temperature and pressure in 30-minute intervals. The approximate depth measured during deployment was 2.1 meters which accounts for tide level and wave height generated by the wind conditions at the time of deployment.

An examination of the Barrow CMDL Hourly Wind Speed and corresponding Water Surface Elevation, η for a sample period in 2002 shows that the water surface elevation has a direct correlation to the wind speed. Prevailing winds were westerly winds (46% from 180-360°) and easterly winds (54% from 0-180°). The vector wind directions are radially distributed and there is no prominent wind direction during August-September 2002. Two Category 1 storms (wind speeds > 20 knots for at least six consecutive hours) were recorded, one having southwesterly winds (i.e. 225-262°), the other having southeasterly winds (i.e. 131-138°). These storm surges

had a maximum effect on the water surface elevations by raising their levels to sustained peak heights.

Due to the shallow water depth and high storm surge activity over the area, the water waves affecting the Elson Lagoon coastline are considered irregular shallow water waves. A simplified long wave equation in two-dimensional form describes the change in water level induced by wind blowing over Elson Lagoon.

Support provided by an NSF Experimental Program to Stimulate Competitive Research (EPSCoR) fellowship at the University of Alaska Anchorage.

ADDITIONAL EROSION OBSERVATIONS FOR THE ELSON LAGOON KEY SITE, BARROW, ALASKA

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New data has been added to the published rates of erosion for the Elson Lagoon key site. In the present study, additional time and spatial intervals were acquired for an 11-km long coastal section. Two methods were employed to measure erosion. Method 1 involved using intervals of approximately 200 meters extending perpendicular from the length of the coastline for measuring the coastline erosion rate in meters. A grid was used to establish perpendicular lines for these intervals. Using these perpendicular lines, each coastline shapefile was measured across to the new coastline. With method 2, the average width of land lost per period was calculated as the area lost divided by the length of the coastline segment. The digitized coastlines were used to determine the area of land lost for each period by closing adjacent coastlines into polygon shapes. Methods 1 and 2 gave 1948/49-62/64 as yielding the highest erosion rate for Segments A, B, and D. Methods 1 and 2 gave 1964-79 as having the highest erosion rate for Segment C. Method 2 also gave the highest erosion rate for the period 1979-2000 for Segment A. All segments combined gave the highest erosion rate for 1948/49-1962/64 for Methods 1 and 2. A comparison of mean width rate lost with two previous sets of measurements shows an acceptable match between the values.

Erosion rates and storminess were examined for four different time periods between 1949 and 2003, with a lack of major storms corresponding to lower erosion rates. Erosion rates generally increase in the southeasterly direction along Elson Lagoon during each of three time periods during 1949-2000. Presumably, a submerged bar off Segments A-C influences wave climate, particularly for easterly winds. Segment D has the highest erosion rate due to greater fetch and deeper water. During 2000-2003, Segment C is shown to have the highest erosion rate. Although not reported in this study, summers 2002 and 2003 experienced a series of mid- to late-Summer and Fall storms. The August-September 2002 storm observations in the southeasterly and southwesterly directions may be reflective of the shift in storm direction that produced a higher erosion rate for Segment C and lower rates at Segment D.

Support provided by an NSF Experimental Program to Stimulate Competitive Research (EPSCoR) fellowship at the University of Alaska Anchorage.

RESULTS OF A WAVE CLIMATE STUDY FOR ELSON LAGOON, BARROW, ALASKA

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New results using wave climate applications have been employed to elaborate upon coastal erosion rates and processes for the 11 km long Elson Lagoon site. Wave climate study involving storm surge analysis and wave modeling is used to examine the relationship between storm surges and erosion rates. Available wind data was used to generate wave heights and directions using CEDAS (Coastal Engineering Design and Analysis System software program). The results generate a shallow water wave growth model that depends on fetch length. An analysis of storm events between 1948-1999 shows that the type of storm surge is unaffected by extreme wind events but rather the number of occurrences of lesser wind speeds. The software was used to estimate wave growth over open water and restricted fetches in deep and shallow water. Fetch lengths were measured for locations across the water that would be affected by storm surge waves. SPECGEN, part of CEDAS, was used to create spectrally derived wave parameters (i.e. significant wave height, wave period, wind-generated wave direction).

During 1948 to 1999, the results revealed the highest level of storm surge activity for Segment A occurred at a 90° (E) wind direction and 94° (E) wave direction; Segment B occurred at a 90° (E) wind direction and 94° (E) wave direction; Segment C occurred at a 67.5° (ENE) wind direction and 67° wave direction (ENE); and Segment D occurred at a 90° (E) wind direction and 93° (E) wave direction.

Bathymetric color contour maps showing wave height and wave direction were produced based on the results. The wave direction for all four Segments is from the northeasterly direction. The wind-wave directions were chosen from averaged wave directions for significant wave heights. Wave heights are affected by the fetch. Shorter fetches from sheltered conditions due to the Plover Islands had shorter wave heights and periods than the fetches unrestricted from the open waters of the Beaufort Sea.

Support provided by an NSF Experimental Program to Stimulate Competitive Research (EPSCoR) fellowship at the University of Alaska Anchorage.

THE IMPORTANCE OF METADATA FOR ARCHIVING AND PROMOTING SPATIAL DATA DISCOVERY

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The coastal community of Barrow, Alaska, has fostered a long tradition of research dating back to the 1940s. To date, over 4,000 terrestrial based research locations associated with current and historic research programs and experiments have been mapped in the region. Many of these efforts have a spatial component such as the location of bore holes, sensors, ground control points, vegetation plots, erosion control markers, aerial photography, satellite imagery, etc. Much of this data is not properly archived or documented. Increased interests in the impacts of climate change have made historical data sets more valuable.

A metadata outreach effort has been initiated through a cooperative agreement between the Barrow Arctic Science Consortium (BASC) and the U.S. Geological Survey's Federal Geographic Data Committee (FGDC). The outreach is two fold. The first objective is to capture historic information through mapping and documentation. The second is to promote the development of metadata for new research activities in the region. A synergistic activity related to this effort is the capturing of grey literature associated with historical research in the Barrow area. The goal is to make these references available at the new library planned for the proposed Barrow Global Climate Research Facility (BGCRF).

The outreach effort strives to promote access to spatial data through increased data discovery via integration with the U.S. National Spatial Data Infrastructure (NSDI) clearinghouse system and online data browsing through the Barrow Area Information Database – Internet Map Server (BAID-IMS) that can be accessed at <http://ims.arcticsscience.org>.

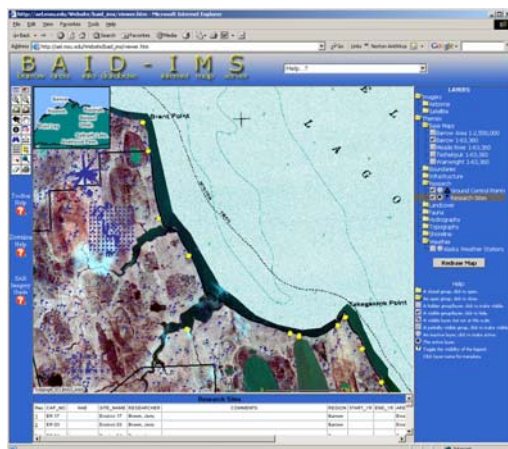


Figure 1. In BAID-IMS a query based on “Erosion” highlights the location of markers used to determine erosion rates for a key ACD site along the shore of Elson Lagoon near Barrow, Alaska

FGDC compliant metadata is ingested into the NSDI clearinghouse system through a node at the Arctic System Science (ARCSS) Data Coordinate Center (ADCC) at the National Snow and Ice Data Center in Boulder, Colorado. This metadata effort is a key part of the Barrow Area Spatial Data Infrastructure (SDI)

initiative. An Arctic Spatial Data Infrastructure has been proposed which will link similar efforts across the region and thus further increase access to spatial data.

The Barrow Area SDI effort is made possible through support from the National Science Foundation (NSF Award OPP-0004401) and the U.S. Geological Survey (USGS Award Number: 03HQAG0177) to the Barrow Arctic Science Consortium.

THE DEGRADATION OF COASTAL PERMAFROST AND THE DEVELOPMENT OF SUB-SEA PERMAFROST IN THE NEAR-SHORE ZONE OF THE LAPTEV SEA

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The dynamics of onshore permafrost and the evolution of offshore permafrost in the near-shore zone are closely interrelated. However, only a few drilling transects within the shoreface of the Asian Arctic Seas have been studied. Under the shallow shelf of the Laptev Sea facing thermal abrasion coasts the sub-sea permafrost table is usually found at a depth of 5-60 metres. Sometimes new formations of sub-sea permafrost were observed on shallows within accumulative bottom deposits. Our previous studies of coastal permafrost degradation at Ice Complex coasts showed that the sub-sea permafrost table slowly submerges from the shoreline to greater water depth. In the Laptev coastal zone sub-sea permafrost was found within many sites: Eastern Taimyr Peninsula, Khatanga Bay, Nordvik Cape, Kozhevnikov Bay, Mammoth Tusk Cape, around the Lena and Yana Deltas, Bykovsky Peninsula, Muostakh Island, Buor-Khaya Bay, Siellyakhsky Bay, Vankina Guba Bay, Svyatoy Nos Cape and around the Big and Small Lyakhovski Islands (Figure 1).

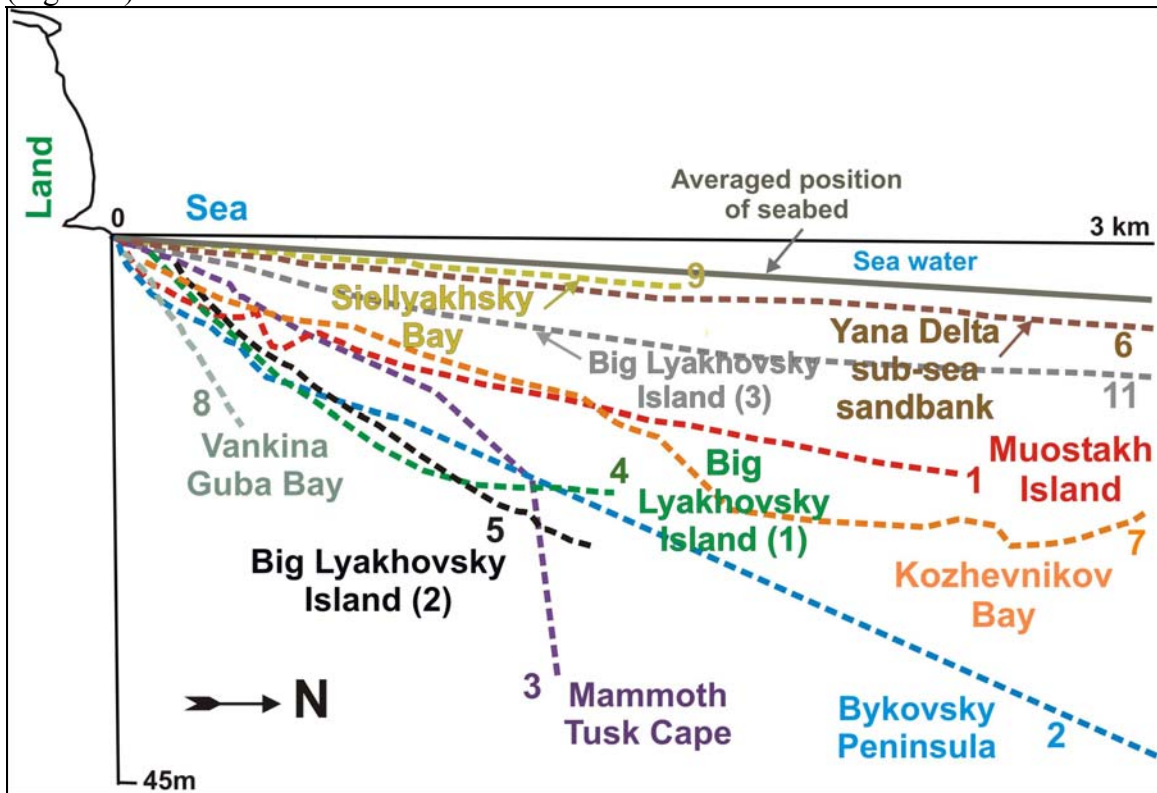


Figure 1. Sub-sea permafrost table position at key sites in the near-shore zone of the Laptev Sea.

During our studies the focus was on ice-rich sub-sea permafrost, which was investigated in detail, because more than 30% of the studied eroded coasts consist of the Ice Complex. According to published and our own data, the foot of the Ice Complex is very often lying below sea level (up to minus 10-20 m). When onshore ice-rich permafrost is transformed into the sub-sea state through coastal retreat its table changes very rapidly, at least initially. Based on coastal retreat rates, the time of submergence of a specific location can be dated back. If, for example, the depth of the permafrost table at a 2 km distance from the shoreline is determined at 15 m below sea level and the long-term coastal erosion rates are about 4 m/year, it is possible to conclude that 500 years ago this specific location was situated at the coast and that the mean trend of degradation of the sub-sea permafrost table is approximately 4 cm/year. However, it has to be noted that during the first stage of submergence the degradation of the permafrost table can be 10-times faster.

Preliminary studies show that depending on the average coastal retreat rate and other environmental conditions, including sediment features, water temperature and salinity regime etc., the dominant rates of degradation of the sub-sea permafrost table during the first stage of submergence vary from 1 to 10-15 cm/year, at a permafrost table inclination of 0.002-0.35 (from the shore to the sea). Preliminary analysis of the sub-sea permafrost table position at the key sites of the Laptev Sea near-shore zone allows us to reveal the regularities and peculiarities in permafrost evolution. The greatest inclination of the permafrost table (0.035) was found in the Vankina Guba Bay – profile 8. It is probably related to slow coastal erosion in this area and environmental specificity. Minimum permafrost table inclinations (0.002-0.003) were observed at the sites where accumulative sedimentation prevails (Yana Delta sub-sea sandbank – profile 6, Siellyakhsky Bay – profile 9). In this case new sub-sea permafrost formation is generated within the very shallow shoreface. Normally, the near-shore sites located at more or less open sea conditions are characterized by steep permafrost table inclination (north-west of Big Lykhovsky Island – profiles 5, 7; Mammoth Tusk Cape – profile 3; Bykovsky Peninsula – profile 2. Moderate permafrost table inclinations were found at Muostakh Island and Bykovsky Peninsula (Central Laptev Sea coast) - 0.007 and 0.013 respectively (average coastal erosion retreat rates are 13 and 3 m/year). In the Mammoth Tusk Cape area (Western Laptev Sea coast) the inclination of the permafrost table is very steep (0.015) within a distance of up to 1.3 km from the shore and extremely steep (more than 0.3) between the 1.3 and 1.4 km distance. This anomaly could be due to ancient thermokarst processes which occurred under subaerial conditions. An estimation shows that the average rate of permafrost table degradation at the studied transect is about 8 cm/year or slightly more.

SEDIMENT AND ORGANIC CARBON FLUXES IN CONNECTION WITH ERODING PERMAFROST COASTS OF THE SIBERIAN ARCTIC

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During the last decade detailed coastal studies along the Arctic Seas have been conducted within the frame of the Arctic Coastal Dynamics (ACD) Program. The results indicate that shore dynamics play an important role in the balance of sediment and organic carbon in the Arctic basin. Arctic coastal sediment flux exceeds river sediment discharge and other terrestrial sediment

sources. Based on newly obtained data, this presentation evaluates average coastal erosion rates as well as sediment and organic fluxes within the Siberian Arctic coastal zone.

The Siberian Arctic sector includes four seas: the Kara, Laptev, East Siberian and Chukchi Seas. The total length of the Siberian Arctic coastline, including the islands, is about 29,500 km. Most parts of this coast are characterized by very active coastal erosion processes. A considerable proportion of the Siberian Arctic coasts (especially for the Laptev and East Siberian Seas) consists of ice-rich permafrost deposits, which are rapidly reworked by sea erosion. It has been found that the coastal sediment flux into the seas listed above plays a dominant role in their sediment budget. Based on the amount of coastal sediment released to the sea and the average organic carbon contents of the key types of coastal deposits, the total organic carbon (TOC) supplied to the Siberian Arctic Seas (SAS) has been estimated. The assessment of these lithologic-dynamic parameters is based on unified methods, which involve detailed coastal segmentation and GIS-analyses.

The calculated values of the sediment and TOC fluxes are considerably different from previously published data. Our results suggest that both coastal sediment flux (158 million tons per year) and coastal TOC flux (4.6 million tons per year) to the SAS significantly contribute to the Arctic Ocean sediment and carbon budget.

This study was supported by the INTAS (grant 01 - 2329).

BOTTOM SEDIMENTS ON THE EROSIONAL SHOREFACE OF THE LAPTEV SEA

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Sampling of bottom sediments on the erosional shoreface of the Laptev Sea was carried out during 1999-2002 on 15 coastal key sections. Altogether 151 samples along the 22 shoreface profiles off the coasts composed of ice complex (7), ice complex on the bedrock basis (5), sand (7), and bedrock (3) were taken at every meter of water depth and analyzed by laser-granulometry. Preliminary results of this analysis were presented at the 4th ACD workshop. Further studies showed that sand prevails on the shoreface of all geological types of coast investigated. Even bottom sediments off the coasts composed of ice complex contain as much as 90 % sand though the ice complex contains 40-90 % of silt. It means that high silt content in perennially frozen unconsolidated sediments significantly favours coastal retreat in the Arctic.

The decrease of sediment grain-size with water depth increase observed in temperate environments manifests itself also in the Arctic. This dependence is very weak off the coasts composed of ice complex and shows itself most strongly off the rocky coasts. The clay content in bottom sediments off all types of coast is low and usually does not exceed 5-6 %.

The formula of power function suggested by Bruun (1954) is usually used to describe the shoreface profile shape. Relationships between shoreface bottom sediment grain-size and coefficients A and m in this formula are examined.

MODELLING BLOCK FAILURE IN VERTICAL CLIFFS OF ARCTIC COASTS UNDERLAIN BY PERMAFROST

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Arctic coasts lie at the interface between terrestrial systems dominated by permafrost, and marine systems that are characterized by long periods of ice cover and short periods of open water when wave action and storm activity are important. Permafrost, sea ice and wind-wave conditions are driven by regional and local climate forcing and interact in such a way that a change in one produces feedbacks affecting the other two. However, under predicted climate change scenarios of warming, increased storm activity and sea level rise will be profoundly affect all three leading to potentially devastating rates of coastal erosion and permafrost degradation. Permafrost coasts are subject to complex erosional processes, however one of the most poorly understood but probably most important erosional process is block failure. Thermo-abrasional falls or block collapses provide the most spectacular form of recession in permafrost areas. The occurrence of horizontal thermo-erosional niches and ice wedges associated with permafrost are the two key reasons for block failure in the arctic coast. The main purpose of this paper is to illustrate different block failure mechanisms of frozen vertical cliffs in the arctic coast. This study provides computational models for block failure mechanisms and investigates the relative contribution of horizontal niche and ice wedge in block failure of permafrost cliffs fronted by a beach.

INITIATION OF A STUDY ON THE FLUX AND TRANSFORMATION OF ORGANIC CARBON ACROSS THE ERODING COASTLINE OF NORTHERN ALASKA

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Although crude estimates of the flux of organic carbon across the eroding coastline of northern Alaska have been developed, little is known about the transformation of terrestrial OC as it crosses the land/ocean interface. We hypothesize that the wave-washed foreshore zone is critical to the transformation of OC once it is released from storage through physical dispersion, leaching, and oxidation. How the bioavailability of OC is controlled by the age, size and composition of the organic matter, and how these factors relate to geomorphic environments that have influenced past soil development, is critical to quantifying OC transformation and to understanding carbon budgets of the Arctic Ocean. To investigate these issues, we are initiating a new research project funded by NSF that has four main components designed to: (1) characterize the nature and abundance of soil OC and ground ice in relation to geomorphic environments, (2) estimate the total OC flux along the entire coast and develop empirical models to assess the vulnerability of the coast to increased erosion resulting from decreasing summer sea-ice, (3) determine the biogeochemical transformation and bioavailability of OC associated with various dissolved and particulate forms across the land/sea interface through field study and laboratory experimentation; and (4) integrate our results to the pan-arctic scale through international collaboration. The study

will involve extensive sampling at 50 sites along the entire Alaskan Beaufort Sea coast to develop precise estimates of erosion and OC flux. Intensive sampling at three primary sites along dominant coastline types will be conducted to evaluate the transformation of the eroded OC. In addition, three secondary sites will be added to broaden the monitoring to other coastline types and to involve local communities in assessing coastal changes.

CRYOGENIC STRUCTURE AND ICE CONTENT OF COASTAL SEDIMENTS, WESTERN SIBERIA

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The ice content is one of the major factors of thermal erosion. The investigations of cryogenic structure and ice content of coastal sediments were carried out at the Kara Sea coasts in the surroundings of Marre-Sale (Western Yamal) and in the southern part of Enisey gulf. In the study area perennially frozen Quaternary sediments composed by sands, sandy-loams, loams and clays have various origin – marine, littoral, alluvial, lacustrine, etc. The type of cryogenic structure depends mostly on the composition of sediments and their cryogenic origin. Syngenetically frozen sandy-loams and loams are characterized by the prevalence of microshlieren close-layered cryostructure; also ataxitic and layered-reticulate cryostructures are abundant. The main cryostructure in epigenetically frozen sands is massive, in clays – lens-layered and reticulate. The volumetric ice content of Quaternary sediments varies from 30% to 80%.

In the Marre-Sale area in the sections of coastal cliffs 20-30 m high two main strata can be recognised. The upper stratum consists mostly of ice-rich syngenetically frozen sands, sandy-loams and loams with ice wedges. In some places the top part had thawed and then refroze epigenetically; such sediments include ice-wedge casts. The lower stratum of folded marine and littoral deposits is formed by saline epigenetically frozen loams and clays with layers of sands and sandy-loams. As usual these sediments are ice-poor, but in several sections they include tabular ground ice. At the accumulative coasts the contemporary syngenetically frozen alluvial-marine sediments were studied. They are characterized by very high ice content (gravimetric moisture content reaches 150%) and include growing ice wedges.

This work was supported by INTAS Grant 2329.

RECENT COASTAL DYNAMICS AND SEA LEVEL CHANGE ON MELVILLE ISLAND, WESTERN CANADIAN HIGH ARCTIC

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During the Last Glacial Maximum, Melville Island occupied the boundaries of the former Laurentide Ice Sheet to the south and the Innuitian Ice Sheet to the northeast. This glaciological

setting generated complex glacio-isostatic adjustments of the earth's crust that are still active today. After more than 10 500 years of land emergence due to glacio-isostatic unloading, morphosedimentary evidence provided by field traverses and air-photo interpretation indicate that the coastline of the island is presently undergoing submergence. Recently activated coastal processes associated with submergence include beach retrogradation, drowning of coastal gullies and terrestrial vegetation, formation of lagoons, barrier reefs and islands as well as accelerated shoreline erosion. We estimate that regional submergence started on westernmost Prince Patrick Island sometime during the mid-Holocene and has progressed eastward, recently reaching eastern Melville Island. This study suggests that the current zero isobase, the threshold between submergence and emergence, is located farther east than previously reported. Submergence on Melville Island is attributed to peripheral crustal forebulge migration towards both the loading centres of the former NW Laurentide and Innuitian ice sheets. Although glacio-isostasy is considered to be the main mechanism acting on the current crustal re-equilibrium in the region, other factors such as subsidence of the Sverdrup Basin, neotectonism (manifested by recent earthquakes in the Byam Martin Channel Zone) and modern eustatic sea level rise may also be contributing to ongoing submergence. Recent climate warming may be playing a role in the intensification of shore-ice erosion, an increase in wave energy due to greater fetch during the summer, and the degradation of permafrost. These processes would have strong impacts on the fine-grained coastline of the northern sector of the island where modern submergence is apparent.

IDENTIFICATION OF STABILIZED AND REVEGETATED RETROGRESSIVE THAW SLUMPS FLOORS ON AN ICE-RICH ARCTIC COAST USING LANDSAT NEAR-INFRARED IMAGERY

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The potential of the near-infrared band of the Landsat-7 Earth observation Satellite to detect the change of vegetation between undisturbed land surface and stabilized slumpfloors was investigated on the south-west coast of Herschel Island, which is affected by strong retrogressive thaw slump activity. Using a false color composite image (Landsat-7 green, red and near-infrared bands) of the southwestern coastal zone of the island, we separated stabilized slumpfloors and non-disturbed land surfaces. We then led a statistical analysis of the spectral signatures of these two regions.

The delineation of the limit between stabilized slumpfloors and undisturbed surfaces on the color composite appeared to match adequately with the same limit drawn independently in a previous study from Ikonos panchromatic imagery.

Zones affected by stabilized slumpfloors exhibited larger radiometric values in the near-infrared band than those marked by undisturbed tundra surfaces. The occurrence of retrogressive thaw slump and the resulting disturbed ground, observed in the field to exhibit less hummocks and larger active layer depths is believed to be responsible for the observed difference.

These results acknowledge this method as a valuable tool for the remote detection of stabilized slumpfloors. Although preliminary, they demonstrate that stabilized slumpfloors undergo a perennial change of vegetation cover, even in some sections where no activity has been recorded since the last century.

SHORT-TERM EVOLUTION OF COASTAL POLYCYCLIC RETROGRESSIVE THAW SLUMPS ON HERSCHEL ISLAND, YUKON TERRITORY

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Following previous analyses on retrogressive thaw slumps pluridecadal evolution on Herschel Island (Lantuit and Pollard, 2004), ten major coastal retrogressive thaw slumps were investigated during August 2004 and surveyed using KDGPS (Kinematic Differential Global Positioning System) in order to assess their short-term (i.e. annual) dynamics.

The KDGPS device was used to mark the active headwalls of the surveyed retrogressive thaw slumps. The use of two Ikonos high resolution panchromatic images from 2000 and 2001 allowed us to compile annual headwall retreat rates for retrogressive thaw slumps. We compiled mean headwall retreat rates of 7.6 m/yr for the 2000-2001 period and of 9.6 m/yr for the 2001-2004 period. The observed strong variability of annual headwall retreat rates was found to be associated with (1) the morphology of the retrogressive thaw slumps and (2) the presence of other juncting retrogressive thaw slumps. Estimated headwall retreat rates were found to be similar in range to those estimated in 1988 by De Krom (1990). On Herschel Island, retrogressive thaw slumps experience an increase in frequency not correlated to an increase in annual headwall retreat rates.

ERODIBILITY AND SEDIMENT STRENGTH IN KUGMALLIT BAY, SOUTHERN BEAUFORT SEA

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In shallow water areas of the Beaufort Sea (<10m) wave oscillations combine with strong coastal currents during storms to cause high bottom shear stress and high rates of resuspension. This storm resuspension is thought to be a major, if not the most important, mode of sediment transport during the openwater season. This paper gives preliminary results of investigations aimed at determining bed strength in Kugmallit Bay. Sediment strength has been measured along a nearshore to offshore transect in Kugmallit Bay by two different methods. The first method uses an insitu underwater annular flume which gives details of the response of the bed to increasing shear velocity, and provides the critical threshold for erosion. The second method uses a laboratory shear vane to give strengths at frequent vertical intervals down pushcores. The measured erosion parameters are compared to available wind and wave data, alongside in situ measurements of suspended concentration. The results of the sheervane analyses show overall decreasing strength from the mouth of the East Channel to more seaward stations. At all stations there is a weak layer between the surface and deeper sediment, rather than a more typical direct relationship between depth and strength. This provides evidence of the deposition of graded silt and sand beds as previously described in the literature, and/or may delineate a mobile upper surface sediment from a more stable lower sediment. Sediment property tests are currently being undertaken to help explain the variation in erodibility and bed strength. These data will help

investigators to determine the conditions required for resuspension to occur, and will provide important inputs to models of sediment, carbon and contaminant transport.

GEOMORPHOLOGICAL SEABED MAPPING BASED ON GIS-TECHNOLOGY

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The Arctic coastal evolution is the result of both exogenic and endogenic processes. In the Arctic region this evolution differs from that in other areas of the world's oceans as a result of interactions between modern wave and ice factors, and the influences of glaciations and large-scale sea level changes in the past. Natural relief-forming processes are important links in the system of "land-ocean interactions" and must be taken into consideration in research of any scale. Among exogenic and endogenic processes it is possible to identify active processes, directly participating in the formation of coastal relief, and passive processes, which predetermine the display of active ones and direct the course for their development. The approach of the present paper is to simultaneously consider all natural factors that took part in relief formation and its evolution. Using GIS technology we suggest to create four layers: bathymetry; structural basement; paleorelief and relief caused by the action of modern processes. As a result of their overlapping a geomorphologic map will be received. In a GIS system various forms of display can be used. For example, the structural basis could be shown in color, the relic forms could be indicated by various lines and the modern relief could be displayed by shading. Using this and other combinations, it becomes possible to create other maps and schemes in GIS format. The poster will include a geomorphologic map of the Pechora Sea in GIS format as an example.

This study is supported by INTAS (grant no.2332).

BATHYMETRIC SEABED MAPPING BASED ON GIS-TECHNOLOGY

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Morphology appears to be one of the most significant relief characteristics, but it is controlled by a set of interactive processes acting over long periods. Initial structures form the basement surface that has been reworked, or is now being reworked, by a complex of environmental processes. Relief morphology does not appear steady and changes with time. Analogous changes took place in the past, occur in the present and will continue in the future. We have developed our understanding that the origin of relief is the main factor that created the existing coastal morphology. Our approach, in which a multitude of interacting factors are simultaneously analyzed and determined, could be called "morphogenetic". Bathymetric seabed mapping is the main component of the developed morphogenetic approach and forms the base of geomorphologic mapping as well.

Today bathymetric digital mapping is developed rather intensively, however, mechanical interpolation of depths is still used during processing, available geophysical, geological, morphological and other data are not involved and complex analyses are not carried out either. Electronic maps usually have a base scale of 1:1 000 000, which does not reflect the complete variety of the seabed relief. At the same time, the definition of relief origin already at a preliminary stage of processing has a basic value. Our technique of bathymetric mapping includes (1) joint analysis of structural and exogenic peculiarities aimed at the determination of relief origin (2) manual map processing on the base scale of 1:200 000 (3) digital transference. In this poster bathymetric maps of the Pechora Sea, the Laptev Sea (eastern sector) and the offshore bathymetry of Yamal Peninsular will be presented.

This study is support by INTAS (grant no.2332).

THE ROLE OF WAVE ENERGY IN DYNAMICS OF ARCTIC COASTS FORMED BY DEPOSITS WITH LOW ICE CONTENT

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Coasts formed by deposits with low ice content have significant extent in Russian Arctic, particularly, in the Barents and Kara seas. These are primarily the coasts of large accumulative coastal landforms generated during the Holocene, such as barrier beaches and spits. At present, some of these coasts have erosional bluff, while the others represent typical full-profile beaches. Coastal thermoerosion effect is insignificant for evolution of both types of coasts. Periodicity of extreme storm surges and the total wave energy activity in the coastal zone during dynamically active period are the main factors determining dynamics of coasts with low ice content. Thus, to forecast the dynamics of such a coast under conditions of global climate change it is only necessary to predict changes in the regional wind-wave regime. As basic coastal retreat values one can use the values obtained by direct stationary observations during the period with certain wind-wave parameters.

To substantiate this supposition, we performed correlation analysis of the results of stationary observations on coastal dynamics and hydrometeorological data. The Varandei Island (Barents Sea) formed by sandy deposits with low ice content was chosen as a key site. Here, the Laboratory of Geocology of the North (MSU) carries out observations on coastal dynamics during the last 20 years. Hydrometeorological parameters are calculated from the data provided by Varandei HMS founded in 1940. The wave energy volume at the external border of the coastal zone is calculated with the help of Popov-Sovershaev method using the data on wind direction and speed for the time period between 1981 and 2002.

The obtained results permit us to conclude that: 1) For the coasts formed by deposits with low ice content, there is no correlation between the coastal erosion rate and the mean temperature of the dynamically active period. The coastal erosion rate observed in the Varandei area between 1981 and 2002 ranges from 0 to 6 meters per year, while the average temperature of the dynamically active period varies between +2°C and +8°C; 2) At the same time, there is a clear dependence between the wave energy volume at the external border of the coastal zone and the coastal retreat rate.

This work was supported by INTAS grant no. 03-55-2506.

FEATURES OF STATISTICAL DISTRIBUTION OF ORGANIC CARBON IN CONTINENTAL PERMAFROST OF ARCTIC SHORE (EAST SIBERIAN SEA SHORE LINE)

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To calculate an input intensity of organic carbon (OC) in the Arctic ocean at coastal thermal erosion, we need an evaluation of OC contents in the eroding permafrost deposit. The OC concentration is changed between zero and tens % in the syncryogenic continental permafrost sediment depending on the facial features of permafrost deposits. We have considered the data on OC in permafrost of both ice complex and alas complex on the ACD key site Malii Chukochii Cape, East Siberian Sea coast (276 measurements totally). These sediments are typical for thermal eroding shores of the East Siberian Sea. The statistical tests showed that the distribution of the contents of OC has binomial character. The form of a histogram of general sample with two maxima confirms binomial character of the statistical distribution. The first maximum is situated at a level of the mean contents 0.85 % of OC and corresponds to "mineral layers" of the continental subaqual sediment. These layers have not morphological indicators of subaerial soil formation such as specific soil structures, horizons and profiles. The second maximum (4.05 %) is dated for lenses of peaty horizons of buried soils inside the permafrost massif. Selected statistical samples of the OC content are authentic differ with probability, greater than 0.95 for "mineral layers" and buried peaty horizons. The peaty horizons of buried soils take about 9 % of permafrost massif of the alas complex deposit, which is compacted and does not contain thick ice wedges. The binomial statistical distribution of OC confirms, that the permafrost deposit can be described as a product of both sedimentation and soil formation under the cold climatic conditions (cryopedolite). The updated technique is offered for determination of the contents of organic carbon in eroding permafrost.. It is based on the account of a binomial non-uniformity of statistical distribution of organic carbon in permafrost deposits.

ARCTIC COASTAL DYNAMICS OF EURASIA - RESULTS OF TWO ACD-RELATED INTAS PROJECTS

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Under the framework of the Arctic Coastal Dynamics (ACD) program two projects of the International Association for the Promotion of Co-operation with Scientists from the New Independent States of the Former Soviet Union (INTAS) focused on ACD related topics.

The objectives of the first project “**Arctic coastal dynamics of Eurasia: classification, modern state and prediction of its development based on GIS technology**” (2002-2004) had been to develop a coastal classification and to generate GIS based map products for the coastal zone of the Eurasian Arctic. The Russian part of the circum-Arctic ACD classification and segmentation has been completed within this project.

The overall objective of the second project “**Arctic coasts of Eurasia: dynamics, sediment budget and carbon flux in connection with permafrost degradation**” (2002-2005) is to quantify the material flux through coastal erosion in order to improve our understanding of the Arctic sediment and organic carbon budget.

This presentation summarizes the main results of the two projects and provides an overview of more specific results which are shown in a series of posters.

PERMAFROST DISTRIBUTION OFFSHORE WEST YAMAL

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The results of seismic studies in the near-shore, shallow waters of the south-western Kara Sea – at the Shpindler, Kharsavey and Mare-Sale sites - showed the presence of a seismic interface which can be interpreted as submarine permafrost table. The proposed permafrost exhibits a continuous distribution and strongly dissected top surface overlain by unfrozen sediments. The permafrost table is located at a depth of 4-6 m and 5-10 m below the sea floor at the Shpindler and Mare-Sale

sites, respectively. 3D modeling of the permafrost table suggests the presence of relict buried thermodenudational depressions (up to 2 km across) at a minimal sea depth of 40-45 m at the Shpindler and Mare-Sale sites. The depressions may be considered as paragenetic to thermocirques found in cliffs at the Shpindler site. At the Kharasavey site permafrost table has an elongated depression lying along the modern shoreline. The maxima depression depth is 20 m below seafloor. At present, relict thermocirques (Shpindler and Mare-Sale) and elongated depression (Kharasavey) are completely filled in with sediments and not exposed in modern bottom topography.

THE MAIN RESULTS OF ASSESSMENT OF HUMAN IMPACT ON ARCTIC THERMAL-ABRASION COASTS IN THE PROCESS OF INDUSTRIAL EXPANSE

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Within the frame of the INTAS project "Arctic coastal dynamics of Eurasia: classification, modern state and prediction of its development based on GIS technology" an industrial impact assessment on Arctic coasts has been carried out. The main method of this task are based on a coastal types classification and mapping of a series of different scale maps of engineering geocryological zoning. The mapping scales of engineering geocryological zoning varied from 1:8000000 to 1:200000.

The engineering-geocryological zoning was performed in matrix form. This allowed to connect different types of the coasts to the main types of the grounds (rocks and sediments) composing the coast. Based on this methodical approach, 26 engineering-geological areas of the Arctic coasts of Russian Eurasia were parcelled and a map of engineering geocryological zoning (1:8000000) was compiled.

The next step of investigation was the engineering geocryological zoning and mapping of the European North of the Russian Arctic coast (Barents sea coast) (1:1000000) and an engineering geocryological zoning and mapping of the key-site Varandey Peninsula (1:200 000).

Based on the series maps of engineering geocryological zoning, maps illustrating the intensity of destructive coastal processes and maps presenting the industrial impact assessment on Arctic coasts have been compiled. These maps were prepared for each level of engineering geocryological zoning.

First level maps (1:8000000 scale):

- Engineering geocryological zoning of the Arctic coast of Russia
- Estimation of the intensity of natural exogenous processes on the Arctic coast
- Industrial impact assessment of the Arctic coast.

Second level map (1:1000000 scale):

- Engineering geocryological zoning of the Arctic coast of European North of Russia (Barents Sea coast). The zoning of the coast was correlated with the segmentation of the Barents Sea coast and with ACD Data Base on this map.

- Estimation of industrial impact on the activation of natural exogenous processes at the Barents Sea coast.

Third level maps (1:200000 scale):

- Engineering geocryological zoning of the key-site Varandey Peninsula (Barents Sea coast).
- Zoning of geocryological process (frost heaving) activity of the key-site Varandey Peninsula (Barents Sea coast).
- Zoning of potential hazard of geocryological process as a consequence of industrial impact.

SUSPENDED PARTICULATE MATTER DYNAMICS IN THE NORTHERN DVINA DELTA, THE WHITE SEA, DURING THE FLOOD

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The Northern Dvina is the main source of riverine suspended matter supply of the White Sea. The most part of this suspended particulate matter (SPM) is delivered to the White Sea during the floods. The distribution of SPM and hydrological characteristics of Northern Dvina and its tributaries and branches were studied during the flood period from 13 till 30 May, 2004. The studies were carried out onboard the RV “Iceberg-2”. 141 samples of SPM have been collected by filtration of water through the nuclepore filters with pore size 0.45 µm.

Concentration of SPM at the Ust’-Pinega cross-section varied from 4 to 14.7 mg/l (8.9 mg/l, n = 16 samples). In the Maimaksa Branch from the Solombala Island to Lapominka concentration of SPM varied from 10 to 20 mg/l. In the mixing zone the concentrations of SPM sharply decrease with the increase of salinity. Near the Mud’yug Island they were 1.9 mg/l. In the marginal filter of N. Dvina the same as in Siberia, the following processes sequentially change each other at the way from the river to the sea: gravitational sedimentation, physico-chemical processes in colloid system (coagulation and flocculation, formation of sorbents), and, finally, biological processes (growth of phytoplankton with conversion of dissolved elements to biogenic suspended matter and the process of biofiltration). Riverine SPM is mostly consists of mineral grains and allochthonous organics (fibers of terrigenous plants), and the SPM in the open sea is mostly planktonogenic. The character of geochemical processes in the Northern Dvina marginal filter is similar to large Arctic estuaries, described elsewhere.

EFFECT OF MASSIVE GROUND ICE ON THE COASTAL DYNAMICS IN THE RUSSIAN ARCTIC

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The present-day Arctic shelf and coastline was formed in the Late Cenozoic (approximately, for the last 250 kyr) under the action of the two types of natural processes: (1) planetary processes that caused considerable changes in sea levels and (2) permanent local exogenous processes complicated by permafrost. Massive ground ice plays a special role in coast formation. This ice is distributed very irregular in the coastal zone because of different ice genesis.

Eurasian massive ground ice should be divided into four main genetic types: (a) syngenetic submarine ice is formed under the conditions of deep sea (40-200 m) in the regions of ancient transgressions; (b) syngenetic offshore-marine ice is confined to the marginal parts of ancient sea basins and was formed in periodically flooded offshore areas and on laidas; (c) injective ice – it was formed epigenetically in subaerial regions under hydrogeological conditions favorable for its replenishment; (d) buried ground ice – it is most often represented by large buried remains of glaciers in mountain regions.

Mostly submarine and offshore-marine ice occurs in the coastal zone within Pleistocene sea plains. We can confidently state that, during the Pleistocene, the plains and coastline were formed and changed at a direct participation of frozen bottom rocks on the shelf and massive ground ice of this types that was formed within these plains.

At the end of the Pliocene - beginning of the Pleistocene, deterioration of climate and intensification of differentiated tectonic movements caused sea transgression and origination of ice caps and permafrost everywhere on the Arctic coast. In the Middle Pleistocene (II2-4), the coasts of the western part of the Russian northern regions, Urals, Taimyr, and the mountain regions of Eastern Siberia and Chukot Peninsula were covered with glaciers slipping into the sea, were subjected to glacial exaration, and were not affected by waves. The northeastern part of the East European Plain and the northern part of Western Siberia, deltas of large Yakut rivers, and Chukot lowlands were occupied by a cold-water basin. The low-temperature thick cryolithic zone of a offshore-marine type was formed in shallow offshore parts of the shelf. The submarine cryolithic zone represented by marine, ice-marine, and glacial-marine dense silty-clayey sediments with low ice content and without massive ground ice was formed in deep sea sectors. Coastal processes were inactive. A short ice-free period and low temperature of frozen soils composing coasts hindered thermal abrasion and erosion of coasts and river banks and simultaneously limited income of material to be accumulated. Accumulative coasts were formed only in deltas and inner parts of bays.

The Late Pleistocene Mikulino (Kazantsev) Interglacial (III1) is a warm epoch. The position of the Arctic coastline reflected complex processes that proceeded at that time. On the one hand, different tectonic movements were among these processes: pronounced upward movements of the shelf and coast in the western sector; downward movements of the shelf, neutralized by accumulation of fine-grained alluvial and lacustrine-alluvial continental sediments, in the central in eastern sectors; and upheaval of the eastern margin of the Chukot Peninsula. On the other hand, disappearance of ice caps caused glacial-eustatic rise of sea level. Much less pronounced sea transgression took place in the western sector and on the Chukot Peninsula. Bottom soils froze and thick massive ground ice of a submarine type were formed on the shelf of Western Siberia and Chukot Peninsula. Coasts of mountain regions that became free of ice caps were dissected in the form of fiords. Coasts of sea plains without water were composed of the Middle Pleistocene very dense perennially frozen (except such soils in northern Europe) silty clay with low ice content. An increased ice-free period and wide water areas free of pack-ice, caused a larger fetch, had to favor an enhanced development of thermal abrasion. Thermoabrasion flattened coasts with high cliffs and deep offshore slopes were generally predominant. Thermoabrasion-accumulative and

accumulative coasts were formed in shallow straits. Submarine cryolithic zone hindered accumulation due to transformation of seafloor sediments.

The Late Pleistocene Valdai (Zyriansk-Sartan) epoch (III2-4) is a prolonged cold stage. The Arctic transgression continued and drained shelf to a bottom contour of 110-140 m 18-20 kyr ago. The air temperature at a latitude of the present-day coastline was $-15 \div -170^{\circ}\text{C}$. Coastal processes could not be active. Only rocks with high ice content and with large amount of massive ground ice, which composed coasts of drained Kazantsev plains, decreased stability of coasts. According to Vasil'ev, action of waves with a height of less than 1 m mainly contributes to destruction of coasts. Slow action of these waves in an ice-free period results in erosion of a cliff bottom, destabilization of cliff, and recession of coast. In this epoch, coasts were mainly thermoabrasion-accumulative with indistinct features.

Holocene (IV) is a warm interglacial period which started 10.5 kyr ago and still continues. The post-glacial (Flanders) transgression took place in the Holocene. As a result of this transgression, sea level reached its present-day position 6 kyr ago and only insignificantly fluctuated afterwards. In the Holocene, coastal processes were intense and various. They were most intense in the regions of maximum occurrence of underground ice, as a rule, submarine and offshore-marine massive ground ice in coastal zones. Many coastal areas including such ice are eroded at average rates of 1 – 2 m/yr (for the Yamal, Gydan, Yugor and Taz peninsulas) and 2-5 m/yr (for the coasts of the Chukchi and East Siberian seas with polygonal-wedge ice). Injective and buried ground ice is usually encountered far from the coastal zones and, therefore, almost does not affect coastal processes.

This work was supported by the INTAS (grant 01 - 2329) and by the Russian Foundation for Basic Research (project no. 02-05-64263).

REMOTE SENSING OF BOTTOM-FAST ICE IN THE MACKENZIE DELTA REGION, NORTHWEST TERRITORIES, CANADA

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Bottom-fast ice (BFI) refers to sea- or lake-ice that freezes to the bed during the course of the winter season. The timing and distribution of BFI controls the mean annual temperature at the lake(sea) bed and therefore the potential for development and maintenance of permafrost and the thickness of the subaqueous active layer. The areal extent of BFI has been mapped using ground-penetrating radar (GPR) from the ice surface and satellite synthetic aperture radar (SAR). Regions of low radar backscatter are associated with charted shallow water in lakes and the Beaufort Sea region of the outer Mackenzie Delta. Relatively higher backscatter is found in the deeper parts of the lakes and of the nearshore region. The maximum extent of low radar backscatter occurs in April and is associated with regions of the sea and lake bed that are generally less than 1.5 m water depth. Interpretations of the radar imagery become problematic in May and June because of the presence of a wet snowpack and flood or meltwater on the surfaces of the ice. A time series of Radarsat scansar images is used to monitor the growth of these low backscatter zones beginning with inception around subaerial shoals in November and culminating in extensive regions by April. Differences between interpretations of BFI extent based on Radarsat and GPR suggests that the former may be more sensitive to areas that are either marginally bottom-fast or potentially

subject to tidal influences (i.e. periodic lift-off from the seabed). Additional validation of the technique in the shallow coastal estuarine environment is presently underway.

ORGANIC CARBON IN THE COASTAL QUATERNARY SEDIMENTS OF BARENTS AND KARA SEA

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The content of organic carbon in the coastal sediments of Barents and Kara Sea is still under poor investigation. During fieldwork the samples of the Quaternary sediments from different sections were taken. Such sampling was made in the regions of Shpindler, Marre-Sale, Maresalskie Koshki, Bovanenkovo Gas Field and others. As the rule 2 – 3 samples were taken from every lithological layer of studied geological section.

Our results and published data allow us to make first approximations of organic carbon-content in coastal sediments of Barents and Kara Sea. Analysis shows that existing data is still not enough for representative conclusions about distribution of the organic carbon-content. For thermoerosional coasts organic carbon content was found 0.1 – 0.6% in sands and 0.8 – 1.2% in clays and was found as independent from geological features (genesis, age and others). In the regions with accumulative forms such as places where low sandy islands form, the organic carbon-content is fairly low and usually is only 0.1%. In the laidas, especially in the rivers estuaries organic carbon content in sands increases to its usual level – 0.1 - 0.7% in the sand and to 1.2% in the clay sediments. The sources of organic carbon to Arctic basin under coasts destruction is also organic carbon of soils and peat, but these sources could not be found significant under coastal erosion. Our investigations of organic carbon distribution in the coastal Quaternary sediments in Mare-Sale region show that organic carbon-content does not depend on type of ground freezing. Under thawing and repeated freezing the content of organic carbon does not change.

This work was supported by the INTAS (grant 01 - 2329) and by the Russian Foundation for Basic Research (project no. 02-05-64263).

COASTAL EROSION ALONG THE CHUKCHI COAST DUE TO AN EXTREME STORM EVENT AT BARROW, ALASKA

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Along the north slope of Alaska, shorefast ice protects the coast 9 months of the year and negligible tides and waves minimally disturb the beach during the remaining summer months. Most of the coastline change, then, is thought to occur during summer and autumn storm conditions, where heightened sea levels and increased wave action accelerate movement of coastal materials. Our research examines the coastline change on the Chukchi Sea experienced during an intense storm at Barrow, Alaska (established as a key site with the Arctic Coastal Dynamics program) on October 3, 1963. We compare this to the normal transport of coastal materials to assess the vulnerability of the Barrow community to erosion from increased storm activity from

climate change. Two sets of aerial photographs from 1962 and 1964 were geospatially corrected and used to determine the coastline positions at Barrow before and after the 1963 storm. Changes in bluff edge were measured where present and changes in water line measured where only beach existed. Over the two year period spanning the 1963 storm, the coastline change was highly spatially variable, with only erosion occurring at the bluffs to the southwest of Barrow and both erosion and accretion occurring at the beach in front and to the northeast of Barrow. The bluff erosion at Barrow was found to contribute up to 1/3 the total erosion occurring over the 49-year period from 1948 to 1997. We are currently evaluating the human interaction with the coast at Barrow to help explain our findings.

THE COASTAL EROSION SEDIMENT AND ORGANIC CARBON INPUT TO THE KARA SEA

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The estimation of the coastal erosion sediment and organic carbon input to the Kara Sea was fulfilled on the basis of the coastal mapping and the study of coastal sediments composition, contents of ice and organic carbon. The total length of the Kara Sea coasts evaluated on the GIS basis (Drozdo & Korostelev, 2003) reaches 15000 km, including thermal erosion coasts (2600 km), accumulative (6200 km), stable (5900 km), glaciers (about 300 km).

For the each homogeneous segment the following values were determined: length, elevation, retreat rate, ice -content, sediments organic carbon-content , soils organic carbon- content, and salinity. The main problem is to evaluate the content of organic carbon in the coastal sediments. On the basis of the published data and the results of our own field works it was established that the average content of organic carbon in clays reaches 0.8-1.2%, and in sands – 0.1-0.6%. The total input of sediments, organic carbon and soluble salts was calculated as the sum of values determined for the each homogeneous segment. The results of calculations are shown at the Figure.

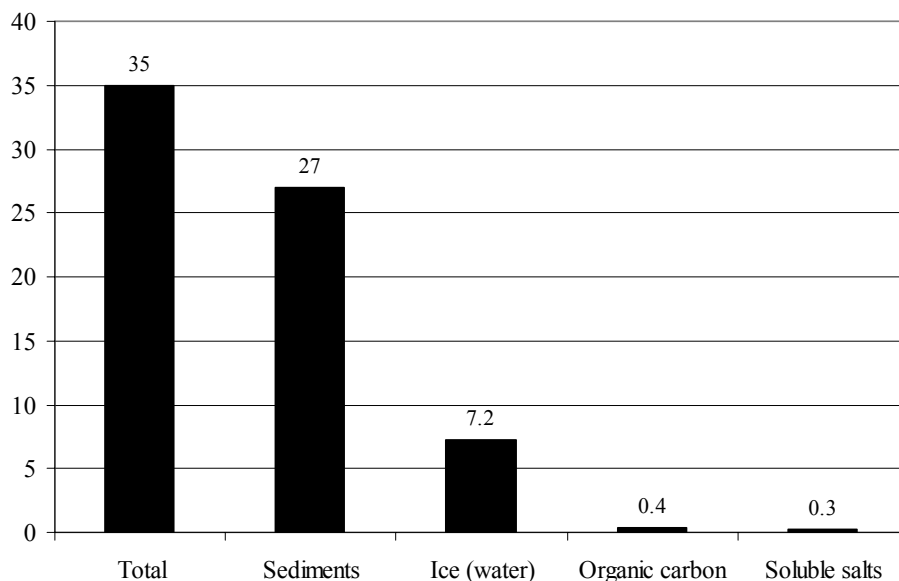


Figure. Coastal erosion sediment input to the Kara Sea (mil. ton/year).

The comparison of these results with the published data (Romankevich & Vetrov, 2001; Mikhailov, 1997) shows that the organic carbon input from the coasts subjected to thermal erosion, determined by our calculations is approximately 2-3 times less than it had been evaluated before.

This work was supported by INTAS grant no. 01-2329.

MEASURING COASTAL CLIFF EROSION BY MEANS OF TERRESTRIAL PHOTOGRAMMETRY IN THE KONGSFJORDEN AREA, SVALBARD

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Four sites for measuring coastal cliff erosion in the Kongsfjorden area on Svalbard (79° N, 12° E) were established in the period August 2nd to 8th 2002. The sites were measured again in August 2nd to 9th 2004. Comparison and calculation of changes in surface morphology are done. The sites were chosen to compromise different kinds of material and exposure. Both cliffs consisting of rock and deposits were chosen. The changes are generally small in this two year period. More details will be given in the presentation at the workshop.

At each of the sites fixed points were established and surveyed with GPS and traditional surveying equipment in 2002. Photos were taken at distances ranging from 7 to 15 meters from the cliff walls with a Hasselblad camera. The camera positions were also measured by surveying from the fixed points. At each site photographs were taken from 2-3 different camera positions to get 3-D coverage of the cliffs. The same procedure of surveying and photographing was repeated in 2004.

The photos are scanned and digital terrestrial photogrammetry is applied to construct digital terrain models of the cliffs. The erosion rate is simply the difference between these two sets of terrain models. Due to the short distance between camera and cliff, the accuracy is in the millimetre to centimetre range and small enough to enable measurement of the low erosion rates.

ROCK-LOADED ICEBERGS IN THE NARES STRAIT A THREAT TO NAVIGATION: TRACKING THEIR SOURCE AND POSSIBLE LINKS WITH ARCTIC WARMING

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During the foggy night of August 17th, 2001, the Canadian-German Nares Strait Geo-cruise 2001 expedition on board the icebreaker CCGS Louis S. St-Laurent encountered a large tabular iceberg weighed down with dark rocks and thus barely visible to radar. The locality (80° 07.705' N; 069° 53.908' W) is near Cape Hayes, northeast Ellesmere Island. The iceberg had an area of ca. 6300 m² and an average elevation of ca. 5 m. The loose rock cover formed an irregular layer between 0.01 and 1 m in thickness. The (angular) rock fragments ranged in size from 4 m blocks to fine

sand and brown silt, all lying on the surface of, rather than embedded in the ice. Samples collected consist of sedimentary rocks, some fossiliferous, and a few petroliferous. Petrography, fossil identification, and limited organic maturation analyses allow matching the geology and petroleum maturation levels of the debris to strata in southern Hall Land and Washington Land. The most likely source of the rafted debris is in the 500m high steep slopes flanking the Petermann Glacier of NW Greenland. It is speculated that warm summer temperatures and a record breaking precipitation in July 2001 may have triggered mass wasting and possibly glacial surging which resulted in the calving of the encountered debris-loaded iceberg. A tanker-iceberg collision reported from near Valdez, Alaska, and recent sightings of rock-loaded icebergs as far south as the offshore petroleum producing areas of Atlantic Canada indicate that these barely buoyant icebergs may pose a significant threat to navigation.