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THE ARCTIC CIRCULAR

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190th meeting of the Arctic Circle, Tuesday, 12 January, 1971. This was the occasion of the Annual General Meeting.

The Treasurer's Report was presented and adopted. Among other items, the report stated that the use of the Mess facilities for its meetings now costs the club $35.00 per meeting. The question of membership subscriptions was discussed and it was decided the annual fee should be increased from $5.00 to $7.00 for in-town members, $3.00 for out-of-town members and $5.00 for institutional subscriptions.

The club has received several orders for complete sets of the Arctic Circular, (Vols. I to XX inclusive) at $100.00 a set. Dr. G. Hattersley-Smith is lending the club his complete set so that copies may be made of the out-of-print issues. These sales will help to move the club's finances from a debit to a credit basis.

There was discussion of steps to be taken to collect dues that are in arrears.

Members were reminded that Arctic Circle ties are still obtainable from the Treasurer at $3.50 each.

Mrs. Margaret Montgomery Larnder has agreed to assume the duties of editor of the Arctic Circular. The previous editor, Dr. A.H. MacPherson, has been transferred to Edmonton. A plea for articles and news items for the Circular was made on behalf of the new editor.

Election of officers

The following slate of officers was proposed for 1971:

President	-	Brigadier General Keith R. Greenaway
Vice President	-	Mr. Stan A. Kanik
Past President	-	Dr. Roger J.E. Brown
Secretary	-	Mr. Keith C. Arnold
Treasurer	-	Mr. Stewart D. MacDonald
Editor	-	Mrs. Margaret Montgomery Larnder
Publications Secretary	-	Miss Mary Murphy

The Advisory Committee:

1969-1972

Dr. Arthur H. Clarke, Jr.
Dr. Geoffrey Hattersley-Smith
Mr. Frank P. Hunt
Dr. P.D. McTaggart-Cowan

1970-1973

Mr. Douglas A. Hodgson
Dr. Donald E. McAllister

1971-1974

Dr. Weston Blake, Jr.
Mr. Keith Crowe
Mr. C.R. (Dick) Harington

Following the adoption of the proposed slate, Brigadier General Greenaway took the chair. Thanks were expressed to the outgoing Executive.

Following the business section of the meeting, Dr. G. Hattersley-Smith and Mr. Harold Serson showed two short films about Defence Research Board field work in northern Ellesmere Island. The first, twenty minutes in length, was taken on the north coast of Ellesmere Island in 1954 by the joint Canadian-United States party investigating the Ward Hunt Ice Shelf and the coastal geology. The party was assisted by two Greenlanders from Thule who are shown with their dog teams on the ice shelf between Ward Hunt Island and Cape Columbia. The main interest of the film lies in the shots of the Ward Hunt Ice Shelf prior to the 1961-62 winter, when massive calving took place. The film also has sequences showing oceanographic and seismic work from a dog sled.

The second film, sixteen minutes in length, shows operations out of Tanqueray Fiord, where a field station has been maintained since 1963. There are sequences showing resupply of the station by Otter aircraft, oceanographic work at a field camp on Nansen Sound, glaciological work on the Ice Shelf, and sea-ice studies in Tanquary Fiord. (Report on films by Dr. Hattersley-Smith).

191st meeting of the Arctic Circle, 9 February, 1971.

The guest speaker was Mr. C.R. (Dick) Harington, since 1965 Curator of Quaternary Zoology, National Museums of Canada. Previously, from 1960 to 1965, he was employed with Canadian Wildlife Service where he made studies of polar bears. The subject of his illustrated address was "Canadian Ice Age Mammals". He outlined the number and distribution of Canadian Quaternary sites already examined in greater or less detail and described, often with slides of actual fossils or reconstructed animals, the fauna found in each and the type of habitat apparently existing at the site in the period the animal lived there.

Dr. J.S. Tener, Director, Canadian Wildlife Service, thanked the speaker, whose thorough and reliable work he knew well. He pointed out how much more fortunate were the researchers of today who, like Mr. Harington, are able to interpret, or at least extrapolate from evidence, the environment of the fauna they studied. At the rate man was influencing ecological relationships, researchers in the distant future might be hard pressed to determine what the "natural environment" had ever been.

192nd meeting of the Arctic Circle, 9 March, 1971.

The guest speaker was the celebrated artist, Dr. Maurice Haycock, to whom the Canadian Arctic is a well-known and much visited land. With his friend, A.Y. Jackson, whom he first met in Baffin Island in 1927, he has travelled on many painting expeditions and there are few parts of Canada's North which he has not visited, his travels even extending to the North Pole.

As well as giving a series of reminiscences of his early travels in the North, Dr. Haycock brought to the meeting the haversack and painting equipment he carried on such expeditions, and, in addition to a 30-minute movie of his northland, showed a superb series of slides of the pictures he had painted there. He also displayed, after the talk, some of his original paintings.

The speaker was thanked for this most interesting and enjoyable evening by Dr. G. Hattersley-Smith.

REPORTS ON ACTIVITIES

Field Studies by the Geological Survey in the North, 1970, by R.G. Blackadar.

A major aspect of the Geological Survey's work is to describe and explore our main geological regions and thus provide basic geological data needed to forecast, discover and evaluate our mineral resources, to provide an understanding of the physical environment and to support administration and policy formulation in mineral and energy resources. In support of these objectives the Survey carried out field studies in widely separated parts of the Northwest Territories and Yukon Territory. Some of these were designed to complete mapping in little known areas, others to refine existing data to meet the increasing demands of government and industry, and others to test new techniques for mineral exploration. In mid-January 1971 the Geological Survey's "Report of Activities, April to October 1970" was released as Paper 71-1, Part A and that report forms the basis for this résumé.

The last large geologically unmapped part of Canada, central Baffin Island, was mapped during the summer of 1970 under the direction of G.D. Jackson. An area of about 54,000 square miles was covered with the support of two Bell helicopters, one 47G4 and one 47G4A, and an Otter aircraft equipped with oversize wheels.

Nearly all the rocks in the area are Precambrian in age. Nearly half the area is occupied by a charnockite-granulite complex. Migmatite, layered gneiss and massive to foliated granitoid rocks outcrop in belts adjacent to the complex. There are several groups of highly metamorphosed sedimentary and volcanic rocks; one an eastward-trending belt up to 80 miles wide extends from Longstaff Bluff on the west to Horne Bay on the east, the second outcrops throughout the southern half of Cumberland Peninsula. Patches of unaltered, flat-lying basalt are exposed between Cape Dyer and Cape Searle. These flows are reported to be up to 1,400 feet thick and to rest on or to be interbedded with up to 500 feet of Upper Cretaceous to Eocene sedimentary rocks.

No significant mineral occurrences were seen although the rusty, pyrite-pyrrhotite bearing zones associated with the volcanic rocks of the two metasedimentary groups are rather spectacular when seen from the air. Some chalcopyrite mineralization is associated with the metasedimentary strata on Cumberland Peninsula as is lean iron-formation.

A reconnaissance of the Prince of Wales Island region with helicopter and Piper Super Cub support was carried out under the direction of R.L. Christie. About 570 landings were made for geological observations and numerous ground traverses were completed and stratigraphic sections measured.

Detailed studies of lower Paleozoic clastic units were made by H.P. Trettin at three locations in the Tanquary Fiord and Canyon Fiord regions of northern Ellesmere Island. The studies of Tanquary Fiord indicate that regional subsidence occurred in Early Ordovician or late Cambrian time. Work at Caledonian Bay was to elucidate the stratigraphy and sedimentology of the Cape Rawson-type rocks (a sequence of sandy to argillaceous, partly calcareous and cherty sediments first reported from northeastern Ellesmere Island in 1878) and their relationship with the calcareous, slaty shale and silt stone Cape Phillips Formation. These studies suggest that the Cape Rawson-type rocks are comparable to modern submarine fan- and trough-deposits resulting from turbidity currents and that the Cape Phillips rocks result from deposition on the slopes over which these currents flowed. Studies were also made of a predominantly Devonian succession south of Canyon Fiord.

W. Blake, Jr. continued his studies on the glacial geology and geomorphology of southern Ellesmere, Coburg, and Devon Islands. A Piper Super Cub equipped with low pressure tires was used for local travel. Special attention was given to collecting samples for radiocarbon dating, to studying the distribution, elevation, and stratigraphy of marine deposits, and to recording fluctuations in the marginal positions of glaciers by means of aerial photography.

Many of the glaciers in the area are now at, or have recently retreated from, their maximum extent since general deglaciation over 8,000 years ago.

Officers of the Geological Survey participated in Phase 8 of the HUDSON 70 cruise between August 26 and September 22. A number of programs were carried out including seismic, gravity, magnetic, side-scan sonar and echogram profiling, bottom coring, grab-sampling and dredging. Sediment studies were made by C.J. Havard and C.J. Yorath of the Beaufort Sea between 69° and 72° N and 128° and 141° W. Ninety-four van-veen grab samples and 47 piston cores were taken along 13 lines which ran from near shore to beyond the Continental Shelf break. About 1,200 miles of shallow seismic profiling was carried out under the direction of J. Shearer. Over the shelf area where water depths are shallow the records show a flat but dissected surface 300 to 400 feet beneath the present surface. Below this the surface dips gently seaward. As the water deepens the quality of the records improve

and show a seaward-dipping, progradational sequence of sands and muds which have been subjected to downslope creep and/or slumping.

Several pingo-like structures were encountered in the shallow water areas. Seismic records over one of these show flat-lying strata beneath a conical dome with a relief of about 80 feet. This indicates a near-surface mechanism for its formation and the presence of ice in one of the cores from this feature suggests a mechanism similar to that which gives rise to on-shore pingos.

M. Bouchard studied the surficial deposits of Herschel Island, Yukon Territory. Most are glacially deformed gravel, sand, silt, silty clay and sand-silt laminae. Pockets of gravel are found throughout the island but till is exposed only in the southwestern part. The deformed marine beds are almost everywhere covered by a mantle of unfossiliferous silt 5 cm to 1 m thick. Some of the pebbles scattered on this surface were derived from the bedrock of the Mackenzie Mountains.

As part of the Geological Survey's study of the Mackenzie Delta area V.N. Rampton mapped the Quaternary deposits and landforms of NTS map-sheets 97 F, 107 C, 107 D, and 107 E. This region appears to be made up of 13 areas each having a unique arrangement of surficial deposits and near-surface unconsolidated sediments. These are described in some detail in Geol. Surv. Can. Paper 71-1, Part A, pp. 173-177.

J.A. Heginbottom continued a study begun in 1969 of erosion in a permafrost environment. The area is the site of the 1968 forest fire at Inuvik. Continuing observations are planned and, for these, four bench marks were installed and six plots marked out.

J. Ross Mackay continued his study of geomorphic processes in the Mackenzie Valley and along the Arctic coast. Features such as permafrost, pingos, ground ice and coastal retreat were examined. He also continued his investigation of the mixing of the waters of the Liard-Mackenzie and Great Bear-Mackenzie Rivers.

Operation Norman, a regional study in the lower Mackenzie River area, initiated in 1968, was completed in 1970 with the mapping of a small area of the Mackenzie Mountains under the direction of D.G. Cook. The information obtained is pertinent to petroleum exploration in that the facies changes mapped and the effects of unconformities in Paleozoic rocks in the mountains must be understood to fully appreciate the geology of the plains areas to the northeast which are now the site of widespread petroleum exploration.

F.G. Young began a study of Jurassic and Cretaceous strata in northern Yukon and northwestern District of Mackenzie. J.A. Jeletzky undertook paleontological studies of Mesozoic rocks in northern and west-central Yukon and D.K. Norris continued a study of the structural geology of northern Yukon and northwestern District of Mackenzie.

Regional mapping on a scale of 1:250,000 was completed in central Yukon Territory under the direction of S.L. Blusson and a geochemical study of 74 intrusive, acidic plutons north of Tintina Trench was made by R.G. Garrett. The data collected during the geochemical study are being analyzed and will when released be of considerable value to those engaged in mineral exploration. D.J. Tempelman-Kluit initiated a reconnaissance of the Snag area, Yukon Territory, a study of which will be completed later by a helicopter supported operation.

R.J. Allan continued a program designed to develop regional geochemical exploration techniques in zones of continuous permafrost. The study, carried out in 1970 in the central outcrop area of the Coppermine Basalts (of Middle Proterozoic age), involved both a regional program and a detailed control study for the regional program. The techniques and results are fully described in Geol. Surv. Can. Paper 71-1, Part A, pp. 61-67. It appears that the method outlined can be applied to the volcanic rocks of Bathurst Inlet, Victoria Island, northern Baffin Island, the Cape Smith-Wakeham Bay belt and the Labrador Trough.

E.H.W. Hornbrook conducted studies near Kaminak Lake, District of Keewatin, in order to develop biogeochemical exploration methods for winter use in the search for metallic mineral deposits. About 1,000 water samples and 400 sediment or soil samples were collected and these are currently being analyzed.

W.W. Shilts began an esker and till sampling program in the Kaminak Lake area. Samples were collected on a predetermined grid and these will be analyzed to determine the dispersal patterns caused by glacier transport or mineral and rock fragments.

A study of the stratigraphy and structure of Aphebian (Lower Proterozoic) sedimentary rocks in Nueltin Lake and Edehon Lake areas was continued by K.E. Eade. Scintillometer readings were made on orthoquartzite, greywacks and conglomeratic greywacks but values were in the background range or only slightly above. Readings on granites and granitic rocks intrusive into the sediments were commonly 15 to 20μ R/hr and ranged up to 35μ R/rh. Quartz-magnetite iron-formation occurs at the north-

east corner of Tatinnai Lake and minor molybdenite mineralization is present in a granitic intrusive near 60°29'N, 96°51'W.

Mapping of the Yellowknife map-area for publication on a scale of 1:250,000 was begun by J.B. Henderson and to the southeast of Great Slave Lake J.C. McGlynn completed field work for the study of the Nonacho Group.

P.F. Hoffman continued a study of the stratigraphy and structure of the Epworth Fold Belt south of Coronation Gulf in order to revise the reconnaissance map published in 1960 and to obtain structural data across the north end of the belt.

A sedimentological and stratigraphic study of the Hornby Bay and Coppermine River Groups was continued by J.A. Donaldson. Sedimentary rocks of the Coppermine River Group were studied along Richardson, Rae, Coppermine and Asiak Rivers and on the north shore of Richardson Bay. It appears possible that the basin of deposition deepens to the north, a fact of importance in evaluating the economic potential of these rocks in that copper mineralization has been observed. If the basin deepens to the north then there is a possibility that stratiform copper deposits may be present beneath the gently dipping overlying strata.

A petrological study of the Daly Bay Complex, north of Chesterfield Inlet, was begun by T.M. Gordon. Traversing was restricted to the shoreline and those parts of the area accessible by rubber boat. The complex, composed of anorthosite, gneiss and migmatite, was chosen for a study of the relations between possible Archean rocks (anorthosite) and a variety of gneisses, some of which may represent remobilized older gneisses and some younger rocks which may have been metamorphosed, migmatized and deformed during the Hudsonian Orogeny. No concentrations of iron-titanium oxides were seen in the anothosite and the frequently observed gossans in the gneissic rocks are due to weathering of iron sulphides or biotite.

Using the CCGS LABRADOR as a base and the ship's helicopter for traversing, W.W. Heywood and B.V. Sanford completed the reconnaissance mapping of Coats, Walrus and Bencus Islands. Most of Coats Island is underlain by Ordivician and Silurian strata. The remainder of Coats and Bencus and Walrus Island are composed of Precambrian rocks. Foliated to massive granitoid rocks and gneiss predominate on the first two islands but Walrus Island is almost entirely layered gabbroic anorthosite. No minerals of economic interest were noted.

As part of a study of the geology of lead and zinc deposits in Canada, D.F. Sangster spent a short time examining the Tom Group of claims in the Yukon (NTS map-sheet 105 O/1), the Bankeno Mines property on Little Cornwallis Island and the Texas Gulf Sulphur property near Arctic Bay, northern Baffin Island.

During the 1969 season the Geological Survey ran an airborne, cross-country gamma-spectrometric profile from Ottawa to Yellowknife. This indicated that the area between Fort Smith and the East Arm of Great Slave Lake was of particular interest and, in 1970, ground studies were undertaken on 3 of the most interesting anomalies. Details of this work were presented in Geol. Surv. Can. Paper 71-1, Part A and will be useful in evaluating future similar airborne survey results. These studies were supervised by A.G. Darnley and B.W. Charbonneau.

During 1970 aeromagnetic surveys were continued in the north and 35,000 square miles of survey were completed in NTS map-area 65 (Dubawnt Lake area) and 11,000 miles were flown in central Baffin Island.

Details of the Geological Survey's 1971 field program are not yet available but it appears likely that the increasing emphasis being placed on northern studies by many federal government agencies will be reflected in a continuing widespread and extensive program of earth science studies in the north.

Arctic Investigations Sponsored by the National Museum of Natural Sciences by A.H. Clarke

Several staff members and contractees carried out terrestrial or marine field research during 1970. Mr. S.D. MacDonald, assisted by Mr. D.A. Gill, established a permanent field station on Bathurst Island and nine of thirteen current projects on mammals or birds were active there in 1970.

Mr. C.R. Harington continued his investigation of Pleistocene vertebrate localities during 10 days in the vicinity of Dawson City, Yukon Territory. Between June 27 and July 20 Dr. A.E. Porsild carried out a botanical expedition to the Ogilvie and Stewart plateaus, also in the Yukon Territory. Dr. R.K.S. Lee continued his research on the systematics and phytogeography of arctic marine algae by collecting in the southwestern portion of the Canadian Arctic Archipelago. Dr. D.J. Faber collected zooplankton for one month between Beaufort Sea and Lancaster Sound on board C.S.S. HUDSON. Mr. L. Marhue spent three weeks in the Tuktoyaktuk region surveying the zooplankton. Dr. D.E. McAllister collected fishes for three weeks in Frobisher Bay, N.W.T., in cooperation with the Fisheries Research Board. Dr. A.H. Clarke, assisted by Mr. Brian Kidd, collected abyssal benthic marine invertebrates from Baffin Bay for three weeks on board C.S.S. DAWSON. Dr. E.L. Bousfield and Dr. James Markham visited the subantarctic on board C.S.S. HUDSON and collected intertidal marine invertebrates, especially amphipods, for 3½ weeks from the Cape Horn Islands in Chile.

Planned field investigations for 1971 include further ethological work at Bathurst Island by S.D. MacDonald and his associates, additional Pleistocene investigations in the Dawson and Old Crow areas by C.R. Harington, and continued abyssal marine dredging in Baffin Bay and Labrador Sea by A.H. Clarke and his associates. Several curators also plan to conduct a general biological survey of the Otish Mountains region in Central Quebec.

Polar Continental Shelf Project Activities 1970-71, by John O'Shea

Scientists, engineers and surveyors of various disciplines carried out numerous studies in the Canadian Arctic between February and October of 1970. Based at Tuktoyaktuk and supported by fixed-wing aircraft and helicopters, these scientific groups, under the auspices of the Polar Continental Shelf Project (PCSP) operated in several areas of the Arctic but investigations were most intense in the Beaufort Sea and Mackenzie Bay areas.

During the months of February, March, and April a joint expedition of Americans and Canadians conducted water depth gravity and various oceanographic observations from an ice floe about 240 miles north of Tuktoyaktuk. In the summer months, scientific vessels of the Dept. of E.M. & R. supported by PCSP services, launched major programs in hydrographic charting and oceanography.

Many nationalities were represented in the PCSP program in 1970. Anthropologists from the University of Heidelberg, Germany, carried out investigations on Banks Island and a research team from the University of Hokkaido, Japan, studied sea ice dynamics in the Tuktoyaktuk area.

Parties ranged in size from a one-student wildlife "group" to the modern oceanographic vessel HUDSON and most disciplines concerned with Arctic exploration were represented.

During 1971, the Polar Continental Shelf Project will support 54 scientific investigations. As in previous years, programs will encompass many varied studies and will range over the vast areas of the Arctic from Mackenzie Bay to Alert on the Lincoln Sea.

The largest program will be a joint Canadian - United States study operating from an ice floe about 280 miles out on the ocean. This group, comprising 47 people, will conduct various oceanographic, hydrographic and gravity observations and will remain on the ocean from February to April.

Again as in 1970, the Marine Sciences ship PARIZEAU will carry out standard charting programs in the Beaufort Sea and marine geologists will investigate shoals located and positioned by BAFFIN of the Atlantic Oceanographic Laboratory, Dartmouth, N.S.

The 54 varied fields of study represented two things in common - they are interested primarily in Canada's North and they are co-ordinated and supported by staff of the Polar Continental Shelf Project.

Activities of the Division of Building Research, National Research Council of Canada in Northern Canada in 1970. ✱

General

Permafrost studies directly related to engineering and construction problems were continued at widely separated locations in northern Canada during 1970. Several major field projects were carried out in northern Manitoba with the support of the staff of the small field station maintained by the Building Research Division at Thompson, Manitoba.

Numerous requests for information and assistance on permafrost and related engineering problems were received throughout the year. Many meetings and discussions were held with persons and agencies involved in northern exploration and construction, especially those associated with development of petroleum resources in the North. Considerable time was devoted to meetings of the newly established Subcommittee on Pipeline and Land Use Technology in Northern Terrain of the NRC Associate Committee on Geotechnical Research.

Permafrost Distribution and Terrain Studies

The survey of the distribution and nature of permafrost in the vicinity of the boundary between the discontinuous and continuous permafrost zones was continued. Four fifty-foot thermocouple cables and frost gauges were installed at Yellowknife, N.W.T. Air temperature, snow cover and ground temperature observations are now being taken regularly at eight sites representing the major terrain types. Reconnaissance visits were made to Churchill, Manitoba, and to Rankin Inlet, N.W.T. in preparation for similar installations in 1971.

Ten-foot thermistor cables were installed at seven micro-wave station sites on mountain summits in southern British Columbia as part of the study of permafrost distribution in the Western Cordillera. Monthly temperature readings will be taken by station maintenance crews. Additional cables will be installed at other sites in 1971.

Investigations on the nature and distribution of permafrost in the Arctic Islands were carried out at two locations. Ground temperature measurements, including readings using a portable potentiometer, were taken on three thermocouple cables fabricated by the Division and installed, one to the 50-foot depth and two to 100 feet, at Cambridge Bay, N.W.T. The permafrost in this region is continuous,

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✱ Based on the Annual Report of the Division of Building Research, NRC, for 1970.

exceeding 1,000 feet in thickness, with an average temperature at the 50- to 100-foot depth of 12°F (-11°C).

Observations on surface features associated with permafrost and on the thickness of the active layer were carried out during a reconnaissance visit to the International Biological Programme (IBP) Canadian Tundra Biome Study Site on the north coast of Devon Island. Investigations are underway to determine the possibility of installing 50-foot thermocouple cables in the summer of 1971 in various types of terrain to measure permafrost temperatures.

A detailed examination was carried out of infra-red thermal imagery obtained in 1969 on flights over northern Manitoba in the discontinuous permafrost zone. Thermal patterns related to variations in vegetation were noticeable on the film but no direct correlation with the distribution of permafrost could be observed. A paper summarizing the results was presented at a workshop organized by the NRC National Aeronautical Establishment. No further flights are planned but developments in the use of this technique are being closely followed.

The Division participated in arrangements made by the Geological Survey of Canada to test an airborne radio phase device developed by Barringer and Company, Toronto. The objective was to determine whether ground electrical conductivity patterns obtained by this method could be related to the distribution of permafrost in the discontinuous zone. Flights were made at several locations in northern Manitoba including Thompson and Kelsey.

Investigations of micro-climate and terrain factors affecting the distribution of permafrost in the discontinuous zone were continued at Thompson, Manitoba. Weekly observations of air and ground temperatures, precipitation, snow depth and density were continued through 1970. Daily observations were taken of ground heat flow. Wind speeds were recorded at the 6-foot level throughout the year. Tests were carried out on net radiometers at each site. Integrator systems for continuous monitoring of net radiation were assembled and tested during 1970 and will be installed early in 1971. Preliminary investigations were carried out to determine the most suitable method of measuring evaporation (evapotranspiration) at the sites. A data logging system was installed to record all temperature and heat flow readings. Initial consideration was given to the possibility of automated data handling.

A preliminary aerial reconnaissance was carried out in the Kettle Lake IHD (International Hydrological Decade) water basin 100 miles northeast of Thompson, Manitoba, to select sites for installing thermocouple cables to measure permafrost ground temperatures.

Investigations continued on the freezing regime in Canadian peatlands. Two sites under observation are 1) a peat bog near Ottawa where ground freezing is entirely seasonal and 2) the terrain test site at Thompson, Manitoba, located in the middle of the discontinuous permafrost zone. Records of the freezing patterns and their geotechnical implications are being analyzed.

Permafrost Engineering

A comparison of predicted and observed thaw and settlement of the sand dyke constructed on permafrost at the Kelsey Generating Station in northern Manitoba was published. Observations of ground temperature and dyke movements are being continued at this site. Similar studies have been undertaken with Manitoba Hydro at the Kettle Generating Station further downstream on the Nelson River. Ground temperature measurements begun in 1969 at two dykes were continued and dyke movement and related observations were initiated in 1970. The reservoir was filled to summer operating level in the late fall and two water temperature recorders were installed near one of the instrumented dykes.

Contact was maintained and assistance given in a co-operative study with the federal Department of Public Works of a buried water supply line at Churchill, Manitoba. Ground temperatures and water flow and temperatures were monitored regularly at several locations along the line to assess changes in the ground thermal regime and the performance of the pipeline. A general investigation into the hydraulic, thermal and structural aspects of hot (oil) pipelines in permafrost was undertaken to assist in identifying the more important geotechnical problems associated with pipelines in northern Canada. Laboratory investigations of the thaw-settlement characteristics of frozen soils are being planned, and the development of equipment and procedures for the measurement of soil thermal conductivity both in situ and in the laboratory and other thermal properties of frozen soils has begun.

Studies to assess the performance of several structures at Inuvik, N.W.T., that are supported by pile foundations or placed on a duct ventilated gravel pad were continued. Ground temperatures were measured regularly and surveys were conducted in the spring and the fall to detect any foundation movements that may have occurred. Observations were continued at the Inuvik airstrip which was paved

in 1969. Ground temperatures and heat flow were recorded continuously at shallow depths under the paved taxiway and the adjacent crushed rock shoulder. Ground temperatures were also measured weekly at several locations under the runway and adjacent shoulder and at a nearby undisturbed site. No significant change in the ground thermal regime under the runway has been observed in the year since the crushed rock fill was paved.

A field study of anchors in permafrost, begun in 1967, was completed during the summer when the last of a series of anchors installed at a test site at Thompson were tested. This study was undertaken by this Division to obtain information on the resistance of frozen soils to uplift forces, a factor that must be evaluated in the design of anchors for guyed structures in permafrost. An initial appraisal of various kinds of anchors suggested that grouted rod and power-installed screw anchors were the most promising types and should be investigated. Early in 1967 several of each of these two types of anchors were installed in permafrost at Thompson and at Gillam, Manitoba. The test sites were underlain by frozen stratified clays and silts (varved clays) containing ice lenses ranging from hairline to three inches thick. The mean ground temperature was about 31°F and the materials were frozen to depths greater than 30 feet. The grouted anchors (a duplicate set of 9 at each site) consist of cylinders approximately 10-ft. long placed by backfilling a 6-inch diameter drilled hole with a cement-sand mix. The top of the grout cylinder varied from 5 to 14 feet below the ground surface. The screw anchors (12 at Thompson and 5 at Gillam) are single and double helix, varying in diameter from 8 to 15 inches, and were screwed into the frozen ground to depths of from 8 to 20 feet by truck-mounted power equipment. Testing of the anchors was carried out to determine the creep characteristics and capacities. Uplift loads up to 40 tons were applied using special test frames and hydraulic jacks, calibrated "box car" springs or cantilever beams. Some anchors were subjected to constant loads for periods varying from several hours to more than one year. Others were "stage loaded", i.e., loads were applied in 2- or 5-kip increments, each load increment being maintained for periods varying from $\frac{1}{2}$ hour to 20 hours. After testing, many of the anchors were excavated to observe the deformations that had occurred and to assess the mode of failure in situ.

An analytical theory has been developed to solve the complex problems of time dependent deformation (creep) and long term strength of frozen soils associated with the bearing capacity of buried footings and anchors.

Mammal Research Activities in the Arctic, 1970-71, by C.J. Jonkel, Canadian Wildlife Service, Eastern Region, Ottawa

Caribou

Research on the caribou of the Keewatin mainland, carried out during the summer of 1970 by the Canadian Wildlife Service, included a continuation of the range studies by D. Miller and a study of the causes of calf mortality by F.L. Miller. Statistical analyses and writing up of data collected during the major three-year study of the Kaminuriak herd continued.

The range work of D. Miller was centered in the forest and taiga along the Manitoba-Keewatin border. Problems yet to be resolved include the refinement of precise techniques for studying different types of caribou range, the proper statistical treatment of data, the role of fires in different mainland caribou habitats, a complete vegetative analysis of winter ranges, determination of the importance of mainland barren-grounds to wintering caribou, and definition of the prductivity of caribou winter ranges.

Additional problems suggested by the studies of F.L. Miller and other members of the Caribou Project include the intriguing questions of whether post-calving mortality is the real limiting factor in caribou populations, whether hunting pressure by wolves and man have greater effects on caribou numbers than heretofore suspected, and what long-term changes in caribou numbers and behaviour can be expected from economic developments within caribou ranges such as the growth of population centres and the building of pipelines. Studies of these problems must await increased funding.

Vegetative analyses of potential caribou ranges on Southampton Island were initiated in 1970 by G.R. Parker. A small group of caribou from the insular Coats Island population was introduced to Southampton Island in 1967 and has apparently become established. Range studies on Southampton Island will be continued in 1971 so that basic range data can be assembled before the caribou become abundant there. These data may provide the information necessary to prevent extermination of the eventual herd as occurred several decades ago. Mr. Parker may also begin a preliminary study of the unique Coats Island caribou.

Peary Caribou

Peary caribou on islands in the High Arctic have been neglected by both game managers and scientists. Study of the Peary caribou has been

limited to that done by J. Tener who noted its distribution and productivity during his studies of muskoxen in the early 1960's. D. Pimlott's research group from the University of Toronto has done some work (unpublished) on the Baffin form of barren ground caribou in Central Baffin. Otherwise the island forms of caribou remain almost totally unstudied. Preliminary range work, marking animals of known-age, and locating seasonal aggregations will begin in 1971, but a major research effort in 1972 and subsequent years is possible only if other government field parties, company exploration teams, university groups, and inhabitants of the various settlements help by providing information necessary for planning such work. Notes on distribution and numbers, and biological specimens such as jaws and reproductive tracts (with data), are especially needed.

Muskoxen

During 1970, the Canadian Wildlife Service supported muskoxen studies undertaken by university students on Bathurst and Devon Island.

C. Jonkel in cooperation with D. Gray of the University of Alberta, made preliminary attempts to capture and mark muskoxen on Bathurst Island. Six animals, immobilized by shooting drugs into them from a helicopter, were marked and released. On the ground, Gray marked additional animals, by means of a "paint pistol". His studies of muskox behaviour are nearly completed.

Additional muskoxen will be captured and marked on Bathurst and Devon Islands in 1971 and will, by the selection of young animals, provide marked, known-age animals for long-term Canadian Wildlife Service studies. This work will again provide support for Gray's studies and a similar project will be initiated on Devon Island by B. Hubert of the University of Manitoba. Radio transmitters placed on certain muskoxen will permit the animals to be monitored and tracked by the two students. If an appropriate site can be selected this year for studies on muskox/Peary caribou/arctic wolf relationships, additional muskoxen in the area will be marked to provide animals of known-age for future research. Preliminary studies of both summer and winter ranges of muskox and Peary caribou will also be initiated in 1971 to help in the planning of future Canadian Wildlife Service research. The rapid pace of petroleum exploration and economic development in the high arctic sedimentary basin has caught biological researchers unprepared, and increased staff and budgets are urgently needed by the several agencies conducting biological research there.

Polar Bears

Research on polar bears began in February 1970 with a 1½ month productivity study, carried out in co-operation with the Manitoba Wildlife Branch, of the Owl River-Broad River maternity denning area along the Manitoba coast of Hudson Bay. Data on the numbers of bears, litter sizes, behaviour and winter den construction were gathered.

During late April and early May, 18 bears were marked in the Lancaster Sound-Barrow Strait area, and data were recorded on the hunting habits, movements, food habits, and denning areas.

During 1970 bears of known-ages were recaptured in the Hudson Bay-James Bay areas. Sixty-two bears were captured or recaptured during a two week period on Cape Churchill, and 25 during summer and autumn in James Bay. The Manitoba-Ontario coast was searched in September for marked bears and 14 were captured or recaptured. During September, additional studies of the summer denning habits or polar bears south of Cape Churchill revealed a close relationship between active dens and permafrost. Brian Knudsen, a Ph.D. candidate, continued behavioral research on the polar bears of North Twin Island, James Bay from July through October, 1970. The comparative study of the food habits of island and coastal polar bears by Richard Russell, an M. Sc. candidate, is near completion.

Field work on polar bear maternity denning areas is planned for March and April 1971. I. Stirling will capture bears, locate denning areas, and calculate the productivity of denning areas in the Beaufort Sea-Banks Island area. R. Robertson of the Manitoba Wildlife Branch and C. Jonkel will again calculate the productivity of the denning area south of Cape Churchill; and H. Kiliaan will search for dens and record information on the productivity of Devon Island. Capture and recapture of bears across the High Arctic from the Beaufort Sea to Baffin Bay, and gathering of information on bear movements, growth rates, and population characteristics, will take place in April and May.

Summer and autumn studies will include additional behavioral and physiological studies in the summer-autumn denning area along the Manitoba coast, population studies based on marked bears in western Hudson Bay and the High Arctic, and behavioral studies of marked bears in James Bay. A search of islands in eastern Hudson Bay will be conducted to locate tagged bears which may have dispersed from the Manitoba-Ontario shore. Collections of specimens from bears killed by hunters

will be continued through 27 Indian and Eskimo assistants in the various arctic and sub-arctic settlements.

Barren-ground Grizzly Bears

A new project on barren-ground grizzly bears in 1971 will be restricted to the assembling of published and unpublished data from Canadian Wildlife Service files. I. Stirling may extend his field studies of polar bears on the western arctic mainland to preliminary field work on available barren-ground grizzlies.

Arctic Wolf Studies

The arctic wolf project will also be restricted in 1971 to assembling published and unpublished data from Canadian Wildlife Service files. A major arctic wolf project on Baffin Island supported by CWS and the University of Toronto will be examined for the applicability of its results to high arctic areas and its game management value in mainland areas.

REVIEW OF DRILLING IN THE ARCTIC ISLANDS

by

Oil and Gas Section,
Department of Indian Affairs and Northern Development

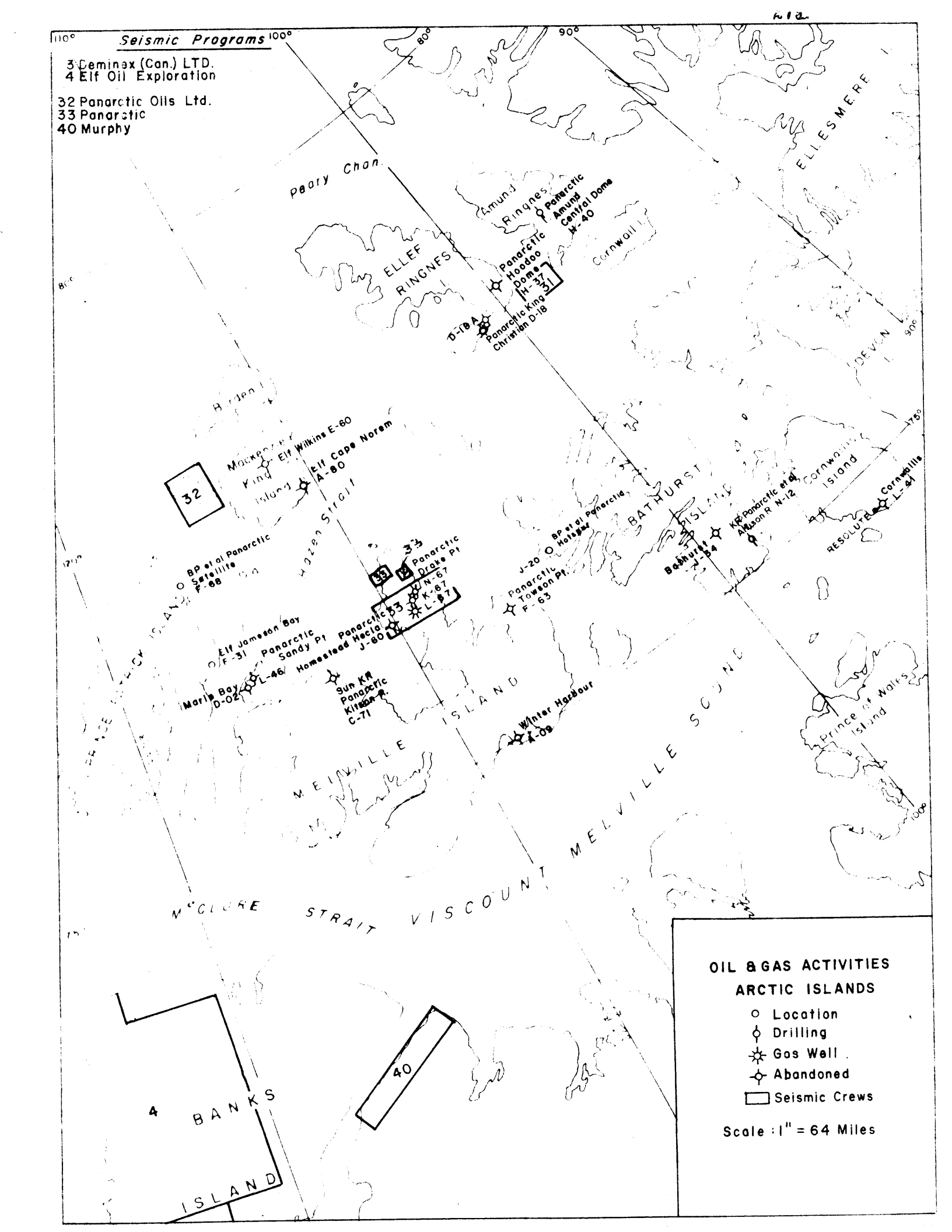
Wildcatting in the Arctic Islands began in 1961, when Dome Petroleum Ltd. of Calgary transported a drilling rig to Winter Harbour on Melville Island. Since then a total of 13 wells have been completed or abandoned. The following is a summary of the wells that have completed drilling to date.

Name of Well	Date Spudded	Date Completed	Total Depth
Dome et al., Winter Harbour A-09	10-9-61	24-3-62	12,543
Lobitos et al., Cornwallis, Resolute Bay L-41	4-9-63	15-12-63	4,840
Dome Explorers et al., Bathurst Caledonian R J-34	24-9-63	19-2-64	10,000
Panarctic, Marie Bay D-02	13-8-69	24-9-69	4,175
Panarctic, Sandy Point L-46	12-5-69	2-8-69	6,895
Panarctic, Drake Point L-67	22-9-69	26-2-70	10,671
Panarctic, Drake Point N-67	14-4-69	9-11-70	8,454
Panarctic, Drake Point K-67	19-7-70	9-11-70	3,198
Panarctic, Hecla J-60	31-5-70	16-9-70	11,865

Name of Well	Date Spudded	Date Completed	Total Depth
Panarctic, Hoodoo Dome H-37	20-12-69	17-8-70	11,072
Panarctic, Towson Point F-63	23-3-70	16-6-70	5,123
Elf, Cape Norem A-80	20-4-70	21-8-70	9,744
Elf, Wilkins E-60	11-10-70	20-1-71	11,140

Locations of the above wells are plotted on the map following this page.

In future Arctic Circulars the status of the current drilling programs and the results of the exploratory drilling to date will be discussed.


Seismic Programs
3 Ceminex (Can.) LTD.
4 Elf Oil Exploration
32 Panarctic Oils Ltd.
33 Panarctic
40 Murphy
110°
100°
90°
80°
Peary Chan.
ELLESMERE I.
Amund Ringnes I.
Panarctic Amund Central Dome K-40
ELLEF RINGNES I.
Cornwall I.
Panarctic Hoodoo Dome H-37
31
D-18A
Panarctic King Christian D-18
DEVON I.
Borden I.
Mackenzie King Island
Elf Wilkins E-60
Elf Cape Norem A-80
32
BP et al Panarctic Satellite F-68
Hazen Strait
33
Panarctic Drake Pt. N-67
K-67
L-67
Elf Jameson Bay F-31
Panarctic Sandy Pt. L-46
Panarctic Homestead Hecla J-60
Marie Bay D-02
Sun KR Panarctic Kitson C-71
BP et al Panarctic Hotspur J-20
Panarctic Towson Pt. F-63
BATHURST ISLAND
KR Panarctic et al Allison R N-12
Bathurst J-54
Cornwallis Island
Cornwallis L-41
RESOLUTE
Winter Harbour A-09
MELVILLE ISLAND
Prince of Wales Island
M'CLURE STRAIT
VISCOUNT MELVILLE SOUND
75°
100°
4
BANKS ISLAND
40
OIL & GAS ACTIVITIES
ARCTIC ISLANDS
Location
Drilling
Gas Well
Abandoned
Seismic Crews
Scale : 1" = 64 Miles

OIL SPILL AT DECEPTION BAY, HUDSON STRAIT
(preliminary report)

by

René O. Ramseier
Glaciology Subdivision, Inland Waters Branch, Dept. of Fisheries & Forestry

The following is a brief account of on-site investigations made June 12-19 and June 24-27, 1970.

The author was responsible for on-site research and laboratory follow-up to determine the cause of an oil spill at Deception Bay, to observe the movement and distribution of the oil, the effect of oil on ice, permafrost and water, and to evaluate methods of clean-up and disposal. He was fully responsible for the research program but acted only in an advisory capacity on clean-up and disposal. Most of the work was carried out by R. Bergeron, L. Colby, G. Gantcheff, and the author, assisted for part of the time by J. Code, W. Hoek, and C. Phillips. Mr. F. Barber was the on-the-scene coordinator for the federal team.

Location

The oil spill occurred at Deception Bay, west of Ungava Bay, on Hudson Strait. The distance across the bay is about 7,400 feet and high tide averages about 12 feet. An air strip, base camp, and tank farm, separated from each other by approximately three miles, are located on the southwestern shore of the bay. The tank farm, consisting of six tanks (total capacity 1,348,000 gallons) and a dispensing area, was situated 400 feet from the shore at an elevation of 60 feet, and was above a small delta that was in line with a major gully.

Cause of the spill

A slush avalanche destroyed the tank farm on June 6, the date being deduced from study of the local meteorological conditions. The accident was not known to those at the camp until June 8, when the news was brought by an Eskimo party.

Extent of damage and amount of oil spilled

Tank No. 1 was swept down the man-made embankment and out onto the sea ice; Tank No. 2 was split open; Tanks Nos. 4 and 5 came to rest at the bottom of the embankment; Tank No. 6 was punctured by rocks and bent out of shape. Tank No. 3, containing gasoline, was undamaged. About seven feet of snow were piled up in front of Tanks Nos. 3 and 6.

The entire distribution centre, which was located below the tanks, was also swept onto the shore-fast ice and the sea ice.

According to company estimates, the total spill was approximately 427,000 gallons, consisting of 369,000 gallons of arctic diesel oil and 58,000 gallons of gasoline.

Distribution of the oil

The oil and gasoline were spilled down the embankment and onto the shore-fast ice that extends from the shore to the tidal-crack network of elongated puddles and leads. Due to wind conditions prevailing at the time of the incident and for most of the days following, as well as to the temporary blocking of the tidal crack by the snow of the avalanche, the oil accumulated almost entirely to the southwest of the site of the spill, that is, for about 2,700 feet along the coast toward the camp.

The major forces affecting the movement of the oil are wind, tidal action, gravity and the area in which they act. Based on consideration of all these factors, the oil budget was as follows:

Oil distribution in puddles - Due to the prevailing westerly winds, the oil was driven from the spill site and along the tidal cracks, and accumulated in pre-existing puddles on top of the ice. The puddles acted as natural containers, particularly at low tide. High tide gave more mobility to the wind driven oil since more cracks and passages became flooded. The estimated quantity of oil in visible puddles was 37,000 gallons. The length, width and depth of these pools could be easily measured.

Oil distributed along the tidal-crack network in puddles under the ice - These puddles were visible only when the surface ice was broken away or when one looked underneath the ice from a prone position. The quantity of oil estimated here was 37,000 gallons, based on the area of the puddles thus exposed.

Oil under the shore-fast ice - The quantity of oil retained under the ice was difficult to estimate as it was in constant motion due to the tide. Large man-sized caverns entirely contaminated by oil were observed in this area. Estimated quantity - 120,000 gallons.

Oil in shore-fast ice - Due to the rising and falling water level, oil penetrated the pores of the shore ice, which resembled porous snow ice. By drilling holes to a depth of three feet, water and oil would accumulate in the hole and from this an estimate of the quantity of oil contained in the porous structure could be made. Estimated quantity - 33,000 gallons.

Oil in snow and fill at spill site - Several holes were drilled and pits were dug in this area. The quantitative estimate of oil present was based on the thickness of the overlying snow on the permafrost and the amount of oil collected in the depressions. Estimated quantity - 24,000 gallons.

Oil on top of sea ice - Due to strong winds, some oil was blown out of puddles and driven across the sea ice, almost reaching the opposite shore. Subsequently, the wind changed to a northeast direction, that is, blowing toward the camp. The amount of oil involved is small but no estimate will be available until final calculations are completed.

Oil lost due to evaporation - It is assumed that most of the gasoline directly exposed to the atmosphere evaporated, as did also some of the lighter fractions of the diesel oil. An estimate of the amount lost by evaporation will be available when present laboratory tests are complete. Tentative estimate - 74,000 gallons.

Oil under the sea ice - calculations not yet complete.

The estimated totals account for 325,000 gallons, about 100,000 gallons short of the estimated spill. These figures may be revised after further study.

Discussion

According to the classical concepts of a snow avalanche, this site should not have presented any avalanche danger, the slope being too small - only about 17 degrees in the upper part of the gully and levelling to about 6 degrees midway down. The walls of the gully provide a good footing for the accumulated blown snow. The snow depth at the head of the gully, six days after the spill, was about 20 or 22 feet near the fracture line. The very gentle slope of the ground immediately above the gully was completely snow free.

A small gully collects meltwater from a large area and channels it into the steeper major gully.

From observations made June 12-13 and from study of the meteorological record, the following situation seems to have existed prior to, on, and after June 6:

Air temperatures on June 4 and June 5 were 42° F and 43° F respectively, and reached a maximum of 49.5° F on June 6. The wind was light on the preceding days, with speeds varying between 3 and 6 mph. On June 6, the wind was south and southwest at 70 mph, gusting to 80 mph - conditions that prevailed from 0900 to 1400 hours. On June 7 and 8, conditions returned to normal with daytime temperatures between 34° F and 37° F and wind speeds of 23 to 26 mph.

As is very common in these regions, the gully was filled with blown snow and the small stream under the snow was frozen. From the meteorological conditions just described, it would seem that unusually large quantities of metlwater were present and were driven by the very strong winds into the snow-filled gully. It was noted that vegetation above the gully had been flattened toward the northeast by a movement of the snow that had previously lain there and/or by the meltwater as it came rushing down. This large quantity of meltwater was partially absorbed by the snow in the gully, causing an increasing stress in the snow field. At sometime on June 6, possibly between 1200 and 1400 hours, the presence of water caused a failure in the snow field near the top of the gully. The fracture zone consisted of an exposed 8-foot snow wall, circular in form.

This 8-foot snow slab broke loose, riding on top of the snow for about 200 feet, after which it took up the underlying snow right down to the ground. Because of the large amount of water present, the snow slab was well lubricated and picked up large boulders - some as much as four feet in size - on its way down the gully. A small earthen dam in front of the tank farm retained some of the avalanching snow and slush, but the greater amount of snow, water and rocks continued on in the direction of the tank farm completely destroying four of the six tanks of arctic diesel oil and gasoline and puncturing a fifth with rocks. The slush avalanche came to rest on the sea ice, carrying with it one large tank (Tank No. 1).

The effect of the oil on the ice

The oil did not affect the ice except for dissolving an extremely small quantity. From the author's previous work with snow/oil systems, this is what he would have expected. The oil easily penetrated the surface layers of the sea ice to a depth of four or five inches, or until the water table was reached. It also penetrated the shore-fast ice, which is porous but resembles snow ice or high density snow in texture.

Such melting as occurred resulted from the change of albedo, causing puddles to increase in area and depth. However, as compared to puddles affected by organic matter blown from the surrounding land and to the discolouration of the water due to algae and other biological matter, this melting was not much above the normal amount.

It was also observed that, during a cold night, a primary ice layer could grow at the water/oil interface in a bore hole.

Methods for disposal of the oil

Suggestions came from many quarters on how to dispose of the reclaimed oil. The methods of disposal (clean up) are listed in terms of the least amount of contamination:

i) - Removal of oil by pumping, using an oil skimmer
ii) - Burning
iii) - Evaporation
iv) - Doing nothing
v) - A combination of these ideas

i) Removing the oil from the water surface could have been easily achieved by the use of oil skimmers. The problem was then what to do with the reclaimed oil. There was no facility big enough to store it. Several ways of disposal were discussed: a) spraying the road system, b) burning the garbage, c) using the oil for the heating system, d) burning the oil in a gravel pit. All these possibilities were appropriate, except d). A careful selection of the site would be necessary to prevent the oil spreading on top of the permafrost table and out onto the tundra.

ii) Burning the oil had great appeal because areas not accessible to pumping could be cleared by burning. Test burns, made under conditions of complete calm as well as

during 35 mph winds, showed that the fire could be well contained by the ice depressions and that the wind acted as an effective barrier to keep the fire offshore.

iii) Disposal of the oil by evaporation was seriously considered and unanimously rejected for two reasons:

a) information on the evaporation rates of arctic diesel oil were not known to those at the site and were unobtainable in the circumstances; and

b) most of the oil that would be pumped into the sea ice for evaporation would be absorbed into the top four or five inches of porous surface ice.

iv) Since the ice acted as an excellent barrier to contain the oil and since economically-attractive clean-up methods were available, the suggestion to do nothing and leave the oil where it lay was considered unacceptable. Further discussion of this solution will be included in the final report after more specific results from the analysis of samples have become available.

After consideration of all the suggested means of disposal, the federal co-ordinator, Mr. Barber, decided in favour of burning.

Final Report

A final report, prepared jointly by R.O. Ramseier, G.S. Gantscheff, L. Colby, will be available when results of the laboratory research are completed. Most of the points to be considered have been touched on in this preliminary report, but additional aspects that will be considered include:

- analysis of ice and water samples taken from boreholes;
- infrared scanning flight;
- recommendations for coping with other such occurrences;
- proposals for future research programs in both field and laboratory.

EXTINGUISHING THE GAS-WELL FIRE ON KING CHRISTIAN ISLAND

On January 24, 1971, the fire which had been burning out of control in the gas well on King Christian Island since October 1970, was extinguished. An account of how this was accomplished is here reprinted with permission of the Financial Post in whose issue of February 13, 1971, this report by W.L. Dack first appeared.

INUVIK - Successful capping of the wild burning gas well on King Christian Island in the high Arctic must go down as one of the most remarkable feats in oil exploration history.

Although the capping of wild gas and oil wells has become a fairly common occurrence in recent years, a combination of unusual conditions made the Arctic "kill" a very special operation.

The well, drilled by Panarctic Oils Ltd., caught fire when it went out of control on Oct. 24.

It had been burning continually, with flames shooting 250 feet in the air.

The intense heat generated and the smaller fires that broke out around the well, from the gas escapes through fractures, kept the wild-well fighters at a respectful distance.

The closest a directional relief well to quench the flames could comfortably be spotted was 700 feet away.

The whole operation was completed during the period of 24-hour Arctic nights.

Temperatures ranged from -25 degrees F to -45 degrees F.

Through a good part of the operation, blizzards gusted wind and snow up to 65 miles an hour. On returning to camp men found the pockets of their tightly zippered parkas filled with granulated snow.

Panarctic president, Charles Hetherington, on the spot for the kill, walked right past the well-lighted entrance to the camp without seeing it or hearing the camp generator, usually audible for several hundred yards. He eventually realized his mistake and groped his way back.

A Hefty Hurdle

The success of the undertaking became a great deal more than the assembling of special personnel and equipment on this tiny, remote Arctic Island - and this was a hefty hurdle in itself since all had to be moved in by aircraft under unpredictable and difficult flying conditions.

The challenge was to keep the men and equipment operating at all.

Briefly, the plan was to pump Arctic sea water into a relief well, which was drilled on an angle to meet the wild well at a vertical depth of 1,945 feet (see diagram).

By forcing huge quantities of the water, under heavy pressure, into the bore hole of the wild well, the operation planners hoped to snuff out the flaming gas.

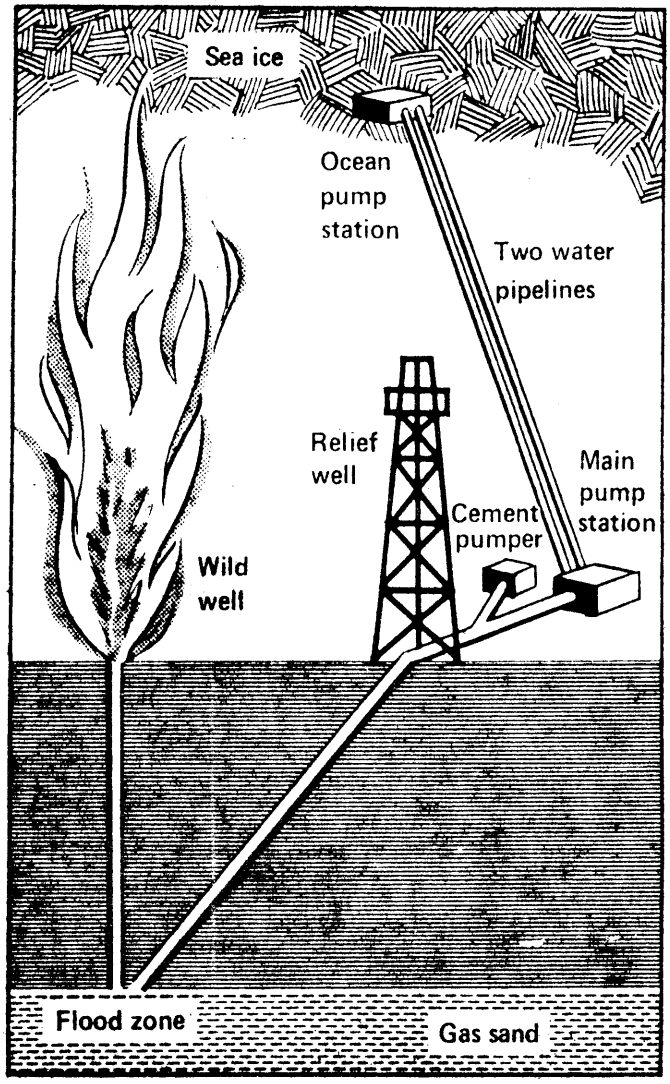
But the success of the venture depended heavily on overcoming two major difficulties:

- The successful piping of large quantities of extremely cold Arctic water over a distance of $1\frac{1}{2}$ miles to the relief-well site and then forcing it down the well under very heavy pressures.

Despite the considerable amount of Arctic drilling already accomplished in Canada and Russia, there was little scientific data available on this type of operation.

- The ability, in drilling the relief well, to hit a 25-foot target area at the prescribed depth. This was all the leeway that could be given the drillers if the bore hole was to establish the necessary ventilation into the wild well bore at the prescribed penetration of some 15 feet into the gas producing zone.

Suction holes for the ocean pumps were drilled through five feet of ocean ice. But it was found that the weight of the pumps and a large hot water tank located nearby caused the ice to sink about two feet, flooding the pumps. Operations were delayed while the hot water tank was moved closer to shore.


Sea ice
Ocean pump station
Two water pipelines
Relief well
Main pump station
Cement pumper
Wild well
Flood zone
Gas sand

Series of Setbacks

When all was ready on Tuesday, Jan. 19, the first of a series of discouraging setbacks slowed the operation.

A severe blizzard diverted the Electra aircraft carrying Canada's wild-well expert, "Tip" Moroney, and the Haliburton Oil Well Drilling Co. pump operators to a small landing strip on Amund Ringnes Island.

It was only possible to make one Twin Otter trip to bring in Moroney and some 10 of the pumpers before the blizzard stopped all flying.

A decision had to be made whether to delay the "kill" or proceed under the blizzard conditions.

The whole operation had been well organized and rehearsed. All the equipment was ready. The low-pressure pump station on the ice was manned, as was the high-pressure station near the site of the relief well.

A mixing tank for the mud that was to be forced down the hole at a later stage in the operation was prepared near the well site.

The whole operation was to be directed by Jim Strain, Panarctic vice-president, operations, from a Bombardier Ltd. tracked vehicle. All communication was by radio.

The decision was to go ahead as planned, despite the weather. First move was to test the water flow in the small lines from the ice holes to the sump near the relief-well site. Sea water freezes at about 27 degrees F, and the water below the ice was 28 degrees F. First pumping attempts were made with the water heated to 180 degrees and, although the water arrived at the sump some $1\frac{1}{2}$ miles away free of ice or slush, a large leak developed at one location.

It was discovered that the hot water had expanded the line so that it moved a couple of feet at each end. This damaged a flange which, in turn, produced a leak. Operations had to be stopped while the line was drained and then plugged with alcohol. Working in the dark and in the blizzard, it took the operators six hours to repair the leak.

Problem Licked

Over the next two days, the same thing was to happen five times at different locations. With experience, the repair time was reduced sharply and water temperatures were gradually lowered. By Friday, Jan. 22, water circulation was established with water at a temperature of 35 degrees.

With this water problem licked, the signal was given to drill out the last small section of the relief well to hit the target area.

Then tension mounted.

Was the hole on target? A Dowell high-pressure cementer was used to inject some salt water at a relatively slow rate into the well. Before the pressure reached 1,000 pounds per square inch (psi), circulation was established and mud and water appeared in the wild well.

Two critical operations had now functioned properly. At about the same time the blizzard subsided and the temperature dropped to -45 degrees.

At eight p.m. on Saturday, Jan. 23, a start was made on the key killing operation. Sea water was pumped into the small pipelines to the main pump station which, in turn, started pumping the water down the relief well. The pumping rate - using eight pumps - gradually increased from 10 to 117 barrels per minute at a pressure of 700 psi. After one nervous moment the water roared out of the wild well blowing to a height of 250 feet. But it did not stop the burning gas.

The heat of the burning gas vaporized all of the water so that not a drop of liquid reached the ground. Instead, the steam encountering the -40 degrees temperature condensed into salt water snow which, in turn, created three-foot drifts around the well.

For hours nothing seemed to change. Spirits dropped. At three a.m. Sunday morning, many of the operators wearily went to bed and a standby crew kept the water flood operation in full force.

Rushed Out of Bed

At six a.m. Sunday the camp was awakened by the wild shout of drilling superintendent Alan Gates: "She's out, she's out!"

Drillers rushed out of bed to confirm the miracle. The flames had gone and the sea water was now blowing out of the wild well in a solid stream of water.

Pumping was continued until eight a.m. In 10 hours a total of 50,000 barrels of water had been pumped down the well.

Next, heavy mud of 14.8 pounds per gallon was pumped for about 30 minutes. To double-check the effectiveness of the "kill", the pumping of the mud was then stopped whereupon the mud flow out of the formerly wild well also stopped. When pumping recommenced the mud flow would also recommence.

With this reassurance, the well was cemented with 2,000 sacks of cement. Killing was officially complete at 11.05 a.m. Jan. 24, three months from the date of the blowout.

The subsidiary fires burning from fractures in the permafrost mostly went out during the water flooding operation. Finally, all of the gas bled out of these fractures and the small fires died. The fractures filled with mud and water and froze to their original state.

Although Panarctic officials have not disclosed the total cost of the wild well "kill", Hetherington said it is within the $2 million cost covered by insurance.

Equipment used to kill and plug the well is being flown out by Hercules aircraft. Panarctic, the operating company, is preparing to deepen the relief well to find the thickness of the producing sand zone and what is under it - water, oil or non-productive rock. Canadian oil and gas industry officials and particularly the 19 industry partners of the Panarctic consortium are eagerly waiting for the answer.

EXPEDITIONS

Monzino Polar Expedition

An adventurous Italian, Guido Monzino, has already made his mark as a world traveller. Patagonia, Sahara, Himalaya, and the jungles of the Amazon have all revealed their secrets to him, and in turn he has captured their beauty, their primitiveness and their isolation in a series of illustrated books.

For the past two years he has set his sights on the North Pole, and not necessarily in the manner of the modern explorer, that is by aeroplane or snowmobile. He has decided that he will simulate the manner in which Peary did it in 1909, by dog-team. Guido Monzino, through his Danish friends, had heard of the wonderful sleigh dogs of Quanak, a Greenland Eskimo village north of Thule. During the winter of 1969-70, he went to Quanak and by dog-team set out for Cape Columbia, the northernmost point on Ellesmere Island, N.W.T. It was from here that Peary made his dash to the Pole, and while there is considerable doubt as to whether Peary achieved his objective, since little or no proof was supplied, the U.S. Congress believed he had done so and gave Peary the satisfaction that it, at least, believed him.

Since 1909, no one has travelled to the North Pole by dogs, and there have been several attempts. In recent years, Bjorn Staib, a Norwegian, attempted and failed - in 1964. Staib and his team planned to ski across the Arctic ice to the Pole. Dogged by bad luck and the death of their radio-operator, the expedition was forced to abandon its attempt. The next attempt was by Plaisted, an American who discarded dogs and skis for the motor toboggan; he failed in 1968 but tried again in 1969 when he finally reached the Pole. By this time, the Arctic ice was becoming cluttered with polar expeditions. A Dr. and Mrs. Simpson, a couple who had previously crossed the Greenland Ice Cap on skis, attempted to do just that from Ellesmere Island to the Pole. Together with a third person, they pulled a sleigh with 45 days supplies, this being the time allotted for an 800-mile return trip, Ward Hunt Island to the Pole and return. They hardly reached a point 20 miles from land when both Dr. and Mrs. Simpson went through the ice and lost their only means of communication with the outside, a hand-cranked radio transmitter. Prudence taught them to return to safety. An Australian, Humphries, with three companions made an attempt but ended up at Cape Morris Jessup on Greenland. The successful epic was the expedition led by

(1968-69)

Wally Herbert and three companions who took over 18 months/to walk from Cape Barrow in Alaska to Spitzbergen via the Pole. With considerable help from the Canadian Forces Hercules aircraft which made periodic airdrops of food and supplies, Herbert was able to sustain a steady pace over a year and a half.

Now an Italian, with 25 Greenland Eskimo dog drivers and 10 Italian and Danish explorers with 300 dogs, is preparing for an assault over the polar ice to the Pole in 1971. The massive logistical operations involving one Hercules aircraft, one twin Otter, an Armed Forces Argus surveillance aircraft, 70 tons of dog food and 20 tons of pemmican, make this one of the biggest attempts to conquer the Pole in the history of polar exploration. At the moment of writing this narrative, a base camp is being set up at Cape Columbia. Supplies which arrived at Thule, Greenland from Copenhagen are being ferried to Alert, N.W.T. From Alert, the dog drivers are taking sleigh loads overland to Cape Columbia. Moving some 90 tons of supplies by dog sleigh is a big job and Signor Monzino will not be satisfied until the job is completed. Only then will be begin to make his trip over the pack ice to the Pole. Navigational aids to the expedition will be supplied by Canadian Forces "Argus" aircraft by regular flights over the pack ice. Information concerning open leads and pressure ridges will be relayed from the aircraft to the ground party.

However, with the sun ever present in the heavens, and water appearing on the ice, the sleighs will have to move quickly to reach the Pole before the entire ice pack begins to disintegrate. These are some of the hazards confronting the expedition. If they achieve their objectives, they can thank their efforts to the detailed planning which has been going on for over a year. Should they fail, they join the company of so many before them who have tried without success.

L.A.C.O. Hunt

Tokyo University Canadian Arctic Research Expedition (TUCARE)

This project has been planned, organized and managed by the Tokyo University Arctic Committee * of which Professor Atsuuji Ashikaga, President of the University, is Chairman. Although backed by the University, the Nihon Keizai Shimbua and the Japan Polar Research Association, the character of the program remains essentially that of a student club undertaking. It is intended that an expedition of from three to six members will be sent to the Canadian Arctic each year from 1970 to 1975.

The project aims
- to develop a group of students well experienced in living, travelling and surveying in arctic regions by learning from Canada's northern peoples and explorers;
- to carry out scientific programs in geography, geophysics, ecology, ocean sciences, meteorology and cultural anthropology;
- to undertake certain expeditions of adventure.

The 1970 TUCARE expedition (TUCARE '70-'71) consists of two parties. The advance party and their equipment arrived at Tacoma, Washington, U.S.A., in early June and reached Cambridge Bay, N.W.T. in early August to prepare for field surveys at Cambridge Bay and at other northern points along the way. The second or follow-up party landed at Vancouver in late August and reached Cambridge Bay in early September.

The members of the expedition are:

Chiharu Miyamoto (33 years of age), expedition leader, a staff member of a private company's institute on tourism, editor of a graphic travel magazine, member of the Japanese Alpine Club, and a student of cultural anthropology. He was one of the advance party which arrived at Tacoma in early June.

Tetsushi Isono (21 years of age), deputy leader of the advance party, a student of earth magnetism at Tokyo University.

Norihian Kaido (21 years of age), assistant leader of the expedition, a student of city planning and civil engineering at

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* The address of the Committee is
c/o Department of Aeronautics and Space Engineering,
Faculty of Engineering,
Tokyo University,
1117 Kitakanamo, Hiratpuka, Kanagawa, Japan

Tokyo University. He was one of the follow-up party that arrived at Vancouver in early September.

Fujio Nishi (21 years of age), who arrived with the advance party, is studying metal engineering at Tokyo University.

Toshiaki Kasuga (22 years of age), a member of the follow-up party and the photographer of the expedition. He is a student of industrial engineering at Tokyo University.

Funds for TUCARE '70-'71 were about $16,000 (Canadian) of which $7,000 had been raised by the members of the expedition and the University. The remainder was raised from citizens and private companies through efforts of the Committee. Expenses included $9,000 spent in Japan for preparations, insurance and equipment, and for transportation of the expedition members and their gear to and from Canada. The amount of $1,200 had been set aside to cover the costs of publishing the report and developing the films in Japan. A further $5,800 was brought by the expedition to cover expenses while in Canada.

The program for TUCARE '70-'71, which can be altered to adapt to the conditions actually encountered, is as follows:

Victoria Island Party

From early October to late November, Miyamoto and Isono are to travel by ski and sledge along the southern coast of Victoria Island from Cambridge Bay to Wollaston Peninsula surveying earth magnetism. In preparation for this trip, several food depots are to be established along the northern coasts of Dease Strait and Coronation Gulf by chartered boat or airplane. On completion of this trip, Miyamoto and Isono will return to Cambridge Bay, remaining there until the beginning of the year to observe the pattern of community life in winter. Isono will then leave for Vancouver and return to Japan by ship. Miyamoto will proceed to Norman Wells to join the second TUCARE '70-'71 party which should have arrived there by then.

Mackenzie River Party

In late September, after helping to establish the food depots, Kaido, Kasuga and Nishi will leave Cambridge Bay for Tuktoyaktuk

and will ski and sledge along the Mackenzie River to reach Norman Wells by the beginning of the year. Along the way they will study special problems of community planning, civil engineering and man power in the North. Kasuga and Nishi will then proceed to Vancouver and join Isono on the return trip to Japan.

Miyamoto and Kaido are to continue on skis to Yellowknife, arriving there in late March or early April. From there they will go to Vancouver and return to Japan by ship.

The Polar Research Center of Japan, Change of Address

The Japanese Polar Research Center (formerly the Department of Polar Research or Polar Section) has moved from the National Science Museum at Ueno Park, Tokyo to a new office. The address is now:

Polar Research Center,
National Science Museum,
Kaga 1-9-10, Itabashi-ku,
173 Tokyo, Japan

NEWS ITEMS

Joint Arctic Weather Stations

February 1971 marks the twenty-fifth anniversary of five weather stations in the Canadian Arctic which have been operated jointly by Canada and the United States since shortly after World War II. The stations are: Resolute on Cornwallis Island; Mould Bay on Prince Patrick Island; Isaachsen on Ellef Ringnes Island; and Eureka and Alert on Ellesmere Island. Accounts of their establishment and of early supply operations to maintain them appeared in the first issues of the Arctic Circular (Vol. I, pp. 2, 45, 60, 90; Vol. II, p.70).

Services provided by these stations include:

- surface and upper air (radiosonde) data on temperature, humidity, barometric pressure, wind speed and direction - data that is forwarded to collecting stations in southern Canada for incorporation into weather charts;

- observations for Air Traffic control on flights and position of aircraft crossing the Arctic - information that is relayed to control stations in Anchorage and Goose Bay.

From southern Canada Arctic weather maps are radioed to Resolute by a photo-scanning process and are made available to all agencies requiring them, notably aviation services, ice-breakers and the supply ships that yearly help maintain northern operations of all kinds. The stations and their environs also frequently serve as the sites for base camps or advance bases for exploration or research parties in the High Arctic.

After a quarter of a century of joint operations, the five stations will become an all-Canadian responsibility by the end of October 1972, (with an almost-complete phase-out of United States personnel by October 1971). The change-over will take place gradually, Canadian personnel replacing United States operational staff.

"Twinning" of northern and southern radio stations

A report presented by the Mid-Canada Development Foundation, Inc. (of which Mr. Richard Rohmer of Toronto is the Head) contained a proposal for what is called the "twinning" of radio stations in Northern Canada with southern stations. Under this plan a 1,000 watt radio station has been established at Tuktoyaktuk, N.W.T. The process involves an arrangement under which southern Canadian radio stations undertake to provide the basic requirements for the installation of radio stations in the North at locations where reception is irregular and infrequent. This includes assistance with engineering work, the provision of station and transmitting equipment and the installation of it. The first project involves the twinning of a station at Tuktoyaktuk with private radio station CHUM in Toronto.

While there are, of course, certain advantages accruing to the sponsoring stations (in the form of tax deductability), there is no question that the northern communities will benefit from the arrangements which will provide them with regular broadcasting with some "outside" programming from the sponsoring station. One of the most interesting principles involved in the arrangement is that the ownership and operation of the stations established in the North will remain with the local people.

Basic responsibility for ensuring the success of the twinned stations would rest with the sponsoring station in the south.

The CBC, which has never had adequate funds for the installation of radio stations in all the northern communities where they are needed, is supporting this first twinning experiment by providing training for station and technical personnel.

The Tuktoyaktuk Station is now on the air, broadcasting approximately four to five hours a day. The CBC has trained a total of four Eskimos and has indicated its willingness to assist in other ways, including the provision of some program material. Baker Lake and Cape Dorset have been suggested as centres in which other twinned radio stations might also be established.

The CBC Northern Service does, of course, have its own criteria and priorities for the extension of radio service in the North and these may not coincide with those of the Mid-Canada Development Foundation. However, the possibility of some collaboration and affiliation between the two programs should not be ruled out as there seems little doubt that the service provided under the twinning arrangement is quite adequate and acceptable to the communities involved.

This project will undoubtedly fill a gap which now exists between the service available to very few communities in the North and the comprehensive broadcast service that will probably be provided via staellites in the relatively near future. In the meantime, there is a lack of radio coverage in many northern communities which might well be provided by the Foundation's program.

L.A.C.O. Hunt

The N.W.T. Ski Team - extract from a letter, dated 19 February, 1971, written by B.A. Jackson, M.D., of Saskatoon, to members of the Musk-Ox Circle, appealing for funds to aid the team.

(Editor's Note: This extract is included in the belief that the dedication and determination of these young Indians and Eskimos, as portrayed by the writer of the letter, will be of interest to any group, such as the Arctic Circle, which is concerned with all aspects of the Canadian North, social as well as scientific.)

> Here in Saskatoon, and right across the country, many people have been inspired by the leadership of northern youth provided by the determined young Indian and Eskimo people who have become the best cross-country skiers in Canada. Indeed they are now believed to be amongst the best in the world, with a real chance of bringing home an Olympic medal from Japan in 1972. All of us who know the north are concerned about the social problems of the area, and have been encouraged by the way these youngsters have given the Indian and Eskimo people so much reason for pride - and stimulated many others into this socially and physically healthy activity, mainly through the Territorial Experimental Ski Training program.
>
> In the recent Canada Winter Games the members of the N.W.T. cross-country ski team again showed their spirit and potential: the boys coming in near the head of the field against older, much stronger, and more experienced competition - and the girls sweeping all before them, winning all the available medals in their events, with great dynamism. It is a matter of record that they came in 1-2-3-4 in the cross-country race and finished a full seven minutes ahead of Ontario, their nearest rivals in the relay. This activity takes enormous courage, endurance, skill, and determination. It is proved to extend life-span, and is a profoundly valuable character-builder.
>
> All of this indicates that here we have a northern evelopment which is greatly worthy of support, both at the Territorial and at the national level. But unfortunately government funds are insufficient to keep the N.W.T. team in the first-class

competition necessary to maintain their momentum toward the top. This means a lot to northern people and to Canada. But, as a matter of fact, in order to come to the Canada Winter Games, the team had to pay $90.00 each out of their own money. On their present journey to the three world-class cross-country ski competitions in Scandinavia they left Canada with $2,000.00 yet to be found. The coach has paid many expenses himself and is presently personally several thousand dollars out of pocket. Meanwhile, back in the north, the basic and all-important development program among the young people this year had to be reduced through lack of funds. For some time now, the people responsible for the N.W.T. cross-country ski program have been doing their own fund-raising among the already far-from-affluent northerners. The young Indian and Eskimo athletes themselves have worked hard, sending out letters and directly requesting support by personal contact.

I think that as Canadians and as people interested in the north, we might well consider adding our own support to this valuable social endeavour. . . . The Institute for Northern Studies at the University of Saskatchewan, Saskatoon, has offered to provide the facilities for reception of donations . . . made out to the N.W.T. Cross-Country Ski Team. . .

International Geological and International Geographic Congresses, Montreal, 1972

In August 1972, the 24th International Geological Congress and the 22nd International Geographical Congress will be held in Montreal. The first International Geographical Congress took place in Antwerp in 1871 and the forthcoming meeting in Montreal will be the centennial reunion.

Programs for both Congresses include field trips to all parts of Canada. Due no doubt to the present general interest in the North, and to the realization that it is probably North America's last geographic frontier, all proposed field trips to the Arctic are already heavily oversubscribed - even to the apparent by-passing of some of the very fine trips organized for more southerly locations throughout the country.

PUBLICATIONS

Problems of the North

A note in the Arctic Circular (Vol. XX, p.9) gave the Table of Contents of issue No. 12 of "Problems of the North", the English translation of the Russian series "Problemy Severa", and mentioned that issue No. 13 was being translated. This issue has now been published. The Table of Contents is as follows:

The introduction of pasture rotation as an important factor in further development of reindeer husbandry, by I.I. Bagaev and V.S. Shatalov

Protection of reindeer from insect pests, by D.V. Savel'ev

Cost accounting in kolkhoz reindeer husbandry, by A.P. Roslyakov

II. HUNTING AND FISHING

Fur harvesting by kolkhozes and sovkhozes of the North, by E.I. Rebrova

Some problems in the development of the fur industry in Yakutiya, by V.A. Tavrocskii

Development of wild pelt production in the Evenki National Okrug, by A.A. Mukhopad

The hunting industry on Yamal and ways of increasing its productivity. by V.D. Skrobov and F.I. Khudoleev

Muskrat management in Yakutiya, by M.M. Davydov

Arctic fox harvesting in the tundra, by V.D. Skrobov

The present state and future prospects for the development of northern gospromkhozes under the authority of Glavokhota, R.S.F.S.R., by D.A. Udachin and S.M. Tarasov

Development of fisheries in the Khanty-Mansi National Okrug, by I. Yu. Karpovich

III. FUR RANCHING

Fur ranching in the Far North, by V.A. Afanas'ev and M.V. Shumov

Ways of increasing the efficiency of fur ranching in the north of Tyumen' Oblast and Krasnoyarsk Krai, by L.R. Michurina

Experience of the Kola fur ranching sovkhoz, by I.I. Grinkevich and A.A. Makarov

Some problems of improving the quality of feed rations for ranch-raised fur-bearing animals in the Far North, by O.L. Rapoport

IV. AGRICULTURE AND DOMESTIC ANIMAL HUSBANDRY

Vegetable growing in the Far North and methods of increasing its efficiency, by G.Z. Berson, A.I. Ivanovskii, Sh. R. Saitburkhanov and I.A. Abzaev

Methods of developing and increasing the efficiency of animal husbandry in the Soviet North, by N.V. Trusov, I.A. Abzaev and I.M. Dobrotvorskii

The development of a dairy industry in the Pechora Coal Basin, by P.A. Rochev

Basic problems in the development of the pounltry industry in the Far North (on the example of Magadan Oblast), by I.A. Karachinskaya

Increasing the productivity of natural stock feed resources in the Far North, by Z.P. Savkina

Stock feed production on meadows and crop rotation fields in the Far North, by A.I. Ivanovskii

V. COMMUNICATIONS AND INFORMATION

Reindeer husbandry in Norway, by P.N. Vostryakov and A.A. Mezhetskii

An integrated solution to current problems in the North, by I.P. Avdeev and K.G. Kondakov

Some aspects of the mechanization of agriculture and other primary industries in the Magadan Oblast, by B.V. Garbarets

The advantages of small power plants in the North, by A.P. Bulkin and Yu. M. Dogaev

Design and construction of small settlements in agricultural and hunting and fishing regions of the Far North, by A.M. Shevtsov and A.N. Sakharov

Experience in constructing permafrost cold storage in Chukotka, by M.P. Glushnev

The development of fisheries in the kolkhozes of the Nenetskii National Okrug, by A.V. Arteev and D.M. Volynets

Fenced reindeer pasturing, by V.S. Fedotov

Conference on Problems of the North

1. Integrated utilization of geothermal springs of Kamchatka
2. Provision of consumer goods for the Far North
3. Interregional conference of reindeer breeders

"Machinery for the North" (Exhibition 1968 - 1969)

The Commission on Problems of the North, Presidium of the V.I. Lenin All-Union Academy of Agricultural Sciences

Resolution of the expanded bureau of the Commission on Problems of the North under the authority of the Presidium of VASKhNIL, May 19, 1967

Anniversaries of Northern Agriculturists

Requests for individual issues of "Problems of the North" at $7.00, for single papers at $1.00, or for information on the series should be addressed to:

Translation Section,
National Science Library,
National Research Council,
Ottawa, Ontario
K1A 0R6

Issue No. 14 of "Problemy Severa" has not yet been received from the U.S.S.R. so there will probably be a considerable gap before it is translated and published.

Publications of the Northern Science Research Group, Department of Indian Affairs and Northern Development

The Northern Science Research Group (N.S.R.G.) is now part of the Northern Economic Development Branch, Department of Indian Affairs and Northern Development. It was formed in 1954 (then called the Northern Co-ordination & Research Centre) to conduct research on subjects related to the operation of the Department; to conduct research in areas not covered by other departments working in the north, and to co-ordinate interdisciplinary studies. Most of the research is done through universities by contract or institutional grant, but the group has its own small permanent staff of research workers, including specialists on Greenland and the northern USSR.

In 1964 the Inuvik Scientific Research Laboratory was established, to be operated by the Northern Science Research Group. The library, laboratories and travelling equipment of the Inuvik Laboratory are used by government, university and some private groups engaged in northern studies. A major program of the Group has been the Mackenzie Delta Research Project (M.D.R. Project), a comprehensive study of the problems of social change from which eight reports have been published to date.

Not all research conducted or sponsored by the group is published, but so far sixty reports have appeared, comprising five series - Reports General; Social Science Notes; Technical Notes; Yukon Research Project, and Mackenzie Delta Research Project. The publications are not for sale, but are exchanged on a reciprocal basis with university libraries, and those of institutes concerned with the north. Copies of publications in print and in stock may be obtained from the Ottawa headquarters of the Northern Science Research Group.

Recent publications of the group are available in both French and English, and this will be the rule for subsequent reports. In the past the research interests of the group have been eclectic, with an emphasis on studies in anthropology and sociology. There is now an increased proportion of technical research, and on studies applicable to administration of the north during a period of accelerating development.

In the following list of publications, those marked with an asterisk are permanently out of print, but most universities and institutes have copies. A few of the reports have been reprinted by private publishing concerns, and others will probably be reprinted by the department in answer to public demand.

NORTHERN SCIENCE RESEARCH GROUP REPORTS-GENERAL

*NCRC-57-1	A Draft Orthography for the Canadian Eskimo, by G.R. Lefebvre.
*NCRC-59-1	The Economy and Population Shifts of the Eskimos of Southampton Island, by James W. Van Stone.
*NCRC-59-2	The Caribou Eskimos of Eskimo Point, by J.W. Van Stone and W. Oswalt.
*NCRC-59-3	Legal Concept Among the Netsilik Eskimos of Pelly Bay, N.W.T., by Geert van den Steenhoven.
*NCRC-60-1	Preliminary Report on the Bering Strait Scheme, by M.J. Dunbar.
*NCRC-60-2	Suicidal Behaviour Among the Netsilik Eskimos, by Asen Balikci.
*NCRC-61-1	The Eskimo Community at Port Harrison, P.Q., by W.E. Willmott.
*NCRC-61-2	The Human Ecology and Social Economic Change in the Community of Tuktoyaktuk, N.W.T., by J.D. Ferguson.
*NCRC-61-3	The Subsistence Economy of the Dogrib Indians of Lac La Martre in the Mackenzie District of the N.W.T., by June Helm and Nancy O. Lurie.
*NCRC-61-4	The Economy of a Frontier Community, by J.W. Van Stone.
*NCRC-61-5	An Exploratory Study of Ethnic Relations at Great Whale River, by W.D. Johnson. (see NCRC-62-7)
*NCRC-61-6	Notes on Winter Harbour, Bridport Inlet and Skene Bay, by T.H. Manning.
*NCRC-61-7	The Eskimo of Rankin Inlet: A Preliminary Report, by Robert C. Dailey and Lois A. Dailey.
*NCRC-62-1	Foodways in a Muskeg Community, by J.J. Honigmann.
*NCRC-62-2	Kabloona and Eskimo in the Central Keewatin, by F.G. Vallee.
*NCRC-62-3	An Anthropological Survey of Communities in the Mackenzie-Slave Lake Region of Canada, by Ronald Cohen.
*NCRC-62-4	Notes on the Drinking Behaviour of the Eskimos and Indians in the Aklavik Area, by D.N. Clairmont.
*NCRC-62-5	Age as a Factor in the Social Organization of the Hare Indian of Fort Good Hope, N.W.T., by Janice Hurlbert.
*NCRC-62-6	Second Report on the Bering Strait Dam, by M.J. Dunbar.
*NCRC-62-7	An Exploratory Study of Ethnic Relations at Great Whale River, by M.D. Johnson. (A revised and expanded version of NCRC-61-5).
*NCRC-62-8	Sociological Research in the Arctic, by F.G. Vallee.

*NCRC-63-1	Government Research and Surveys in the Canadian North, 1956-61, Edited by J.R. Latz.
*NCRC-63-2	A General Introduction to Lake Harbour, Baffin Island, by N.H.H. Graburn.
*NCRC-63-3	Vunta Kutchin Social Change, by Asen Balikci.
*NCRC-63-4	The Snowdrift Chipewyan, by James Van Stone.
*NCRC-63-5	The Planned Non-Permanent Community, by V.J. Parker.
**NCRC-63-6	Frobisher Bay 1958, by Toshio Yatsushiro.
*NCRC-63-7	Territorial Sovereignty in the Canadian North, by G.W. Smith.
*NCRC-63-8	Yellowknife, N.W.T. - A Study of its Urban and Regional Community, by L.S. Bourne.
*NCRC-63-9	Deviance Among Indians and Eskimos in Aklavik, N.W.T., by D.H.J. Clairmont.
*NCRC-63-10	Great Slave Lake Fishing Industry, by R.A. Jenness.
*NCRC-64-1	Takamiut Eskimo - Kinship Terminology, by N.H. Graburn.
*NCRC-65-1	Pre-School Children of the Hare Indians, by Hiroko Sue.
*NCRC-65-2	Economic Basis and Resource Use of the Coopermine-Holman Region, N.W.T., by Peter J. Usher.
NCRC-65-3	Air-Cushion Vehicles in the Canadian North, by P.F. Cooper, Jr.
*NCRC-66-1	Social Change and the Eskimo Co-operative at George River Quebec, by Saul E. Arbess.
NCRC-66-2	Social Science Research Abstracts, 1959-1965.
*NCRC-67-1	Mackenzie Reindeer Operations, by R.M. Hill.
NCRC-67-2	Povungnetuk and Its Cooperative. A case Study in Community Change, by Frank G. Vallee.
NSRG-68-1	Problems of Eskimo Relocation for Industrial Employment, by D.S. Stevenson.
***NSRG-68-2	Utkuhikhalingmiut Eskimo Emotional Expression, by Jean Briggs (Restricted, Dept'l use only).
NSRG-69-1	**Patterns of Housekeeping in two Eskimo Settlements by C.T. Thompson.**
NSRG-69-2	**A Cultural Geography of Northern Foxe Basin N.W.T. by Keith J. Crowe.**

** Restricted, Departmental use only.
*** Restricted to Departmental use as the information therein is contained in a book published by Harvard Press Ltd.

SOCIAL SCIENCE NOTES

SSN-1	**Eskimo Education and the Trauma of Social Change by David Omar Born.**
SSN-2	**A Preliminary Survey of Greenland's Social History by H.J.C. Schuurman.**

TECHNICAL NOTES

_Technical Notes-1 Engineering Notes on Two Utilidors by P.F. Cooper, Jr.

_Technical Notes-2 A Comparison of Hovercraft Trials in Northern Canada, by P.F. Cooper, Jr.

_Field tables for the calculation of Ringed Seal weights from length and girth measurements, by Peter J. Usher and Michael Church. Technical Notes - 3

_Table pratiques de calcul du poids d'un phoque annelé d'après sa longueur et son tour de taille, par: Peter J. Usher et Michael Church. Notes techniques - 3

YUKON RESEARCH PROJECT

YRP-1	Yukon Bibliography, by J.R. Lotz.
*YRP-2	The Dawson Area, by J.R. Lotz.
*YRP-3	Yukon Travel Survey 1963, by G.F. Parsons.
*YRP-4	The Chilkoot Trail Today – Dyea to Bennett, by J.R. Lotz.
*YRP-5	Trappers, Hunters and Fishermen – Wildlife Utilization in the Yukon Territory, by Adrian Turner. (Final report in the series).

MACKENZIE DELTA RESEARCH PROJECT

MDRP-1	The Mackenzie Delta – Its Economic Base and Development, by John R. Wolforth.
MDRP-2	The Mackenzie Delta – Technology, by P.F. Cooper, Jr.
MDRP-3	The Mackenzie Delta – Domestic Economy of the Native Peoples, by D.G. Smith.
MDRP-4	Inuvik Community Structure – Summer 1965, by J. Mailhot.
MDRP-5	New Northern Townsmen in Inuvik, by A.M. Ervin.
MDRP-6	Mackenzie Delta Bibliography, Edited by Mary Jane Jones
MDRP-7	**Psychodynamic Problems of Adaptation - Mackenzie Delta Eskimos by J.M. Lubart.**
MDRP-8	**Arctic Suburb: A Look at the North's Newcomers by G.F. Parsons.**

Current research - probable publication 1971-72

- Analysis of the trapping and hunting economy of Banks Island.
- Historical list of Arctic trading posts, 1870-1970.
- Handbook of public utilities in the Soviet far north, translated from the Russian.
- Bibliography of Russian language materials on northern education.
- Selective bibliography of water supply and waste disposal methods in cold climate areas.
- Modernization in Greenland.
- Eskimo adaptation to northern rental housing.
- Occupational preferences among senior native students of the N.W.T.
- Dictionary of the Dogrib language.
- Clippings from the Greenland Press, translated into English.
- Analysis of the writings of Emile Petitot, missionary-ethnographer.
- Indians in a skid road milieu.
- Integration of Indian people in Whitehorse, Yukon.
- Town planning principles for the north.
- Studies of northern sanitation engineering.
- Damage to tundra vegetation by oil fractions.

References

(1) For a detailed description of the N.S.R.G. see Polar Record, Vol. 11 No. 73, 1963, p. 419-422.

(2) Article on Inuvik Laboratory in Polar Record, Vol. 13 No. 86, 1967, p. 655-656.

(3) Article on M.D.R. Project in Polar Record, Vol. 14 No. 70, 1968, p. 348-349

K.J. Crowe

REVIEWS

Harpoon of the Hunter

by

Markoosie

Published by McGill-Queen's University Press,
Montreal and London, 1970
81 pages, illustrations, $4.95

A review by A. Stevenson,
Chief, Northern Services Division,
Dept. of Indian Affairs and Northern Development,
Ottawa.

A milestone for the north was reached with the publication of this, the first novel to be written in English by a Canadian Eskimo. The story, by Markoosie of Resolute Bay, Northwest Territories, tells of two Eskimo hunters, father and son, who set out with a number of other men to track down a rabid and wounded polar bear. This fictional account could be a true portrayal of a way of life of the Eskimos in another era - the battle of survival in a harsh environment. Kamik, the young Eskimo hero of the tale, achieves manhood during this hunt. His companions are killed. Kamik, lost and the only survivor, struggles against disaster, cold and hunger on the long arduous trek home. He is finally rescued by Eskimos from another camp. Destined to continual tragedy, a short time later he witnesses the death of his wife and mother. Their sled breaks through the ice and they perish in the icy waters. Kamik is carried out to sea on an ice pan and commits suicide.

Markoosie, the author,recalls much of the past and some of his experiences as a boy, but it is mainly on the legends and tales passed down to him by the older Eskimo people that he bases his story. He is at present only in his twenties and his work demonstrates the achievements possible to this new generation, given the opportunity and education. In addition to his ability to express his thoughts clearly and to write, he is also a qualified pilot who flies in the High Arctic where not so long ago his ancestors travelled only by dog team. He is a perceptive young man and, although proud of his rich cultural heritage, has no wish to turn the clock back. He looks to the future with great optimism. He plans to do more writing both fact and fiction.

"Harpoon of the hunter" was first published in serial form in the Eskimo Magazine Inuttituut and written in Eskimo syllabics. Markoosie has now translated it into English. It is not the greatest of northern novels, but it deserves recognition as a good dramatic story and brings with it the hope that Markoosie and other Eskimo authors will write and publish more in the not too distant future. Eskimo art has already gained world renown. There is every reason to expect that creative Eskimos like Markoosie will make similar contributions to the literary field. The book is illustrated by black ink drawings done by another talented Eskimo - Germaine Arnaktaujok. She works as a free-lance artist and designer at Frobisher Bay, Northwest Territories.

A Cultural Geography of Northern Foxe Basin, N.W.T.

by Keith J. Crowe

published by the Northern Science Research Group
Department of Indian Affairs and Northern Development,
Ottawa, October 1969

A review by William G. Laatsch
Department of Geography, University of Alberta

With the plethora of recently published material on Canada's north, often concentrating on the Mackenzie Basin and on aspects relative to recent exploration activity, it is refreshing to read of a different region in a different context.

Mr. Crowe focuses on two themes in the Cultural Geography of Northern Foxe Basin, N.W.T.: the continuity in size and shape of settlement during changes in the physical and cultural environment, and the effects of complete social and spatial change since 1966. The author successfully develops and explains these themes in seven short chapters. The first three chapters are traditional treatments of the settlement and regional environment, sequent occupancy from prehistoric time to early contact, and changes in population size and location from 1823 - the time of Parry's departure from the basin - to 1966 when the low-rental housing scheme was introduced for Eskimos.

The remaining chapters provide the reader with the real substance of Mr. Crowe's research and reflect his understanding of the Eskimo, his facility with their language, and his years of field experience. Chapter Four examines the camp system with a detailed description of the Ussuakjuk Eskimos living on the fringes of Parry Bay. The author's fine description and perceptive analysis continue through the chapters on the "atrophy of an ecology" and the new communities with their "agencies of tutelage". In his final chapter, Mr. Crowe makes a reasoned plea for a more rational approach in the implementation of social programs to regional problems.

One of the values of this publication is that it describes and analyses a relatively isolated region that, for some forty centuries, until 1966, permitted a pattern of dispersed hunting and settlement. In addition, Mr. Crowe has a thoughtful, forceful, yet unobtrusive way of treating the region and its inhabitants as a symbiosis.

The extensive use of references, numerous photographs, maps, diagrams, and a glossary of Eskimo words are useful. Small annoyances were the typographical errors and some of the maps which exhibited variations in style and were poorly reproduced.

This volume was originally submitted as a master's thesis in geography.

This reader hopes to see more of Mr. Crowe's work, in a less restrictive format, but still with such delightful descriptions as the "unmathematical landscape (page 53) and other sensitive touches.

Freshwater Fishes of Northwestern Canada and Alaska

By J.D. McPhail and C.C. Lindsey

Fisheries Research Board of Canada, Bulletin 173
381 pp. Queen's Printer, Ottawa, 1970

A review by C.G. Gruchy,
National Museum of Natural Sciences

This is the first book to appear on the freshwater fishes of Arctic Canada in over 100 years. It is especially appropriate that an introduction to the northern freshwater fishes should appear at a time when Canadians and Americans are showing an interest in, and concern for, the natural resources of the north. The area covered in the text includes all of the arctic watershed of the Canadian mainland, southern Victoria Island, that part of the Northwest Territories draining into Hudson Bay and the Bering-Arctic drainage of Alaska.

The text is arranged in seven sections: Background Information; Glossary; Use of Keys; Keys to Families; Species Accounts; Collecting and Preserving Specimens; References; and Index. In the Background Information section the introduction and acknowledgements are followed by a comprehensive and very useful history of publications on northern freshwater fishes. A portion of the included area formed an important refugium for fishes during the Wisconsin glaciation, and the zoogeographic significance and postglacial dispersal of fishes in the area is treated in detail. Much of this section is familiar to biologists from the doctoral dissertation of the senior author, and forms a sound base from which additional studies may be carried on. Adequate, but not belaboured, subsections on classification, nomenclature, scope of descriptions, methods of identification and a glossary are included. Keys to the 17 families of fishes treated in the text are enhanced by outline drawings of typical representatives.

The family groupings of species accounts are introduced by succinct, generalized summaries and are followed by keys, some of which are illustrated with line drawings, to the species of the area. For 9

of the 17 families, species are included in the keys but are not treated in the species accounts. These include species from peripheral areas (e.g. river shiner, Notropis blennius) or species which are not strictly freshwater (e.g. Pleuronectidae).

Fifty-nine species (approximately one-third of the known species of Canadian freshwater fishes) are treated in detail. The layout of each species account is one of the best I have ever encountered in any text. Each account includes the derivation of generic and specific names and a concise listing of distinguishing characters. The detailed descriptions are complete and include comments on size and sexual dimorphism. Information on the biology and postglacial dispersal is also found in each account. Furthermore, a "Taxonomic Notes" section points out problems of nomenclature, e.g. Pfrille v.s. Chrosomus or Phoxinus (p. 252) or systematics, e.g. Coregonus clupeaformis complex (pp 80-83).

Spot distribution maps showing the localities of valid records within the study area are given, as well as a written account of world and study area distributions. Small map inset into the spot distribution maps convey an impression of world distribution. A few minor omissions of valid records, e.g. Coregonus sardinella at Fort Simpson, were noted.

Each species is illustrated by a line drawing, but the drawings are variable in quality. The illustrations of the blackfish and ninespine stickleback are excellent, but those of the salmons (Oncorhynchus spp.) are poor. The drawing of the least cisco lacks a pelvic axillary process, and although the description says the dorsal fin is falcate, the drawing depicts a truncate dorsal fin.

The text is remarkably free of errors or omissions, although a few have come to my attention. On p. 89 the authors state that the age of Coregonus nasus is not recorded for North American specimens, yet Cohen (1954) (referred to elsewhere in the text) includes a section on the age and growth of Coregonus nasus. On p. 145 the distribution of arctic char is said to include "the Maritime provinces", but in fact, only includes New Brunswick and Newfoundland.

Five colour plates are included in the book, but for one reason or another all appear slightly out of focus or colour register. Their inclusion, while potentially aesthetically pleasing, adds little to the book.

The book is quite readable and very well organized. The maps of northern North America used as endpapers are not only attractive, but are useful for reference as one reads the text. The printing, except for the colour plates, is up to the usual high standards of the Fisheries Research Board.

The authors may take pride in having produced not only an excellent faunal work, but an impressive and valuable contribution to an understanding of the zoogeography of northern fishes.

Arctic Ecology Map Series

compiled by

Renewable Resources Colsulting Services, Ltd., Edmonton
for
The Canadian Wildlife Service,
Department of Fisheries and Forestry

24 maps, 25 booklets.

The material for this map series was gathered from existing literature and from personal communications with observers familiar with the areas described.

The location of sensitive wildlife habitats have been delineated and described with a view to assisting in protecting the various species from the effects of environmental damage.

The Canadian Wildlife Service has explained that this is a preliminary edition, a sort of internal working paper produced against time, with the aim of providing information for government departments, oil companies and other developers about to begin or renew operations in the North. However, the interest aroused by these maps and the demand for them have been so great that consideration is now

being given to publishing an official edition for general distribution when the amendments and additions contributed by the present users have been completed.

Dr. W.O. Pruitt, Jr., of the Zoology Department of the University of Manitoba, Winnipeg, has made the following appraisal of the present edition:

> In a series of 24 maps (World Aeronautical Charts and National Topographic Series) and corresponding descriptive booklets, the Canadian Wildlife Service has presented a magnificent accumulation of data on the larger vertebrates over most of the Canadian North. Most of the region is presented on World Aeronautical Charts (1:1,000,000) with the Lower Mackenzie River and northwestern Arctic coast on National Topographic Series maps (1:500,000). Missing are most of Ellesmere Island (Jones Sound and Eureka Sound WAC); Chesterfield region (Quoich River WAC); central Baffin Island (Ballantyne Strait WAC). I hope these additional maps appear soon because of the extensive exploitation activity now under way in these regions. The areas marked on the maps are designated either "important" or "critical" and are classified as to use: fawning ground, breeding area, denning area, staging area, range, migratory route or all habitat functions, and by time of year. Each area is keyed to a more complete description in the accompanying booklet.
>
> "Important" areas are defined as those necessary for maintenance or survival of a population while "critical" areas are defined as being particularly susceptible to permanent damage by man's activities. The booklets give examples of the type of human activities that can cause permanent damage.
>
> The information on the maps was assembled by "picking the brains" of virtually everyone with northern experience. Consequently, to some extent the maps show distribution of past human activity rather than distribution of animal activity on a statistically reliable basis. In other words, the maps are a compendium of anecdotal information. But precisely because of this they are especially valuable, since they thus will stimulate attention to and recording of additional areas unnoticed up to now. These maps also underscore the fallacy of the official statements that biologists don't have sufficient information to allow regulation

of exploitation activity. The maps show that most of the information is indeed already available (e.g. Radstock Bay is a critical Polar Bear denning area and year-round range).

The map series should be looked upon as presenting minimum areas; there are many others. Even on this basis there should be no excuse for further deleterious activities by the exploiters - whether they are concerned with oil, minerals, tourist activity or governmental activity. The next important step is to get land-use regulations with sharp teeth in them and a corps of trained and unshakable inspectors to see that the regulations are carried out.

Maps such as these really should have been published 20 years ago. The data necessary to delimit the various area and their seasonal use by the larger vertebrates should be, in a rational approach to resource utilization, gathered first so that any potentially disruptive surface activities are not allowed. Perhaps if we had a viable long-term plan for the North, a plan in which the terrestrial vertebrate resources were not summarily dismissed, basic biological research would not have been starved for so many years and complete basic data would have been available long ago. Because of the long-standing official reluctance to collect and disseminate such data the Canadian Wildlife Service and Renewable Resources Consulting Services, Ltd. are to be doubly congratulated for producing this extremely valuable and useful set of maps and descriptive booklets. I predict there will be many revised editions and reprintings of them.

Arctic Circle correspondence - Correspondence should be addressed to the officer concerned,
c/o The Arctic Circle,
Box 2068, Postal Station D,
Ottawa, Ontario
K1P 5W3

Arctic Circle Meetings

The regular meetings of the Arctic Circle are held on the second Tuesday of every month at 8.30 p.m. in the Officers Mess, No. 9 Transport Company, R.C.A.S.C., Catherine Street at the corner of Bank Street. The bar opens at 8 p.m., giving members half an hour for social and business discussions before the meeting begins and the guest speaker gives his address.

Out-of-town members who wish to receive notices of these meetings and, thereby, be informed in advance regarding the guest speakers and the topics to be discussed, should address their requests to the Secretary, Mr. Keith C. Arnold.

The Arctic Circular

The Arctic Circular is published three times a year - oftener if the amount of material received permits. Correspondence, papers and reports are welcomed from all members, from persons living in the North, or from anyone having information on general northern activities, research and travel, or on technological, industrial or social developments. Contributions and correspondence should be addressed to the Editor, Mrs. Margaret Montgomery Larnder.

Back issues of the Arctic Circular are available, single copies at $0.50 and complete sets (Volumes I to XX) $100.00. Requests should be addressed to Miss Mary Murphy, Publications Secretary.

Arctic Circle Ties

A few Arctic Circle ties - featuring a white narwhal on a navy blue background - are still available. The cost is $3.50 each. Members wishing to purchase ties should forward their request to the Treasurer.

THE ARCTIC CIRCULAR

VOL. XXII NO. 2 Published by the Arctic Circle Spring/Summer, 1971
Ottawa, Ontario

The 193rd meeting of the Arctic Circle, 13 April 1971

This was the last meeting of the winter season. The guest speaker was Mr. Dalton Muir of the Canadian Wildlife Service (CWS). He chose as his subject "Some Environmental Problems in the Arctic Today", impressions of the effects of economic activity in this area gained on a wide ranging tour from Alaska to Baffin and north to Resolute in 1970.

Mr. Muir outlined the aims of the CWS, which was established in 1947 to be responsible for federal interest in all forms of wildlife on lands under federal jurisdiction, and to administer the Migratory Bird Act of 1917. Because most federal lands lie in the North, the interests of the CWS are mainly related to biological and ecological aspects of that region. To meet its responsibilities more effectively the Arctic Ecology Unit was set up within the CWS to study the implications of environmental change in the Far North and its effect on wildlife.

The speaker reminded his audience how wrong and damaging were many of the cliches popularly used to describe the North, cliches such as "land of inexhaustible resources," and "you can't hurt it, there's nothing there."

With the rapidly growing world populations and their increasing requirements for basic materials and recreational areas the North is being threatened with swift and wholesale exploration and exploitation.

Such activity tends to reduce the area available to wildlife, and more often than not, brings in its wake pollution, a scarred landscape, and a wildlife population reduced by overhunting or privation. The speaker stressed the valuable contributions that preservation and planned development of this vast area can hold for society, as a whole, both now and in the future.

Following his talk, Mr. Muir showed a series of coloured slides, most of them quite different in character from the beautiful Arctic shots visitors to the region usually collect. As he pointed out, you usually see what you look for. In his case he was attempting to illustrate the effects of human activity and the possible sources of future trouble as seen through the lens of an expert photographer. The damage effected by 20th century drilling, earthmoving and transport operations were distressing, and viewing the stacked plastic "drums" in a cache of aviation fuel, one thought of the pollution that might result should a polar bear attack these drums with his claws.

The speaker was introduced and thanked by the President of the Arctic Circle, Brigadier-General Keith Greenaway.

How did such intercontinental crossings occur? As great masses of ice - derived from moisture absorbed into the atmosphere from the seas and deposited as snow - built up and flowed over the land during glaciations, worldwide sea level dropped, exposing land in the shallow Bering Strait region. This broad, isthmian connection between Eurasia and North America emerged at least four times during the Quaternary, and was later flooded by rising seas as the continental ice melted during the warmer interglacials thus re-establishing Bering Strait much as it exists today. Apart from man and the woolly mammoth, many species which we consider native North American fauna actually entered this continent from Eurasia during the last two glaciations, the Illinoian and the Wisconsin. Bison, muskox, moose, elk and brown bear are typical examples. A few mammals that still survive in Asia, such as the yak and saiga antelope, penetrated no farther east than northwestern North America, where they died out toward the close of the Wisconsin glaciation. Some ice age mammals that originated in North America, such as camels and horses, migrated west into Eurasia from this continent. Others, like the woolly rhinoceros of Eurasia and the prongbuck of North America remained in areas where they originated.

During the continental glaciations, as ice from the central areas spread over Canada, mammals were forced to shift their ranges north and south until, at the peaks of the glaciations, they occupied three or four main survival areas (refugia): (1) the southern refugium in northern United States; (2) the Beringian refugium in unglaciated areas of the Yukon and Alaska and extending across the Bering Isthmus into eastern Siberia; (3) the Banks Island refugium in the western Candian Arctic Islands and (4) the Pearyland refugium in northern Greenland. Thus, fossils of tundra-adapted mammals such as the collared lemming and the muskox (Ovibos moschatus) have been found in the northern United States, whereas the natural habitat of the same species is at present in the Canadian Arctic and Greenland. Besides the southern refugium, the muskox also seems to have occupied both the Beringian and Banks Island refugia.

Some "warm-adapted" species moved far to the north during interglacial phases, as shown by ground sloth and camel remains in the Yukon Territory and beaver-cut sticks on Banks and Ellesmere Islands in the Northwest Territories. It can be seen from these examples that fossils of species with particular adaptations and

habitat requirements often provide clues to the nature of past environments of a locality or region. The basic assumption is that species represented by fossils had ecological requirements similar to those of the same or closely allied living species. Sometimes preserved stomach contents or other fossils directly associated with ancient skeletal remains, act as clues to habitats of extinct species.

Against this background of a few of the major characteristics of the ice age in Canada, a review can be made of some important Quaternary fossil localities from the Maritime Provinces west to British Columbia, and north to the Yukon and Northwest territories (Fig. 1). Emphasis is placed on listing and commenting on mammal species identified from bones in fossil-bearing beds at each locality. In most cases, species from a single horizon are treated collectively as a "fauna", but it is difficult to tell whether all species identified from each horizon actually lived in the same area at the same time. This is especially true when the remains consist of fragments from stream deposits in which reworking and mixing of fossils of various ages is possible. The faunas considered, range in age from about 1,500,000 to 4,000 years. Occasionally, where interest seems to warrant it, single species or specimens are discussed. Early man is mentioned briefly. Recent evidence suggests that he was present in Canada about 27,000 years ago, perhaps even earlier than 32,000 years ago.

Ice Age Mammal Fossil Localities in Canada

Maritime Provinces

No important vertebrate faunal localities of the Quaternary are known from the Maritimes. Although beaver-cut sticks and unspecified mammal remains probably over 33,800 years old have been reported (Prest 1970) from a sinkhole in gypsum near Milford Station, N.S., the material has not been thoroughly studied, and its significance has yet to be assessed. Scattered mastodon (Mammut americanum) molars have been ploughed up on mainland Nova Scotia and on Cape Breton Island. One interesting find occurred in 1936, when a virtually complete mastodon skeleton was excavated by members of the New Brunswick Provincial Museum from blue clay near Hillsborough, N.B. (Squires 1966). Another possible mastodon find was made in the middle of the last century near Sussex, N.B. - approximately 25 miles from a Paleo-Indian fluted

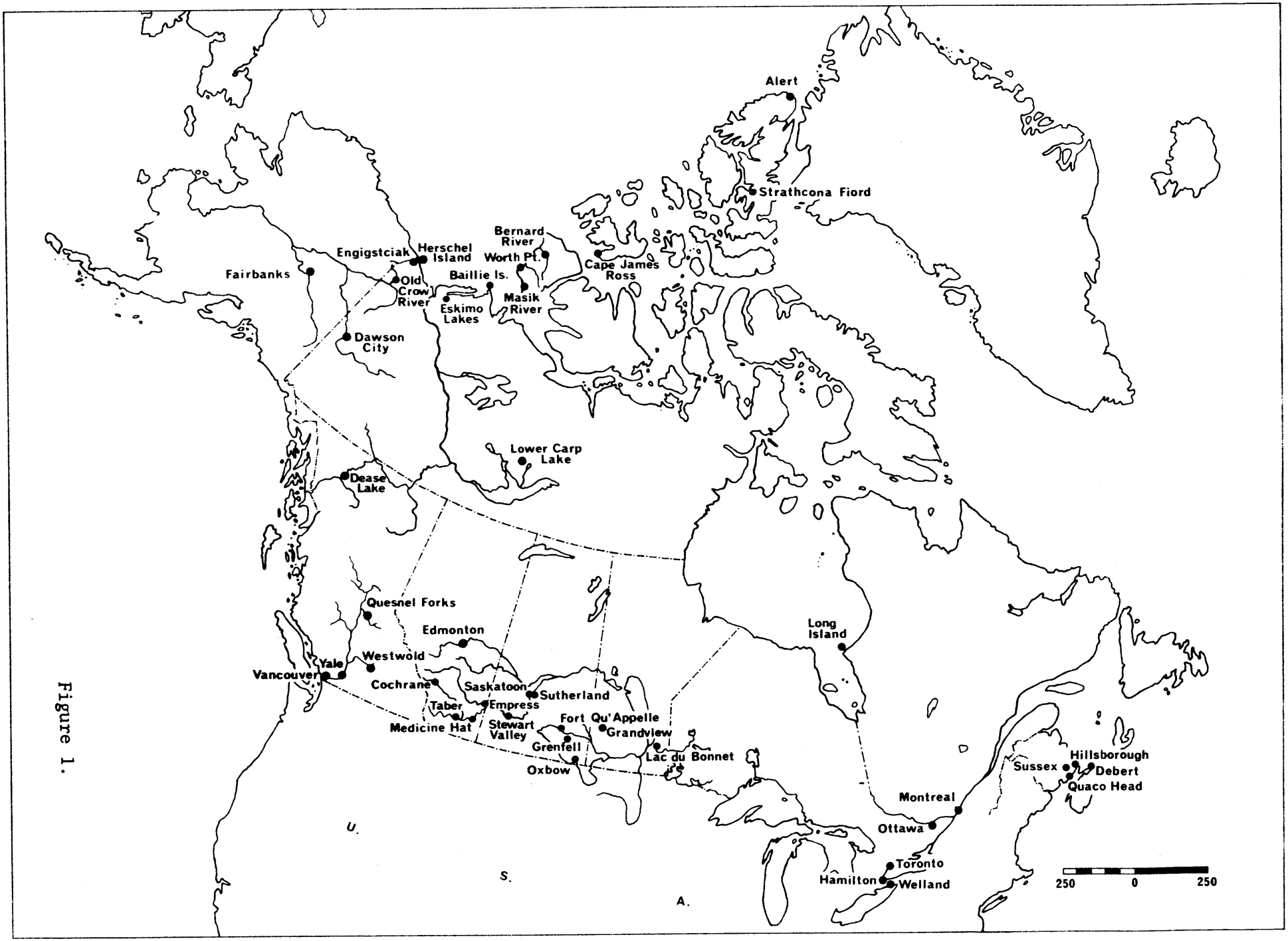
Alert
Strathcona Fiord
Bernard River
Worth Pt.
Cape James Ross
Engigstciak
Herschel Island
Fairbanks
Old Crow River
Baillie Is.
Masik River
Eskimo Lakes
Dawson City
Lower Carp Lake
Dease Lake
Quesnel Forks
Edmonton
Long Island
Westwold
Yale
Vancouver
Cochrane
Saskatoon
Sutherland
Taber
Empress
Medicine Hat
Stewart Valley
Fort Qu'Appelle
Grandview
Grenfell
Lac du Bonnet
Oxbow
Hillsborough
Sussex
Debert
Quaco Head
Montreal
Ottawa
Toronto
Hamilton
Welland
250
0
250

Figure 1.

present Lake Ontario. Specimens of various mammals that lived at that time have been recovered from such deposits in the vicinities of Toronto and Hamilton. Churcher and Karrow (1963) have reported meadow vole (Microtus pennsylvanicus), eastern chipmunk (Tamias striatus) and gray fox (Urocyon cinereoargentatus) remains from a buried soil horizon at Scarborough Bluffs, Toronto, while Wetmore (1958) recorded the short-tail shrew (Blarina brevicauda), eastern chipmunk, gray squirrel (Sciurus carolinensis), red squirrel (Tamiasciurus hudsonicus), flying squirrel (Glaucomys sabrinus), white-foot mouse (Peromyseus sp.) meadow vole, pine vole (Microtus pinetorum), muskrat (Ondatra zibethicus) and red fox (Vulpes vulpes) from sands and gravels underlying the glacial Lake Iroquois beach at Hamilton. Further muskrat specimens - and possibly the porcupine (Erethizon dorsatum) - may be added to this list (Churcher and Karrow 1963; specimens in National Museums of Canada collection.) Bird, snake, frog and fish specimens have also been collected in the Hamilton locality (Wetmore 1958). Another well known fossil locality is Green Creek, east of Ottawa, where vertebrate remains of Champlain Sea age have been found in calcareous clay nodules.

The history of this sea (Elson 1968, Prest 1970) and its vertebrate fauna (see Wagner 1967 for references), merit a brief description. As the Wisconsin ice sheet retreated north of the St. Lawrence valley, the Atlantic Ocean flooded this depressed lowland. When the sea reached its maximum extent about 11,500 years ago, it covered approximately 20,500 square miles and included the area between Quebec City and Brockville, the lower Ottawa River and Lake Champlain valleys. Whales, in particular the white whale (Delphinapterus leucas), the humpback whale (Megaptera novaeangliae) and the common finback whale (Balaenoptera physalus); harbour porpoise (Phocoena phocoena) - particularly those adapted to cool, inshore conditions; and seals like the harp seal (Phoca (Pagophilus) groenlandica) and the bladdernose seal (Cystophora cristata) - adapted to breeding on pack ice, penetrated this sea and exploited its food organisms. Hare, presumably the snowshoe hare (Lepus americanus) and marten (Martes americana) specimens from Montreal and Ottawa areas respectively, suggest the presence of boreal forest along the edges of the receding sea. Birds, possibly shore birds and ducks, apparently fed along its beaches. Fish specimens such as capelin (Mallotus villosus), sculpin (Artediellus uncinatus), smelt (Osmerus mordax), three-spined stickleback (Gasterosteus sculeatus) and lake trout (Salvelinus (Cristivomer) namaycush), preserved in clay nodules from Green Creek, indicate the former

by Paleo-Indians. A skull fragment of the tundra muskox (Ovibos moschatus) from Grandview may represent muskox herds that moved north from a refugium south of the Wisconsin ice sheet with the tundra zone bordering the backmelting ice, until they reached their present range in the Northwest Territories mainland (Harington 1970). Leith (1949) and Young (1966) have reviewed many of the ice age elephant finds in Manitoba. A noteworthy discovery was that of a mammoth or mastodon fibula, worked by man, found near Lac du Bonnet (Leechman 1950). If the elephant represented by this artifact had died or been killed at the site in postglacial time, it would probably be less than 9,000 years old (see Prest 1970, Fig. Xii-16).

Saskatchewan

A few good vertebrate localities have been discovered in southern Saskatchewan. Remains of ?wolf (Canis sp.), badger (Taxidea sp.) columbian mammoth (Mammuthus cf. columbi). horse (Equus scotti), camel (Camelops cf. hesternus), giant moose (Cervalces roosevelti), long-horned bison (Bison latifrons), and an extinct muskox (Symbos cavifrons) have been collected from a gravel exposure of Sangamon age at Fort QU'Appelle. The fauna apparently existed in a temperate grassland environment, to judge from the abundance of grazing mammals represented (Khan 1970).

A fauna similar to that at Fort Qu'Appelle is known from Saskatoon. So far, the following species are represented there (Lammers 1968): mammoth (possibly the Columbian mammoth Mammuthus columbi), horse (Equus cf. niobrarensis - E. niobrarensis is a synonym of E. scotti in the opinion of D.E. Savage and E. Khan), camel (Camelops sp.), deer (Cervidae), and bison (Bison sp.). Specimens of the badger (Taxidea taxus), horse (Equus cf. niobrarensis) and wapiti (Cervus canadensis) have been collected near Sutherland just across the South Saskatchewan River from the Saskatoon site (Russell 1943, and Royal Ontario Museum specimens 5543 and 5545). Stratigraphic studies by E.A. Christiansen (personal communication 1971) suggest that the Saskatoon and Sutherland faunas are somewhat later in age than the Fort Qu'Appelle fauna.

The Wellsch Valley fauna from Stewart Valley is of interest because of its great age. As identified by C.S. Churcher (Stalker 1971) species represented are: ground sloth (Megalonyx sp.) dog-like carnivore (Canidae), bobcat-like carnivore (Lynx cf. rufus), Cook's mammoth (Mammuthus imperator cf. haroldcooki), two horses

(Equus pacificus and E. complicatus),extinct peccary (Platygonus sp.), camel (Camelops sp.), and prongbuck (Antilocapridae). The fauna may be of the second glacial age (Kansan) according to the primitive types of mammoth and horse represented.

Faunal remains from the Oxbow Dam site, one mile south of Oxbow, appear to be equivalent in age (slightly over 5,000 years old according to radiocarbon dates) to the Hamilton Bay fauna in Ontario. Species represented at this archaeological site are distinctly "modern" (Nero and McCorquodale 1958): frog (?Rana sp.) coyote (Canis latrans), ?wolf (Canis lupus), kit fox (Vulpes velox), ?wapiti (?Cervus canadensis) and bison (Bison sp.). The discovery of a bone projectile point or foreshaft at Grenfell, suggests that Paleo-Indians hunted big game near the margin of the retreating Wisconsin ice sheet in southeastern Saskatchewan. The implement, carved from mammoth or mastodon bone, was excavated from postglacial deposits probably less than 10,000 years old (Wilmeth 1968).

Alberta

Many productive ice age vertebrate localities have been found in Alberta. The Medicine Hat site is the most important, for fossils from various localities in that area enable us to reconstruct a picture of successive faunas extending back to Kansan time (Stalker and Churcher 1970; C.S. Churcher, personal communication 1970). Only species from four of the nine horizons represented will be mentioned here.

The Kansan deposits (possibly about 1,500,000 years old) yielded bones of: ground sloth (species not determined), beaver (Castor sp.) , dog-like carnivore (Canis sp.), large cat (Felidae), Cook's mammoth (Mammuthus imperator haroldcooki), stilt-legged ass (Equus calobatus), horse (Equus scotti), ?long-legged llama (?Tanupolama) and camel (Camelops minidokae). The deposits may be comparable in age with the fossil horizon at Stewart Valley, but, except for Cook's mammoth, it is difficult as yet to demonstrate the presence of similar species at both localities.

The Sangamon interglacial beds near Medicine Hat have yielded the greatest variety of vertebrates: grouse(Canachites sp.), hawk (?Buteo sp.), ground sloth (Megalonyx sp.), rabbit (Sylvilagus floridanus) hare (Lepus cf. townsendii) , pocket gopher (Thomomys cf. talpoides),prairie dog (Cynomys cf.

ludovicianus), ground squirrel (Spermophilus richardsonii), vole (Microtus sp.), muskrat (Ondatra zibethicus), porcupine (Brethizon dorsatum), mink (Mustela vison), wolf (Canis lupus), dire wolf (Canis cf. dirus), red fox (Vulpes vulpes), raccoon (Procyon lotor), lynx (Lynx canadensis), lion-like cat (Panthera atrox), Jefferson's mammoth (Mammuthus columbi jeffersoni), Mexican ass (Equus (Asinus) conversidens), horse (Equus niobrarensis), ?Neotropical horse (?Amerhippus sp.) long-legged llama (Tanupolama sp.), western camel (Camelops hesternus), deer (Odocoileus sp.), wapiti (Cervus canadensis), two species of caribou (Rangifer tarandus, and a small type Rangifer sp.) moose-like deer (?Alces), prongbuck (Antilocapra cf. americana), mountain sheep (Ovis canadensis), and long-horned bison (Bison cf. latifrons). Early man may be represented by small pieces of chipped chert, but archaeologists have not agreed that they are artifacts. Six of eight species from Sangamon deposits at Fort Qu'Appelle, Saskatchewan are the same as, or similar to, species represented from this horizon.

Mid-Wisconsin deposits (over 20,000 years old) near Medicine Hat have yielded remains of what appears to be a parkland fauna: hare (Lepus cf. townsendii), pocket gopher (Thomomys cf. talpoides), coyote (Canis cf. latrans),sabretooth cat (Smilodon floridanus), Mexican ass (Equus (Asinus) conversidens),large horse (Equus cf. giganteus), Steven's llama (Tanupolama stevensi), camel (Camelops hesternus), deer (Odocoileus sp.), and large bison (Bison sp.).

The most recent horizon containing fossils of extinct vertebrates is about 11,000 years old according to radiocarbon dating. Species represented are: man(Homo sapiens, indirect evidence), wolf (Canis lupus), woolly mammoth (Mammuthus primigenius), Mexican ass (Equus (Asinus) conversidens), camel (Camelidae) and large bison (Bison sp.).. By 5,000 years ago, a "modern" fauna was evidently present.

Churcher (Stalker 1971) has identified a cold-adapted fauna from a gravel terrace near Empress, consisting of: woolly mammoth (Mammuthus primigenius), Mexican ass (Equus (Asinus) conversidens), camel (Camelops sp.?) and an extinct bison (Bison cf. occidentalis). It may correlate approximately with the 11,000 year old horizon at Medicine Hat, Elephant (Proboscidea cf. Mammuthus), ass (probably Equus (Asinus) conversidens) and lion-like cat (Panthera atrox) remains have been reported (Harington 1971) from a gravel

terrace a few miles upstream from Empress on the opposite side of the Red Deer River, but the geological age of the specimens and their relationship to the finds at Empress are uncertain.

The Cochrane fauna (Churcher 1968) from Bow River gravels near Cochrane, is just over 11,000 years old according to radiocarbon dates, and may thus be correlated with the 11,000 year horizon at Medicine Hat. So far, species identified from Cochrane consist only of grazing mammals: Mexican ass (Equus (Asinus) conversidens), wapiti (Cervus canadensis), bison (Bison occidentalis) and mountain sheep (Ovis canadensis). The presence of the mountain sheep so far east may indicate that the species had a broader range in postglacial time than it does now.

Mammal fossils have been collected for many years in the vicinity of Edmonton and include part of the skull of a tundra muskox (Ovibos moschatus), now in the National Museums of Canada that was collected there in 1898. It supports the suggestion of Westgate and Bayrock (1964) that the latest deposition of Saskatchewan gravels in the area took place under periglacial rather than interglacial conditions. Gravel pits near the eastern limits of Edmonton have yielded remains of the following mammals (Beverly fauna; Fuller and Bayrock 1965): mammoth (Mammuthus sp.), horse (Equus sp.), camel (?Camelus sp.), and three species of bison (Bison latifrons, B. crassicornis, and B. occidentalis). Fuller and Bayrock (1965) infer that these species existed in the vicinity of Edmonton some 8,000 years ago. However, there are some very real difficulties of identification. C.S. Churcher (1968) has referred six horse metacarpals from the Beverly fauna to the Mexican ass (Equus (Asinus) conversidens). Also, in the opinion of the present author, the camel (?Camelus sp.) phalanx differs in no way from Camelops hesternus, and should be referred to that species. Further, it seems unlikely that the three species of bison occupied the same area at about the same time. Bison occidentalis probably belongs to a postglacial fauna, as exemplified by its presence at Cochrane, but the other two species evidently became extinct earlier than 10,000 years ago. This hypothesis should be tested by radiocarbon dating of bone from each species and by additional collecting at the site to determine whether or not some of the bison specimens have been reworked, or were somehow derived from older gravels.

In 1961, the exciting discovery of human skeletal remains was made by a field party under Dr. A. MacS. Stalker (Langston and Oschinsky 1963, Stalker 1969). The bones came from a cliff on the east side of the Oldman River about three miles north of Taber, and consist of cranial fragments, part of a lower jaw containing two unerupted deciduous molars,and a free second molar cap. Some postcranial material was also collected. Evidently, the bones were those of a child less than two years old. Although the bones have not been dated directly, they were found about 60 feet below prairie level in a layer of sand beneath a glacial till deposit. As the till was laid down by an ice sheet that spread over the area some 22,000 years ago, the bones are at least that old. Correlation with other bluffs along the Oldman River suggests the human remains are more than 32,000 years old.

British Columbia

Ice age vertebrate fossils in this mountainous province tend to be rare because of intense glaciation by Cordilleran ice during glacial phases. Many concentrations of fossils must have been crushed and ground under the great masses of ice. Even during interglacial phases, remains of alpine species undergo particularly heavy erosion in fast-running mountain streams and consequently are seldom preserved.

This largely accounts for the rarity of ice age mountain goat remains. So far, this species has been recorded from only eight fossil localities in North America. The earliest known mountain goat record is a partial skull (Oreamnos sp.) from Sangamon, or earlier, interglacial deposits near Quesnel Forks. In addition to the mountain goat, other species have been reported from gold-bearing gravels of the Cariboo District: ground sloth (Megalonyx sp.), woolly mammoth (Mammuthus primigenius), Columbian mammoth (Mammuthus columbi), small, ass-like horse (Equus (Asinus) sp.), mule deer (Odocoileus hemionus), deer (Odocileus sp.), moose (Alces sp.), caribou (Rangifer sp.) and bison (Bison sp.).

It is clear that a relatively rich fauna, or faunas occupied the southern interior of British Columbia during nonglacial phases of the ice age. None of the species mentioned would be out of place in a late Quaternary (i.e. Illinoian to Wisconsin) fauna. From evidence at Westwold, it seems that, at least, small horses (Equus (Asinus) sp.) , bison, rodents and fishes occupied

the region during the Olympia Interglacial (over 35,000 years ago according to radiocarbon dates).

Cowan (1941) has given an interesting list of Quaternary and postglacial mammals from the province. However, it should be noted that the cranial fragment from Dease Lake which he has referred to the tundra muskox (Ovibos sp.) actually belongs to an extinct muskox (Symbos sp.) which was adapted to warmer conditions (Harington 1968). Apart from sedimentary deposits in the interior of British Columbia, most ice age mammal remains have been found in marine or stream-laid sediments near Vancouver and southern Vancouver Island, including small islands in the Strait of Georgia. Fossils derived from marine or coastal deposits include: northern sea lion (Eumetopias cf. jubata), a baleen whale (Mysticeti), and killer whale (Orca sp. - probably of Quaternary age). Land mammals from the region are: imperial mammoth (Mammuthus imperator), Columbian mammoth (Mammuthus columbi), horse (Equus sp.) and long-horned bison (Bison cf. crassicornis) (Cowan 1941). Paleo-Indians, presumably adapted to life along rivers and to salmon fishing in particular, occupied a site near Yale on the Fraser River some 8,000 years ago (Borden 1960).

Yukon Territory

During the ice age, large tracts of Alaska and the Yukon were unglaciated and were occupied by a homogeneous, relatively rich mammalian fauna. Unglaciated areas, in this case part of the Beringian refugium, generally provide more productive fossil vertebrate localities than do regions which have undergone many glaciations (e.g. most of the rest of Canada). However, stratigraphic differentiation of glacial and nonglacial deposits is more difficult in an unglaciated region because the till layers that definitely mark the limits of the different glacial phases, are absent. Vertebrate faunas from two of the best known Yukon localities, the Old Crow Basin and the Dawson City area should be mentioned.

In the Old Crow Basin, most ice age vertebrate remains are derived from oxidized sands and sandy gravels underlain by gray lacustrine clay showing signs of periglacial influence, and overlain by lacustrine silts and peat. Mammal fossils appear

to be of late Pleistocene age (Illinoian to Wisconsin). The base of the surface peat in the area is about 11,000 to 7,000 years old, indicating that the large glacial lake which developed there during the classical Wisconsin, drained about that time.

One of the oldest faunas from the Old Crow Basin comes from Locality 44 on the Old Crow River. The fossil bearing horizon lies beneath about 90 feet of banded silt and clay and is over 39,000 years old according to radiocarbon dates on wood, and on mammoth and horse bone. A tentative faunal list includes: bird (Aves), pika (Ochotona sp.), hare (Lepus sp.), beaver (Castor cf. canadensis), giant beaver (Castoroides cf. ohioensis), carnivore (Carnivora), mammoth (Mammuthus sp.), large horse (Equus sp.), ?camel (?Camelops sp.) and caribou (Rangifer tarandus).

Another fauna from Locality 14 N on the Old Crow River appears to be of mid-Wisconsin age (radiocarbon dates on bones from the site lie between 23,000 and 32,000 years ago) and includes: man (Homo sp., indirect evidence from bone artifacts), giant pika (Ochotonidae cf. Ochotona new species), hare (Lepus sp.), beaver (Castor canadensis), giant beaver (Castoroides cf. ohioensis), muskrat (Ondatra zibethicus), singing vole (Microtus (Stenocranius) miurus), dhole (a short-snouted dog) (Cuon sp.), arctic fox (Alopex lagopus), wolverine (Gulo sp.), lion-like cat (Panthera atrox), sabretooth-like cat (Felidae cf. Smilodon sp.), American mastodon (Mammut americanum), woolly mammoth (Mammuthus primigenius), large horse (Equus sp.), camel (Camelops hesternus), moose (Alces alces), barren ground caribou and, rarely, woodland caribou (Rangifer tarandus), and large-horned bison (Bison crassicornis). Of 19 species reported, 8 are extinct: the wild horse is extinct in the Yukon Territory as is the dhole. The dhole survives in Asia from Siberia to Java (Harington 1970b). A fleshing tool made from a caribou tibia was found at this locality and yielded a radiocarbon date of about 27,000 years. It indicates the presence of man in the eastern part of the Beringian refugium before the peak of the Wisconsin glaciation (Irving and Harington MS.).

In 1967 a "postglacial" horizon was discovered at Locality 11, which is well above the level of the Old Crow River. Two fine long-horned bison (Bison crassicornis) skulls and associated post-cranial material from the horizon were radiocarbon dated to about 12,500 years ago. Evidently this is the most recent date known for Bison crassicornis and the species may have become extinct about this time. As previously mentioned, there is some doubt

about the actual age of the specimen which Fuller and Bayrock (1965) included in the Beverly fauna from Alberta.

A few miles downstream from the Old Crow River mouth, on the Porcupine River, a lens of beaver-cut sticks about 24 feet long and 2 feet thick was found. It appeared to be part of an ancient beaver dam, compressed by the weight of 175 feet of overlying sediments. The beaver-cut sticks are considered to be of Yarmouth interglacial age or older. Large spruce cones, and tree trunks up to 2 feet across project from this basal horizon of compact red sand.

Most mammal remains in the Dawson City area come from near the base of frozen "muck" deposits and the surface of the underlying gold-bearing gravels, which are usually exposed during placer mining operations. As at Old Crow, most of the fossils appear to be of late Quaternary age and have a rather fresh appearance due mainly to their preservation in frozen ground. At Dawson and Old Crow the commonest remains collected to date are horse, mammoth and bison, suggesting the presence of extensive grasslands in the Yukon during the late Quaternary. To give a better idea of the ice age mammals of the Dawson area, a list of species from Gold Run Creek follows: short-faced bear (Arctodus simus yukonensis), badger (Taxidea taxus), lion-like cat (Panthera atrox), American mastodon (Mammut americanum), woolly mammoth (Mammuthus primigenius), small horse (Equus (Asinus) lambei), moose (Alces alces), caribou (Rangifer tarandus), Alaskan bison (Bison alaskensis), large-horned bison (Bison crassicornis). Seven of the 10 species reported are extinct and one, the badger, is extinct in the Yukon Territory. It should be noted that the specimen of Bison alaskensis (a bison with longer, broader horns than B. crassicornis) came from a deep sink in the bed of Gold Run Creek and, evidently, is older than the remainder of the fauna. Bone from the skull yielded a radiocarbon date of over 39,000 years old, whereas bone from other specimens at the locality dated between 23,000 and 32,000 years ago (Harington 1970b).

Approximately contemporaneous mammal faunas from Dawson and Old Crow differ in that beaver and giant beaver remains are common in the latter area, but extremely rare in the former, (only one specimen of Castor is known from Quartz Creek). On the other hand, mountain sheep remains (Ovis cf. dalli) are fairly common in the Dawson deposits but, so far, have not been recognized from Old Crow sediments. Pending further evidence, it can be

inferred that the Dawson area had more of an alpine grassland environment during the mid-Wisconsin than the Old Crow Basin, which apparently consisted of extensive grassy uplands, with spruce woodland, lakes, ponds and sluggish streams in lower areas (McAllister and Harington 1969, Crossman and Harington 1970).

An interesting find from Miller Creek in the Dawson area consisted of arctic lupine seeds probably over 10,000 years old, which were found in burrows of collared lemming (Dicrostonyx torquatus) that were deeply buried in permanently frozen silt. The seeds had evidently been set down as a food store by the lemmings. A few of the seeds readily germinated and grew into normal healthy plants (Porsild et al. 1967).

A variety of mammal remains have been collected from postglacial turf and humic sands at the Engigstciak archaeological site near the arctic coast of the Yukon. According to Mackay et al. (1961), the lower part of the horizon contains: fish, bird, small mammals, seal, wapiti, caribou, bison, mountain goat, and mountain sheep. The upper part of the horizon contains: fish, bird, rodent, fox, bear, sea mammal, moose, caribou, muskox and mountain sheep. A radiocarbon date on an antler suggests this fauna may be as much as 4,000 years old. Artifacts and charcoal are common in this horizon. Bones of ?horse, caribou and large bison were excavated from an organic layer beneath the humic sands.

The following vertebrates, evidently washed from ice age deposits of Herschel Island, are represented in the National Museums of Canada collection: dog-like carnivore (Canidae), elephant (Proboscidea cf. Mammuthus), large-horned bison (Bison cf. crassicornis), ?extinct muskox (?Bootherium), and tundra muskox (Ovibos moschatus). A whale (Cetacea) fragment was collected from preglacial marine sands on eastern Herschel Island.

Northwest Territories

Mammoth (Mammuthus sp.) and large-horned bison (Bison crassicornis) remains are not uncommon in the Mackenzie Delta region (Mackay 1958, 1963), but are nearly absent in the more heavily glaciated areas of the Precambrian Shield. An interesting exception was the discovery of teeth of a ground sloth (Megalonyx cf. jeffersonii) and the fragment of a tooth mastodon (Mammut americanum) from

Lower Carp Lake north of Yellowknife (Stock and Richards 1949). The former specimen, when considered with a Megalonyx phalanx from near Fairbanks, Alaska (Stock 1942) and a Megalonyx tooth and phalanges collected from the Old Crow Basin (Harington 1970b), suggests that large ground sloths inhabited a rather broad east-west range in northwestern North America during a warm phase of the late Quaternary.

Vertebrate specimens collected from beaches on the Baillie Islands, identified by C.R. Harington for J.G. Fyles and V. Rampton of the Geological Survey of Canada, include: bowhead whale (Balaena mysticetus), polar bear (Ursus maritimus), ringed seal (Phoca (Pusa) hispida), woolly mammoth (Mammuthus primigenius), caribou (Rangifer tarandus), horse (Equus sp.), large-horned bison (Bison crassicornis), saiga antelope (Saiga tatarica), and tundra muskox (Ovibos moschatus).

Two successive types of environment are suggested by these specimens: (1) a loess-steppe environment (saiga antelope, horse, bison, mammoth, caribou and muskox); (2) a marine coastal environment (whale, seal and polar bear). The latter group of specimens could range in age from Quaternary to recent. The saiga fossil is the first recorded for Canada. Other specimens have been collected near Fairbanks and on the north coast of Alaska. Because saiga antelopes are particularly adapted to dry steppe grasslands, they probably crossed the wide, steppe-like plains of the northern Bering Isthmus from Eurasia and spread over the broadened Arctic Coastal Plain of North America as far east as Baillie Islands during glacial phases of the late Quaternary. The species became extinct in North America toward the close of the Wisconsin glacial, but survives in central Eurasia.

During the Wisconsin glaciation muskoxen (Ovibos moschatus) and caribou (Rangifer tarandus) may have survived in a Banks Island refugium, as is suggested, but not proved, by: (a) a radiocarbon date of over 34,000 years on a muskox bone from the Bernard River (Maher 1968); (b) a radiocarbon date of about 10,700 years on plant debris from north of Masik River which enclosed a muskox pelvic fragment (NMC 17685) of possible late Quaternary age from laminated sands containing plant remains on the south side of Masik River.

Fossil, beaver-cut sticks, which appear to be in place in buried horizons, have been collected in many parts of the Canadian Arctic. They have been found in interglacial deposits (beyond the range of radiocarbon dating) near Eskimo Lakes in the Mackenzie Delta, and at Worth Point, Banks Island. Sticks gnawed by beavers have also been found in organic sediments on west-central Ellesmere Island (e.g. Strathcona Fiord), but these may be of preglacial (late Tertiary) rather than interglacial age (Prest 1970; J.G. Fyles, personal communication 1971).

Mammoth remains have been reported from three islands in the Northwest Territories. Members of the Canadian Arctic Expedition under V. Stefansson collected most of an elephant tusk (Proboscidea cf. Mammuthus) near Cape James Ross on Melville Island (Kindle 1924). This is the most northerly record of mammoth for North America. The specimen (NMC 11833) is in the collection of the National Museums of Canada. A heavily worn molar of a Columbian mammoth (Mammuthus columbi ; NMC 17618) was collected from the rocky surface of Long Island in southeastern Hudson Bay in 1878 (Bell 1898). Presumably Columbian mammoths lived on temperate grasslands in that region during an earlier interglacial. In a census of mastodon and mammoth specimens in Canada, C.M. Sternberg (1963) listed a tusk from Pond Inlet, northern Baffin Island. The fossil was reported by Constable Dunn of the R.C.M. Police. But until the tusk can be located and examined by a paleontologist, the report must be regarded as doubtful.

A fauna, including collared lemming (Dicrostonyx torquatus), ringed seal (Phoca (Pusa) hispida), caribou (Rangifer tarandus), and muskox (Ovibos moschatus),was collected by Fielden (Fielden and De Rance 1873) near Alert on northern Ellesmere Island. This fauna, which was derived from raised beaches, is possibly of postglacial age. It is difficult to say whether the mammals represented spread to the area from the adjacent Pearyland refugium or arrived by a more distant route from a Banks Island refugium. Where muskoxen and caribou are concerned, existing fossil evidence tends to support the latter alternative (Harington 1970a).

Conclusions

It can be seen from postglacial faunas, such as those from Hamilton Bay, Ont.; Oxbow, Sask.; and Engigstciak, Yukon Territory, that many characteristic mammals of the ice age had died out in Canada over 5,000 years ago. Actually it was during the recession of the Champlain Sea (some 8,000 to 10,000 years ago) that important extinctions occurred - particularly among large mammals such as the mammoths and mastodons and their specialized predators. These late Quaternary extinctions affected mammals of other continents besides North America.

Why did such conspicuous extinctions of seemingly well-adapted, abundant mammals occur so late in the Quaternary? Because much evidence bearing on the problem is well-preserved due to its relative proximity in terms of geological time, it may be possible to discover the most important factors contributing to extinction at the end of the Wisconsin. It is worth noting that extinction of large ice age mammals in North America coincided with: (1) a rapid environmental warming, and (2) a rise in the number of human hunters. Perhaps both of these factors, or these factors together with others, were responsible for most extinctions. Despite the fact that many scientists have studied this problem, and that the recently developed technique of radiocarbon dating has contributed a wealth of information on the time of the extinctions, a generally accepted explanation is still lacking.

So far, man has responded to the challenge of the ice age, and during the last few million years has spread and multiplied from a small number of wandering bands to his present vast populations. Can he overcome the serious problem which these vast populations have created?

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A PROGRAM TO IDENTIFY AND MEASURE ALL THE GLACIERS IN CANADA

by

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Recommendations for the preparation of a complete listing of glaciers in the world was first made for the International Geophysical Year (IGY) in 1955. It was suggested that, as a minimum, information on the location, elevation, name, area and volume be provided. Several countries, including Canada, attempted to produce such a list. The Canadian study, carried out at the University of Toronto by G. and J. Falconer and R. Kellerhals, provided detailed information for Arctic Canada and summarized that for the mainland. The Arctic was divided into two main regions, the Queen Elizabeth Islands and the area south of Lancaster Sound, which were then subdivided. The poor definition of the small scale maps used (1:506,880) meant that it was not possible to divide up the ice masses into hydrological basins and individual glaciers although the main lobes and ice streams were marked and measured.

Because the response to the IGY proposals was not entirely satisfactory, and yet the information was still required, a similar program was suggested for the International Hydrological Decade (IHD). Dr. Fritz Muller of McGill University became Chairman of a Working Group set up to provide a guide for an Inventory of Perennial Ice and Snow Masses On and Beneath the Land Surfaces. This set the stage for the glacier inventory which has now been started and for the inventory of ground ice and permafrost which unfortunately has not.

Organization

In 1968, after the author had completed a pilot study for the glacier inventory of Axel Heiberg Island, a Glacier Inventory Section was established within the Glaciology Subdivision of the Inland Waters Branch. This group was charged with completing an

inventory of all glaciers in Canada in accordance with the recommendations made by the Working Group through UNESCO and the International Association of Scientific Hydrology. At present the personnel working on the project consist of two permanent staff, one casual assistant and one casual on a term appointment. During the summer this group may be augmented by up to eight summer students. For administrative convenience the work in the Glacier Inventory Section has been divided into three separate but closely related projects; glacier inventory, glacier atlas and glacier archive.

The Glacier Inventory

The glacier inventory project covers the basic compilation of data on all glaciers in Canada. The first stage of this work consists of the interpretation and annotating of photographs from the glacierized area being studied. The photos used are the standard vertical air photos available from the National Air Photo Library. Fortunately most of the arctic photography was taken late in the melt season so that some idea of the positive or negative nature of the glacier's mass balance may be obtained. From the interpreted photos basic work maps are prepared. Ideally the map scales used are 1:50,000 but few areas in the Arctic are mapped at this scale so the 1:250,000 maps, or advance prints at 2:125,000 have had to be used. Outlines of the glaciers, where different from the maps, are transferred from the photos, as well as details of drainage, ice, divides and snowlines.

The glaciers are colour-coded on the work maps, with separate colours for the accumulation and ablation areas, for debris-covered ice and for ice-cored moraines. The information required for the Standard Data Sheet (Fig. 1) is then measured from these maps using a D-Mac pencil follower interfaced with a PDP-8/I computer. This equipment provides the quantitative data on co-ordinates, elevations, lengths, widths and area. The other information, such as the glacier classification and orientation, is taken from the photographs. From these completed data sheets computer printouts are prepared for publication in a report series that also includes general information on the physiography, climate, history, map and photo sources and descriptions and summaries of the data.

For the region and basin identification necessary for the establishing of a unique number for each glacier, Canada has been divided into major and minor drainage areas (Fig. 2). In some cases, particularly for small Arctic ice caps, these divisions may not strictly follow drainage divides if it is decided not to dissect a particular glaciological unit. In the Arctic the reference system adopted is the Universal Decimal Classification for Use in Polar Libraries which was developed by B. Roberts at the Scott Polar Research Institute, Cambridge. For mainland Canada, where data from stream gauging stations are available, the subdivisions used by the Water Survey of Canada have been adopted with a decimal system prefix. Figures 3 and 4 show, for part of the mainland, how the major regions are subdivided down to individual basins. Some examples of this numbering system would be - White Glacier (Axel Heiberg Island) *46444E-15, Sverdrup Glacier (Devon Island) *46460E-28 and Barnes Ice Cap (Baffin Island) *46203A-1.

The Glacier Atlas of Canada

All glaciers in Canada, with their individual number will be shown on a series of index maps at a scale of 1:500,000. These maps, in four colours, are to be published at a sheet size of 11 x 14½ inches, the size of a standard computer printout sheet and, when completed, will form the Glacier Atlas of Canada. At least 150 maps will be required to cover all the glacierized areas. A decimal numbering system, which allows complete flexibility in the programming of which areas are to be examined, has been set up to facilitate indexing when the project is completed. All the Axel Heiberg Island maps, for example, will start with the number 4. and those for Baffin Island with the number 5. and so on. Thus the map of southern Axel Heiberg Island will be numbered 4.1, western 4.2 etc. The maps, to be published with the reports described earlier, will form the completed Glacier Atlas of Canada at the termination of the project and will be available in individual sheets to those working in specific areas.

The Glacier Archive

Once the glacier inventory is complete, the numbers of each individual glacier in Canada may then be used as a filing system for all available records, be they photos, maps, sketches, notes or data. This information, together with the computerized inventory data, will be used to select more representative

glaciers for future studies and as a basis for the assessment of glacier fluctuations. Basically it will be a glaciological data bank available to anyone planning to study Canadian glaciers.

How much has been completed?

So far the only complete inventory, that is to say the only inventory that includes information on the climate, history, physiography, etc. as well as the basic data and maps, is that for Axel Heiberg Island. Here 1,121 glaciers have been identified, covering 11,735 km^2, or 31.5% of the total land area, with an estimated 3,222 km^3 of ice. Baffin Island with 10,214 glaciers and Bylot Island with 575 have both been indexed and maps prepared. The survey of Devon Island, with just over 1,400 glaciers, is almost complete and it is hoped work will be started on Ellesmere Island this summer (1971). On the mainland, the work is more detailed because of the larger scale maps and photographs available. The inventories of the following areas are now reaching a final stage - Vancouver Island (208 glaciers), *5A (151 glaciers), *5B (470 glaciers), *5C (67 glaciers) and *5D (928 glaciers). Three other large basins in British Columbia are also under study but final figures on the number of glaciers are not yet available.

Using the data from the Axel Heiberg Island glaciers an analysis program has been developed that will sort the data according to the glacier classification or any of the data parameters. At present it is possible to obtain maximum and minimum values, averages, totals and histograms with variable step sizes and range limitations.

Conclusion

Today there is a need to look beyond the immediate confines of one small glacier to the area of which that glacier is a part and to the glacierized regions of the world. For national and global energy and water balance studies much better information on the extent and quantity of our present day ice cover is required if accurate models of our environment are to be produced. In a sense, glaciers act as water reservoirs augmenting stream flow in hot dry summers (contributing up to 80%) and storing excess precipitation in those cooler and wetter years when the water is not required. On the basis of current estimates, in area alone, the glaciers in Canada are half as large again as the total of our

seventeen largest lakes, yet the figure for the glacierized area could be out by 25% or more as was found for Axel Heiberg Island. For the Arctic, such a reduction would represent an apparent ice loss of 32,000 km^2.

The inventory, besides providing accurate data on the distribution and characteristics of present day glaciers, should also permit, through analysis of records in the archives, to determine the activity of glaciers in Canada over several decades and for much larger areas than has been done in the past. It could thus answer with somewhat more confidence the ever popular question - are the glaciers advancing or receding?

However, it is doubtful if much progress can be made so long as studies are confined to questions of area, volume or activity alone. The inventory, besides providing a necessary data base, must be used as a research tool. Researchers must look beyond their "pet" glaciers to the world outside and find out whether these glaciers are really as representative as has been claimed, determine how many other glaciers similar to the one being studied exist in the immediate field area and whether or not they are behaving in the same ways. It will now be possible to pre-select representative glaciers, at least in terms of their having the same area, the same elevation range and the same orientation, enabling researchers to look at regional mass balances and the importance of glacier melt in regional water balances. Finally, this program provides a tool with which to test glaciation limits and other such indices of glacierization with the real data, and, possibly, to develop new, less abstract, descriptors that are functions of the elevation ranges of present day glaciers.

DATA SHEET FOR CANADIAN GLACIER INVENTORY

(Figure 1)

Province or Territory: _____

Mountain Area: _____

Hydrological Basin:

1st Order: _____

2nd Order: _____

3rd Order: _____

4th Order: _____

Sources: Maps _____

Map Title and Number: _____

Compiled By: _____

Date: _____

Scale: _____

Contour Interval: _____

Reliability:

Vertical: _____

Horizontal: _____

Sources: Photographs

Type: _____

Serial Number: _____

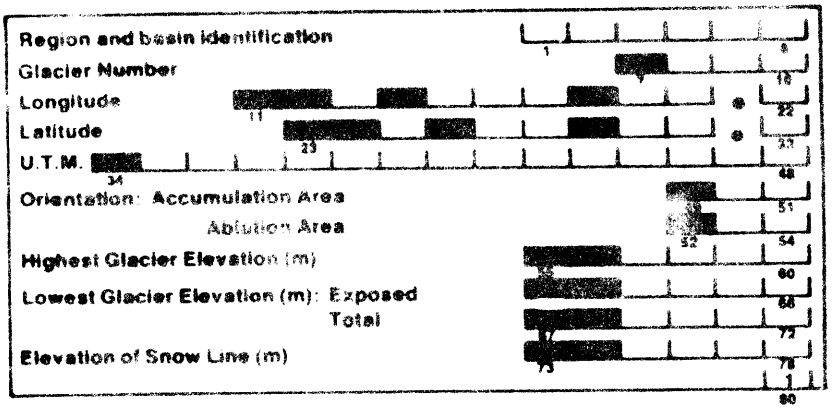
Date: _____

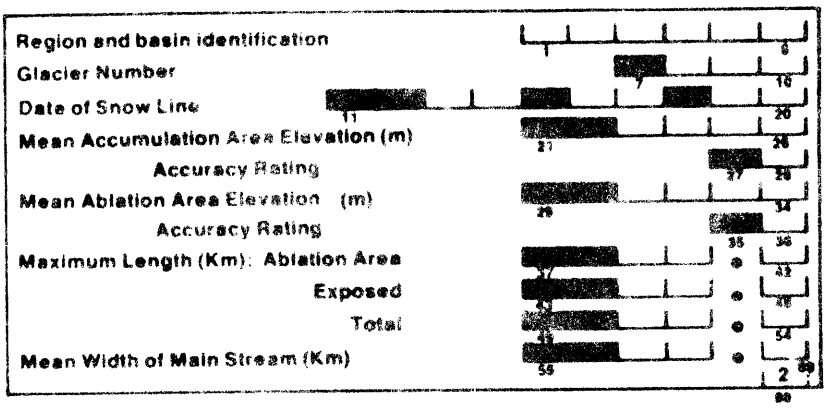
Flying Height: _____

Focal Length _____

Remarks: _____

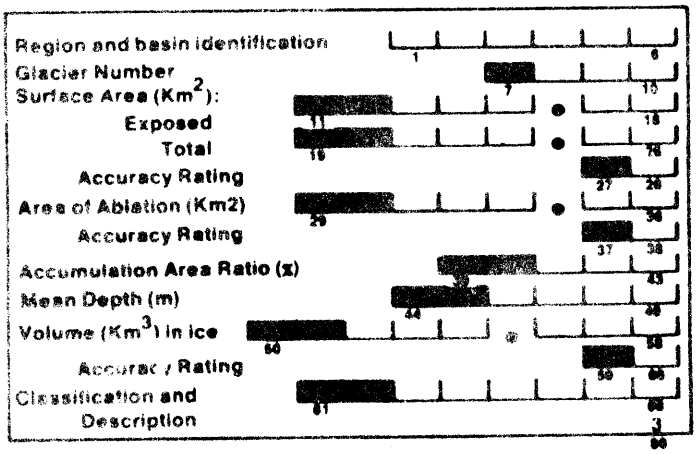
_____



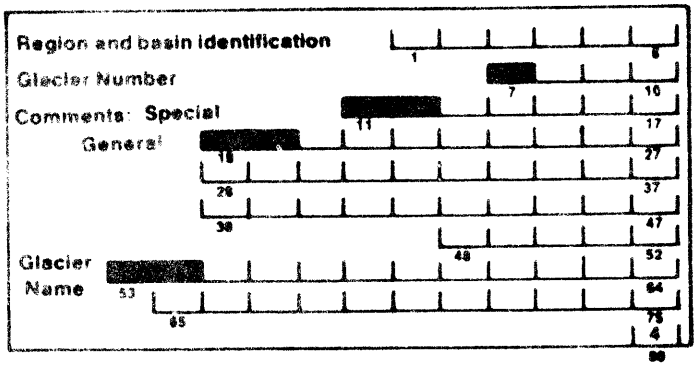


Work Done on Glacier: References

0	
1	
2	
3	
4	
5	
6	
7	
8	
9	



	Other Photos	Special	Moraine	Lake
0				
1				
2				
3				
4				
5				
6				
7				
8				
9				



Remarks _____

_____

_____

_____

Data Compiled by: _____

Date: _____

Supervisor: _____

Centre: _____

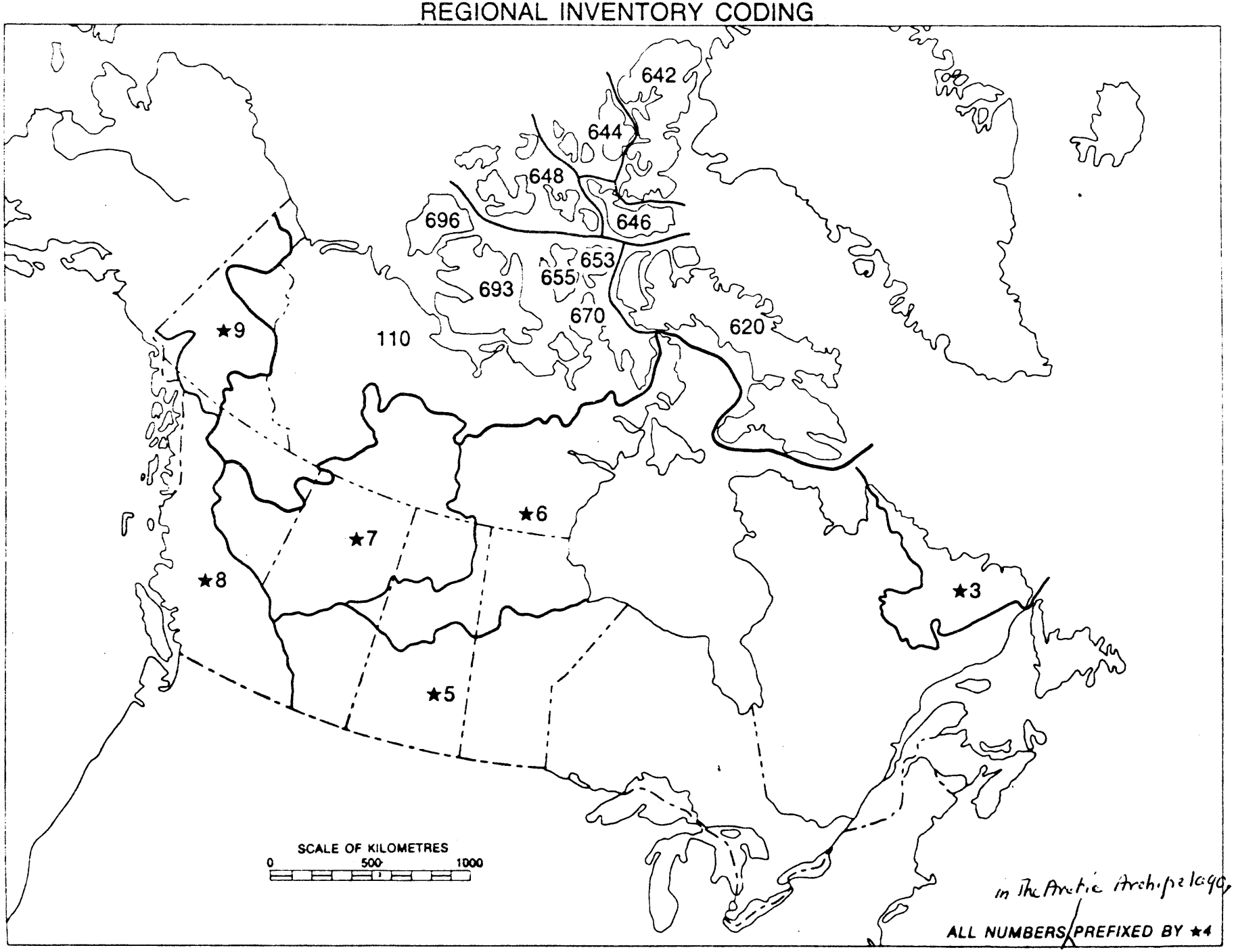

REGIONAL INVENTORY CODING
642
644
648
646
696
653
655
693
670
620
110
★9
★6
★7
★8
★3
★5
SCALE OF KILOMETRES
0
500
1000
in The Arctic Archipelago
ALL NUMBERS PREFIXED BY ★4

Figure 2.

AREA INVENTORY CODING

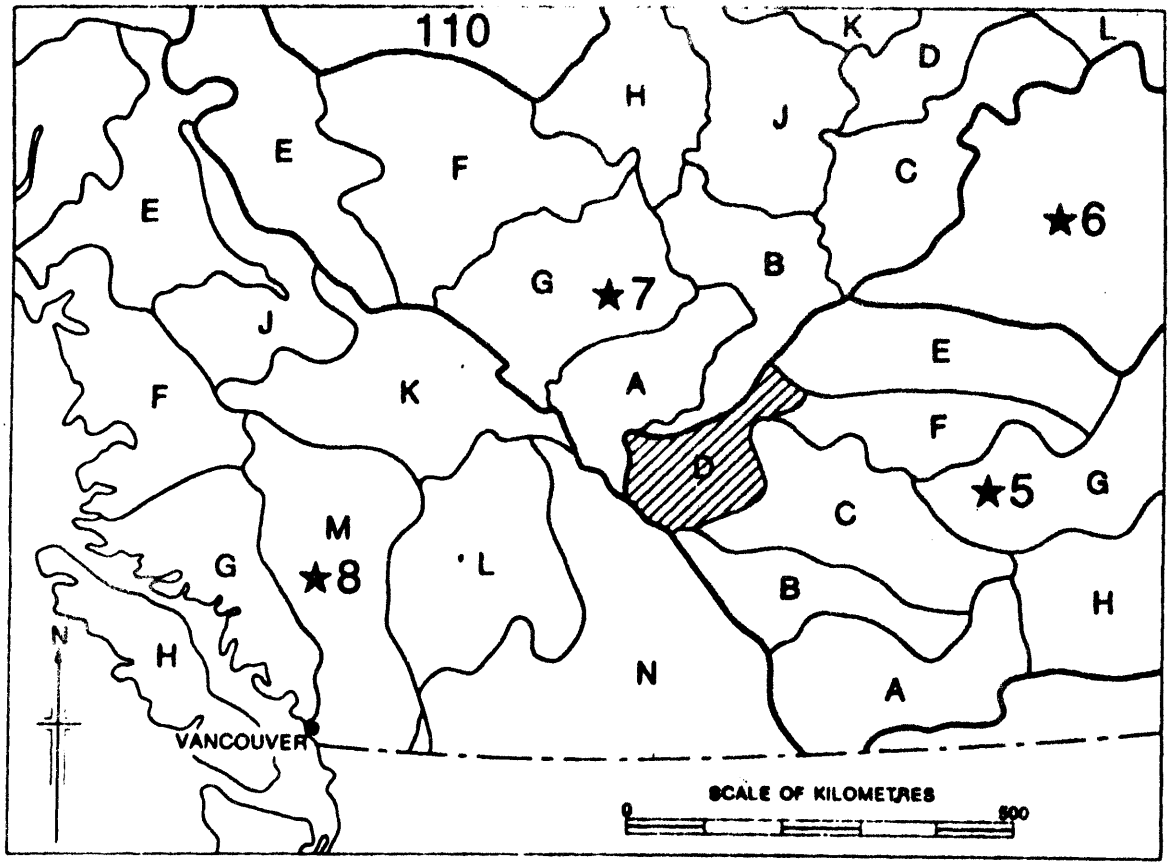


Figure 3

BASIN SUBDIVISIONS (AREA ★5D)

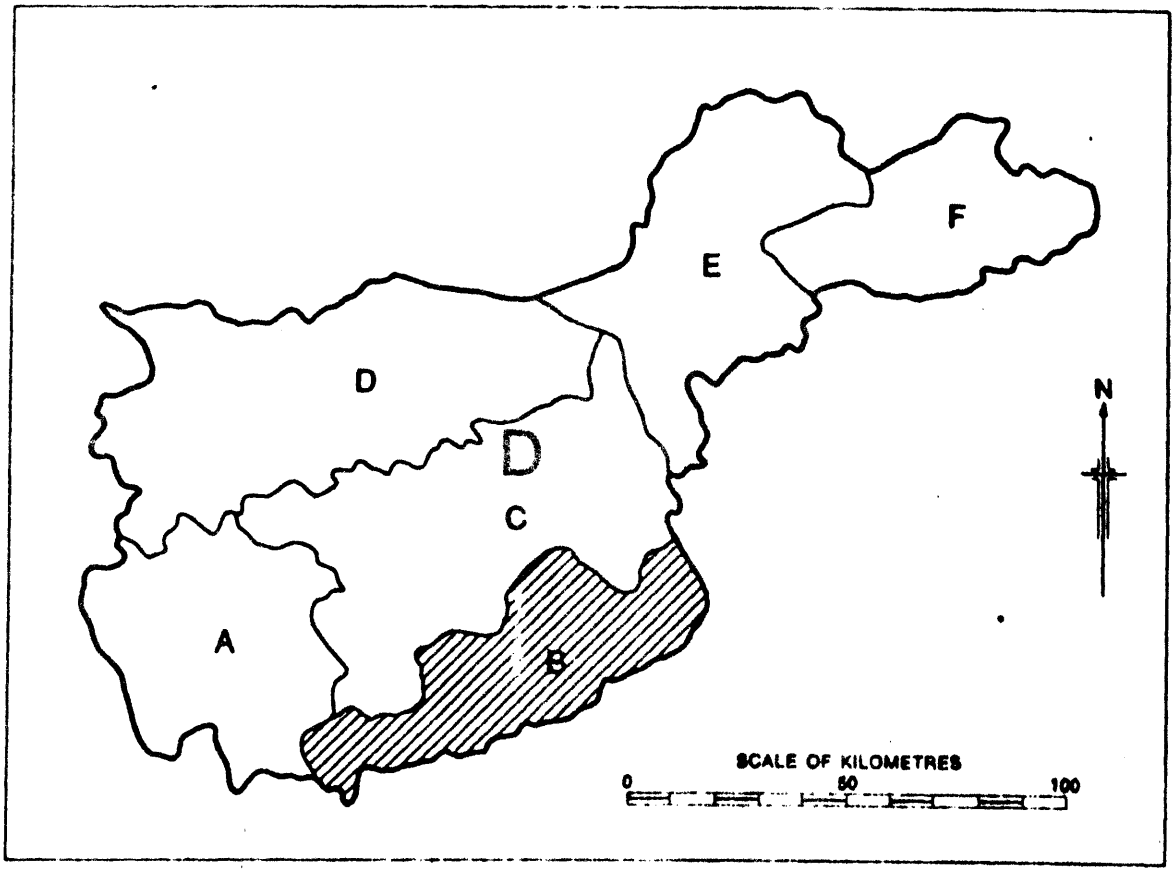


Figure 4

RIGHTS AND RESPONSIBILITIES OF ARCTIC COASTAL STATES: THE CANADIAN VIEW *

by

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Arctic Sovereignty

The term "Arctic sovereignty" has recently gained in currency, and nowhere more so than in Canada. Unfortunately, however, the term suffers from an inherent imprecision which has been aggravated by misuse. Indeed the very term "the Arctic" is itself used and understood in different ways in different contexts, thus compounding the confusion surrounding the notion of Arctic sovereignty.

What geographers refer to as the Arctic comprises the islands and continental fringes north of the Arctic Circle as well as the more than five million square miles of the Arctic Ocean (which itself is often referred to simply as "the Arctic"). Here precisely is the fundamental difference between the Arctic and Antarctic regions: whereas the Arctic consists of an ice-covered sea surrounded by land, the Antarctic is an ice-covered continent surrounded by open sea. The distinction is an essential one not only in geographic terms but also in terms of the applicability of legal principles to the two regions. Unfortunately, however, there is too often a tendency to treat the Arctic and Antarctic together from the legal point of view.

To speak of Arctic sovereignty in a generic sense, with reference to everything north of the Arctic Circle, is to suggest, contrary to all geographic, climatic, legal and political realities, that

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* This presentation of the Canadian viewpoint was given at the Conference on The Arctic Ocean held at Ditchley, England, in May 1971.

there exists a single Arctic region and that the sovereignty of that region remains somehow unsettled. In fact, of course, the Arctic comprises many distinct and widely varying continental, insular and marine regions. So far as the land regions are concerned, there are few if any questions of Arctic sovereignty which remain unsettled. While I cannot speak of other Arctic states, I must say that Canada is aware of no challenge to its sovereignty over the mainland and islands of the Canadian Arctic. Canada's sovereignty over these territories has been established beyond dispute under every test of law and fact since Canada fell heir to the rights of Great Britain in the 1860's and progressively extended its administration to the vast and complex system which today covers every sphere of activity throughout the whole of the Canadian Arctic. Similarly with respect to Canada's exclusive sovereign rights to explore and exploit the resources of its Arctic continental shelf. These rights, in the Arctic as elsewhere, are firmly established under both customary and conventional international law and flow from Canada's sovereignty over the lands adjacent to the shelf areas concerned.

I raise these non-issues only to dispose of them at the outset in order to ensure that the discussion at Ditchley is not diverted down any false trails connected with popular misconceptions about "Arctic sovereignty".

What, then, are the issues of international law which arise in the current debate on Arctic policy? The essential issue, and the one which I propose to examine, relates to the present and potential uses of the various regions of water and ice which together comprise the Arctic Ocean. Those uses are assuming ever greater importance as a result of the quickening pace of Arctic development, particularly as regards the large-scale commercial maritime traffic which will almost inevitably follow that development. The issue can be stated in these terms: Under what authority will the uses of the Arctic waters and ice be regulated and controlled (leaving aside the question of the exploration and exploitation of the continental shelf)? This, of course, is what is often loosely referred to as the "Arctic sovereignty" issue. It is also directly related to issues of international environmental law which in turn reflect national shipping policies and policies of resource development. Finally, the possible approaches to these matters are linked with the varying perspectives which have been

adopted in considering the nature and status of the Arctic waters and ice from the legal point of view.

Arctic Waters and Ice: Varying Perspectives

A number of states, and the USA in particular, have made clear their view that the Arctic Ocean as a whole is an ocean like any other. The proponents of this view hold that beyond the traditional narrow maritime belt of the territorial sea and contiguous zone (in the sense in which the latter term is used in the relevant 1958 Geneva Convention), the Arctic Ocean constitutes high seas and thus the regulation and control of activities therein is subject to the usual regime of the freedom of the high seas, that is to say to flag state jurisdiction so far as shipping is concerned.

Other views of the nature and status of the Arctic waters and ice have been expressed in other quarters. Professor Johnston of the University of Toronto has recently written that the Arctic "is an ocean because people have thought of it as such for a long time. More exactly it is a unique geographical area with some important oceanic properties. . . The Arctic Ocean is largely hypothetical, a peculiar combination of hypothetical waters and hypothetical islands, the distinction mostly covered over by large masses of ice."

The importance of the ice factor is also emphasized in an article in the US Naval Institute Proceedings of September, 1961 by Commander Partridge (a Law Specialist then on duty in the Executive Office of the Secretary of the Navy). He wrote that "the Arctic ice pack is, in fact, subject to occupation and usage very similar to that of certain land areas" and made the point that many Eskimos "are born, live and die on the ice pack without ever having set foot on any form of land or even on ice supported by land." In spite of limited operations by vessels within the Arctic Ocean area, he asserted,

> "the ice pack cannot be accurately described as freely and completely navigable by any known type of vessel. As a route of trade and commerce between nations, the pack ice is more likely to be traversed by dog-sled and snowcat than by seagoing vessels. The forcible navigation of this area by icebreakers is more in the nature of a rape of the frozen seas than it is the free movement of

> seagoing commerce upon which the doctrine of the freedom of the high seas is based. It is no more navigation in the accepted high-seas sense of the word than is the creation and navigation of a canal or ditch by a floating clam shell dredge. The ice so penetrated does not become sea any more than the land so penetrated becomes sea."

The views of Professor Johnston and Commander Partirdge as quoted above are very similar to those of the Canadian Government as expressed in a Note to the US Government of April 16, 1970 (in reply to a US Note objecting to Canada's Arctic waters pollution legislation). In that Note the Canadian Government stated that traditional concepts of the law of the sea were irrelevant "to an area having the unique characteristics of the Arctic, where there is an intimate relationship between the sea, the ice and the land." The Canadian Note added further that it is "idle to talk of freedom of the high seas with respect to an area, large parts of which are covered with ice throughout the year, other parts of which are covered with ice most of each year, and where the local inhabitants use the frozen sea as an extension of the land to travel on it by dogsled and snowmobile far more than they can use it as water".

The permanent or quasi-permanent presence of ice in vast parts of this "hypothetical ocean" gives rise to yet further special characteristics having legal implications. Thus, there are many Arctic regions - such as Canada's Northwest Passage and the USSR's Northeast Passage - where no international shipping routes have developed. Where shipping routes do exist in these regions they have been developed through the efforts of the adjacent coastal state, for which these routes have a vital significance. Navigation through such routes can normally be carried out only with the provision by the coastal state of a complex of special facilities and measures of assistance (such as meteorological and communications services, ice reconnaissance, aerial escort and ice-breaking and pilotage services.)

A final special characteristic of the Arctic waters and ice relates to what might be called the environmental perspective. The Arctic waters and ice have been described by Prime Minister Trudeau (in a statement made in April, 1970) as "one of the most significant surface areas of the globe, for it controls the temperatures of much of the Northern Hemisphere and thus its continued existence in an unspoiled form is vital to all mankind." The unique environmental

characteristics of the Arctic, with its minute rate of decomposition, its relatively low restorative capacity, and the hazards it presents for navigation, all make it particularly susceptible to pollution, and led the Prime Minister to observe on the same occasion:

> "Involved here, in short, are issues which even the more conservative of environmental scientists do not hesitate to describe as being of a magnitude which is capable of affecting the quality, and perhaps the continued existence, of human and animal life in vast regions of North America and elsewhere."

If all these special characteristics are such that the Arctic waters and ice do not constitute high seas to which the traditional freedoms apply, what then is the status of these areas and what regime should govern their use? So far as Canada is concerned, the special characteristics of the Arctic waters and ice combine to give them a special status - however defined - which implies special rights and responsibilities for the Arctic coastal states. Accordingly, for many years Canada has exercised effective control over the uses of the waters of the Canadian Arctic archipelago and over a wide range of activities carried out on their ice-cover. Indeed, as was most recently reaffirmed by the Secretary of State for External Affairs in April, 1970, "Canada has always regarded the waters of the Arctic archipelago as being Canadian waters and the present Government maintains that position."

It should be noted here that Canada's view of the special status of Arctic waters and ice and the concomitant special rights and responsibilities of Arctic coastal states is very similar to the attitude of the USSR as revealed in the writing of Soviet jurists and in Soviet state practice. Soviet jurists have gone so far as to describe the Kara, Laptev, Chukchi and East Siberian seas as internal waters, although the Soviet Government has never officially advanced such claims. The Soviet Government, however, has administered the Northeast Passage which crosses these seas as a national shipping route of the USSR. The Soviet Government has also clearly indicated its support for Canada's Arctic waters pollution legislation, to which I shall now turn.

Canada's Arctic Waters Pollution Legislation

The Arctic Waters Pollution Prevention Act which received Royal Assent on June 26, 1970 manifests in legislative terms Canada's view of the special status of Arctic waters and ice and the special rights and responsibilities of the Arctic coastal states, with particular respect to the preservation of the Arctic ecology. It reflects also the Canadian Government's policy on the environmental implications of economic development. As was stated in the Speech from the Throne by the Governor-General on October 23, 1969:

> "With resource development, and the benefits it entails, may come grave danger to the balance of plant and animal life on land and in the sea, which is particularly precarious in the harsh polar regions. While encouraging such development, we must fulfil our responsibility to preserve these areas, as yet undespoiled and essentially in a state of nature."

This position was further elaborated by Prime Minister Trudeau in the House of Commons on October 24, 1969. He said then that the Canadian Government would never sacrifice, in the name of progress, a clean and healthy environment to industrial or commercial development. With reference to the water, ice and land areas of the Canadian Arctic Archipelago, he said:

> "We do not doubt for a moment, that the rest of the world would find us at fault, and hold us liable, should we fail to ensure adequate protection of that environment from pollution or artificial deterioration. Canada will not permit this to happen. . . It will not permit this to happen either in the name of freedom of the seas, or in the interests of economic development."

It was against this background that the Arctic Waters Pollution Prevention Act was adopted. That act makes clear the Canadian Government's determination to discharge its responsibilities for the preservation of the Arctic environment, but without denying access to shipping from all nations in the waters of the Canadian archipelago and the Northwest Passage in particular. It seeks in essence to preclude the passage of ships threatening pollution of the environment. Commercially-owned ships intending to enter

waters of the Canadian Arctic designated by the Canadian Government as shipping safety control zones will be required to meet Canadian design, construction and navigational safety standards. These zones may extend up to 100 miles offshore. The owners of vessels and cargoes will be required to provide proof of financial responsibility and will be liable for damage caused by pollution.

Their liability will be limited but will not depend upon proof of fault or negligence. In the case of ships owned by another state the necessary safety standards will be given effect by arrangement with the state concerned. Similarly, protective measures will apply to exploration and exploitation of the submarine resources of Canada's northern continental shelf.

In introducing the Arctic waters pollution legislation in the House of Commons, the Secretary of State for External Affairs, the Honourable Mitchell Sharp, emphasized that the problem of environmental preservation transcends traditional concepts of sovereignty and requires an imaginative new approach based on objective functional considerations rather than territorial imperatives. While reaffirming that Canada has always regarded the waters of the Arctic archipelago as Canadian waters, he made clear that the Arctic waters pollution legislation did not represent an assertion of sovereignty but rather a constructive and functional approach whereby Canada will exercise only the jurisdiction required to achieve the specific and vital purpose of environmental preservation.

The Arctic waters pollution legislation does not make and does not require an assertion of sovereignty, no more than it constitutes a denial of sovereignty or is inconsistent with any basis for sovereignty. Together with this legislation, however, the Canadian Government adopted another act extending the territorial sea of Canada from three to twelve miles. An important effect of this action is that it brings two key "gateway" areas of the Northwest Passage, Barrow Strait and Prince of Wales Strait, indisputably under complete Canadian sovereignty under any realistic and reasonable view of existing international law,regardless of differences of views as to Canada's claim to sovereignty over the whole of the Northwest Passage.

International Environmental Law

Canada's Arctic waters pollution legislation responds to Canada's view of the special status of Arctic waters and ice and the special rights and responsibilities of Arctic coastal states. However, even if viewed from the perspective of the traditional law of the sea with all its deficiencies in terms of environmental preservation, the legislation finds support in both principle and practice.

The traditional law of the sea in general is oriented toward the concept of unfettered freedom of navigation on the high seas and thus favours flag-state jurisdiction while seeking to limit the jurisdiction of coastal states. As a result this essentially laissez-faire system is inadequate in its provisions for the prevention and control of marine pollution. Those provisions, as they are found in various conventions, do not properly recognize the paramount need for environmental preservation and do not strike a proper balance between the interests of the flag states in unfettered rights of navigation and the fundamental interest of the coastal states in the integrity of their shores. Flag-state jurisdiction does not carry with it, for instance, the logical consequence of flag-state responsibility for damage to the environment. The whole system is particularly inadequate, as the principle on which it rests is particularly irrlevant, to the special situation pertaining in the Arctic.

At the same time, however, the freedom of the high seas has never been applied in absolute terms and has been qualified, for instance, to provide for universal jurisdiction with regard to crimes of piracy. Moreover, state practice - and the practice of the major maritime powers in particular - conclusively established that states may and do exercise authority over foreign vessels on the high seas in order to prevent injury to their territory and to defend their security and well-being. In the view of the Canadian Government a serious threat to the environment of a state represents a threat to its security. The right to the environmental integrity corresponds, after all, to the right to territorial integrity. Thus the fundamental principle of self-defence permits the state so threatened to take the reasonable preventive protective measures which may be appropriate to the situation. This principle of self-defence against a threat to environmental integrity was invoked by the Canadian Government in bringing forward its Arctic waters

pollution legislation which stresses preventive measures of protection above all and accordingly is at variance with the 1969 Brussels Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties which in effect stipulates that the stable door should be locked only after the horses have been stolen.

It should be recalled here that one of the primary justifications for President Truman's unilateral assertion of United States jurisdiction over the resources of the continental shelf was the principle of "self-protection" which compelled the "coastal state to keep close watch over activities off its shores which are of the nature necessary for utilization of these resources." Security and self-defence are concepts which have been broadly interpreted within the framework of the law of the sea, as noted by McDougal and Burke (in "The Public Order of the Oceans"): "In terms of impacts on its total value position - that is, security most broadly conceived - coastal states commonly and realistically perceived that acts beyond the territorial sea may have harmful effects". These learned authors go on to state:

> "The proposed limitation of permissible purposes for contiguous zones in the reference to 'customs, fiscal, sanitation, and immigration' is certainly no accurate summary of the purposes for which states have in the past demanded, and been accorded, an occasional exclusive competence in contiguous waters. Their mutual demands, and reciprocal deferences, have extended, as we have seen, to important common interests in relation to security and power, as well as to other forms of wealth protection. With developing technology and expanding enlightenment, new uses of the oceans, portending also new benefits and harms unique to particular states bordering on the oceans, would appear certain to emerge. It can scarcely be regarded as an appropriate clarification of the common interests of states to project a formulation of the purposes for which they may exercise a reasonable exclusive competence which both omits important contemporary shared interests and foreclosures the future protection of new, emerging interests, whatever their importance or urgency. . .

> "The projection of a single permissible width of twelve miles, similarly, bears no discernible relation to the flexibilities in widths demanded and honored in past practice. States have in the past found very different widths necessary to the reasonable protection of different interests under different circumstances, and upon occasion have insisted upon, and been accorded, an exclusive competence at distances much beyond twelve miles from their coasts."

With specific reference to the pollution of the marine environment, McDougal and Burke conclude as follows:

> "Since the impact of pollution is usually upon coastal residents, the coastal state has an understandable interest in preventing the discharge of oil and other substances in such a way that harmful pollution results. If it were practicable for the coastal state to enact and enforce prohibitory regulations applicable in adjacent areas, there would seem to be sufficient justification for considering this permissible under general community policy."

It would be a distortion of the freedom of the high seas to view it as a license to pollute the marine environment and the shores of other states, and to argue that states are barred from taking preventive protective measures against polluting activities on the high seas. Such a view runs counter to the fundamental principle of international law laid down in the Trail Smelter Arbitration more than thirty years ago. The tribunal in that case declared that "under the principles of international law ... no state has the right to use or permit the use of its territory in such a manner as to cause injury by fumes in or to the territory of another or to properties or persons therein when the case is of serious consequence and the injury is established by clear and convincing evidence." Many of the precedents cited in this case related to water pollution controversies, and it is not unreasonable to assume that what the Tribunal had to say about pollution by fumes is equally applicable to water pollution. Indeed it has long been accepted that the users of a common water resource should not pollute this water so as to cause damage to one another. This is one of the fundamental provisions of the 1909 Boundary Waters Treaty between Canada and the USA and has been recognized as a rule of general applicability by the International Atomic

Energy Agency panel of experts on the disposal of radioactive waters in fresh water. Further authority in this field is also provided by the decision of the International Court of Justice in the Corfu Channel Case which held that every state is under an obligation "not to knowingly allow its territory to be used for acts contrary to the rights of other states."

If a state is forbidden to use its own territory, where it enjoys full sovereignty, in such a manner as to cause injury to another state, it would be only good law and good logic for this same principle to apply even more forcefully to areas not under its sovereignty or exclusive authority, such as the high seas. Canada like many other states has been the victim of incidents arising from an irresponsible use of the seas which have resulted in serious damage to the marine and coastal environment. For Canada, with its long coastline, much of it within Arctic areas, remedial measures are not enough. Preventive protective steps such as those embodied in Canada's Arctic Waters Pollution Prevention Act are required.

Conclusion

There is, in the Canadian view, an urgent need for concerted international action to accelerate the pace of development of a body of international environmental law capable of meeting the challenges of modern technology and the requirements of modern society. So far as the marine environment is concerned, in the absence of international regimes capable of providing the necessary protection for coastal states, unilateral measures based substantially upon customary international law but, to some extent, breaking new ground have imposed themselves. State practice is an essential part of the international law-making process and, where there is a lacuna in the law, may be the only means for a state, acting reasonably and responsibly, to protect itself. This applies with particular force to the Arctic waters and ice in view of their special characteristics and the special rights and responsibilities to which they give rise for the Arctic coastal states, especially with regard to the preservation of the uniquely vulnerable Arctic environment. Thus the Canadian Government embarked upon a unilateral course of action which is both compatible with existing law and in advance of it; both

based on the most fundamental principle of the law and pressing against its furthest frontier. It is for this reason that the Canadian Government, at the time of introducing the Arctic waters pollution legislation, simultaneously terminated its declaration of acceptance of the compulsory jurisdiction of the International Court of Justice and submitted a new reservation excluding disputes related to the control of marine pollution and the conservation of the living resources of the sea. In a statement to the House of Commons on April 8, 1970, the Prime Minister reaffirmed that Canada strongly supports the rule of law in international affairs. He pointed out, however, that Canada was not prepared to engage in litigation with other states concerning vital issues where the law is either inadequate or non-existent and thus does not provide a firm basis for judicial decision. In this connection it should be noted that the new Canadian reservation does not apply to the establishment by Canada in June, 1970 of a 12-mile territorial sea, since the Government considers that international law on the latter question, while unsettled, is sufficiently developed to permit the Court to arrive at a judicial decision in any dispute on this matter.

Meanwhile Canada is not ignoring the multilateral approach to environmental protection. The Canadian Government is consulting and cooperating with a number of other states on the possibility of convening an international Arctic conference which might develop internationally-agreed standards of navigational safety and pollution control in Arctic waters both within and beyond the limits of national jurisdiction, to complement the protective action taken by Canada itself under its own legislation. This multilateral initiative, it is hoped, would cast an international legal umbrella over the exercise of the special rights and responsibility of Arctic coastal states with respect to the preservation of the Arctic environment, while avoiding any prejudice to the positions of contracting states on the law of the sea and the appearance of a precedent for unwarranted encroachments on the freedom of the seas.

In summary, Canada's position with respect to the protection of the Arctic environment rests upon the special situation pertaining in the Arctic, the fundamental rights of self-defence, and the

general principle that states have a duty not to use or permit the use of their territory or of areas beyond national jurisdiction in such manner as to cause injury in or to the territory or environment of another state. These latter two points apply as well to the protection of the coastal environment generally. On the basis of these concepts, and with its combined unilateral and multilateral approach to the Arctic waters problem, Canada is seeking to contribute to the progressive development of international environmental law. It was with the development of such a body of law in mind that Prime Minister Trudeau described the Arctic waters pollution legislation as "an assertion of the importance of the environment, of the sanctity of life on this planet, of the need for the recognition of a principle of clean seas, which is in all respects as vital a principle for the world of today and tomorrow as was the principle of free seas for the world of yesterday."

ARCTIC SURVIVAL AND SIR JOHN FRANKLIN:

or

Three Incredible Things for Breakfast

by

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Edmonton 20 March, 1971

As part of the 1970 Northwest Territories Centennial Year celebration, the University of Alberta Boreal Institute conceived and sponsored an archaeological expedition to Sir John Franklin's Fort Enterprise. The major purpose was to locate and excavate as far as possible the remains of the Winter Lake outpost.

The field party consisted of six members including one Territorial Government Advisor. Represented in this group were specialists from the natural sciences and humanities. Specialties ranging from archaeology and history to geology, palynology and soils science gave the project an interdisciplinary quality. A total of five weeks of July and August were spent on the site.

A primary effort during this period was directed toward partial excavation of the largest of three buildings which comprised the site. This was not only to confirm but to augment the historic record as contained in the written journal of Sir John Franklin (1969). Beyond this task, an effort to gain some intimate knowledge regarding the total area was made. It was hoped that some new data could thus be brought to bear on the circumstances which played an important part in the successes and failures met by Franklin's first overland expedition.

For the purposes of this paper it is not deemed necessary to engage in a detailed discussion of the archaeology. This will be reported elsewhere (Losey and Bond in press). Suffice to say that, in the main, archaeological evidence confirmed major events referred to in the written record. Such things as dimensions and positions of buildings, location of rooms, fireplaces, etc. are all archaeologically recoverable data. Specific activities and happenings such as tearing up floor planks for fuel, excessive rain causing the mud covering to slide from the roof, and even melting of pewter cups for musket balls were confirmed in the archaeology. The total artifact inventory is small as might be expected. Fort Enterprise was not a trading post but winter quarters, and later, a haven for members of a scientific endeavor. The site was actually occupied for only nine months during 1820-21.

Environmental data ranging from climatic to physiographic have only begun to be analyzed. Several interesting points are already emerging which appear to have some bearing on effects which the environment had on the Franklin party and also, those the party had on the environment. The environment, in turn, seems to have reciprocated by causing certain "discomforts" suffered by the survivors of the Franklin expedition.

The statement that Franklin probably knew less about the North than did the Apollo Astronauts about the moon is a reasonably accurate one. The fact that little if anything was known about the Far North is easily documented (Nanton 1970). This refers particularly to the severe limitations placed on the human species by the extremes of northern climate. The rugged, boulder strewn terrain resulting from repeated glaciation is another factor to be seriously considered by the traveller. Water travel from the earliest times has been a traditional method of transport (Morse 1967). Only the indigenous native population knew the subtleties of the North and could survive its rigours.

It is a fact that travel by land in the Canadian Barrens was not sufficiently developed until nearly thirty years following the first Franklin expedition of 1819-22 (Neatby 1958:140). This resulted mainly from the long search for Franklin's third expedition (1845) and extended well into the 1860's. Many unnecessary hardships were endured by early explorers simply due to their lack

of knowledge and the failure to recognize native methods of susbsistence and survival as worthy of attention.

At Winter Lake evidence of human occupation prior to Franklin's is abundant. The area is literally laced with caribou (Rangifer tarandus) trails which flow southward from the barrenlands. The pattern of caribou migration has a long history and evidence of prehistoric utilization of this pattern is concentrated along the major migration routes. Franklin, influenced by his Copper Indian guide Akaitcho, chose the site of Fort Enterprise partly for availability of building material. Akaitcho urged this decision for he knew the migration pattern (Franklin 1969:204). If the Fort had been constructed away from the route of migrating herds of caribou, the party may well have perished in its first winter.

But a strange and unfortunate accident occurred the very day the party landed at Winter Lake which may have upset this pattern. A signal fire was lit

> . . . on the south side of Winter River to inform the chief (Akaitcho) of our arrival, which spreading before a strong wind, caught the whole wood, and we were completely enveloped in a cloud of smoke for the three days following. (ibid:222).

It is a well established fact that forest fires in the North are extremely devastating (Scotter 1964). Regeneration in this delicate environment is very slow. Following a severe fire where the humus is completely destroyed, 100 years may be required before regeneration occurs and vegetation is restored. The winter range of the Barren-ground Caribou is directly affected by such burned over areas. Such areas are deliberately shunned by the animals until normal vegetation cover, particularly of lichens, is restored.(ibid).

Bearing this in mind, one can speculate on the effects caused by the runaway fire along the banks of Winter River. Certainly a three day burn would have destroyed a considerable tract of natural caribou range-land in this very strategic area. One wonders how important this was one year later when the survivors of the Franklin party returned to Fort Enterprise, starving, and unable to procure any meat save the occasional partridge. Franklin

cites only one instance where caribou were sighted near the house; 30 October, 1821 (1969:447). By this time the animals should have been numerous as they began to migrate through the forest/tundra toward the winter range (Kelsall 1968:132). During this same month one year prior, Franklin reports having stored for the winter 180 carcasses of "deer" (ibid.:245). Was the migration pattern upset by the careless signal fire set the year before? It is certainly an interesting possibility.

Other, perhaps not so devastating environmental effects, were also observed at Fort Enterprise. Coring of spruce trees (Picca glauca) and (P. mariana) in the vicinity gave rise to the fact that no trees within 100 to 150 yards of the site were in excess of 150 years old. Trees beyond this perimeter were found to be upwards of 175 years old. Although no detailed study was undertaken, evidence suggests that a time lapse of from 15 to 25 years may be involved between initial tree removal and subsequent regeneration. The effect is simply the result of tree utilization in the building of the three structures comprising the site.

Here again there seems to have been reciprocal environmental effects in regarding the Franklin party. Following the return overland to Fort Enterprise from the Arctic coast, (a circumstance forced by an early onset of winter), six survivors of an original 19 found themselves faced with two basic human requirements: food and warmth. The lack of fuel for the fireplaces forced the men to tear up the flooring for that purpose (ibid.:438). Archaeological evidence confirmed this. Later the storehouse was dismantled for the same reason (ibid.:464). By this time the effects of slow starvation were making themselves felt. No man was capable of navigating the required distance through deep snow to the standing timber. On the day of their rescue Franklin remarked that the Indians

> . . . brought in a pile of dried wood, which was lying on the river-side, and on which we had often cast a wishful eye, being unable to drag it up the bank. (ibid.:468).

It is interesting to note tha a small Dogrib Indian settlement less than forty miles downstream from Fort Enterprise was recently abandoned under almost identical circumstances.

In connection with the quest for food Franklin recalls,

> We. . . were gratified to find several deer skins (caribou) which had been thrown away during our former residence. The bones were gathered from the heap of ashes, these with the skins, and the addition of the Tripe de Roche, we considered would support us tolerably well for a time. (ibid.:438).

The bulk of this refuse was deposited in a trench which paralleled the west wall of the kitchen. These bones and other debris were found along with repeated layers of wood-ash and calcined bone derived from fireplace sweepings.

Some further points of interest have come to light as a result of soils studies conducted at the site. The Winter Lake area lies within the permafrost zone of Northern Canada (Brown 1970). Maximum thaw in this area occurs in late August at which time the permafrost lies about 30 inches below the surface. During the Spring and early Summer the ground is sodden to the point of saturation owing to the rapid spring thaw. Freezing and thawing occurs repeatedly throughout this time. There is no reason to assume that similar conditions did not prevail during the Spring and Summer of 1821 following the departure of the Franklin party down the Coppermine River to the Arctic Sea.

A soup which provided subsistence for 27 days (11 October to 17 November, 1821) was, as mentioned, derived largely from the refuse pile. It was reported that, "The bones were quite acrid, and the soup extracted from them excoriated the mouth. . ." (Franklin 1825:440). Some of the men could not keep this liquid in their stomachs while others refused it altogether. Two of the Canadians, (Samandre' and Peltier) both died on the night of November 1st. Although their deaths cannot be attributed to much more than their generally poor physical condition, it is suggested that the ingestion of the bone-soup did nothing to improve it. It is further suggested that the soup may, in fact, have contained a substantial quantity of lye!

One very old and common method of procuring lye for the manufacture of soap involves saturating a quantity of wood ashes with water and draining this mixture through a cheesecloth. This renders free two soluble alkali compounds, potassium hydroxide

and sodium hydroxide. It is essentially the same process which would have occurred in the refuse heaps as the earth became saturated with spring meltwater. The alkali would have been in solution for a time and later precipitated in greater concentration at depth, perhaps at the base of the refuse heap. Bones subsequently gathered from this deposit and boiled would again release the lye in solution, this time in the soup broth; a bizarre but nevertheless quite substantial reason for the continued ill health suffered by these men.

The above discussion may seem to some rather speculative. Some of the inferences are substantial while others may be disregarded in the final analysis. However, the trend in contemporary archaeology is toward a greater understanding of man and human behavior in the context of his environment. It has been a particularly fruitful approach to problems in prehistory. The writer suggests it is applicable to historical and modern problems as well.

Looking ahead, much is yet to be done before a final analysis and interpretation can be forwarded concerning these and other data. Climatic information gathered during August, 1970 is being compared with that recorded for the same month in 1820. This comparison may be instructive in interpreting pollen assemblages recovered both from the modern surface and from beneath the buildings at Fort Enterprise. In connection with this, soils analyses are in process to determine the exact nature and development of the forest/tundra transition. An inventory of the local flora is also being compared to the assemblage recorded by Franklin. Artifacts, bones and structural features recovered from the site are in the final stage of analysis and a full report will soon be forthcoming.

If this discussion of relationships between man, i.e. Franklin, and his environment is of no other value, it is at least timely. It is perhaps instructive to observe effects and counter-effects which can occur through abuse or mismanagement of environmental resources. Today, in North America, man has infinitely more destructive potential than he did 150 years ago. The Canadian North (Sir John Franklin's North) is presently undergoing rapid development. Canadians should take a long, hard look at this development to be certain that it does not cause serious,

irreversible damage to one of the world's last and largest natural wilderness resources -- Canada's Northwest Territories.

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NORTHERN PIPELINES

Since World War II there has been increasing oil and gas exploration in northern North America. The major advances in gross national product, standard of living and technology have so increased the demands for energy that fuel supplies on this continent are becoming critical. With growing demand providing the impetus for further exploration, a major oil and gas discovery at Prudhoe Bay, Alaska, brought into focus the need to devise means for transporting hydrocarbon fuels to energy-hungry, southern markets.

Almost parallel to the extension of oil and gas exploration was the growing concern for the environment. Due to the vast increase in human activity, the disposal of waste and the damage to the environment have quickly approached proportions such that the essentials for man's living are being endangered. Economic development can no longer be undertaken without regard for detrimental effects it may have on the environment.

Oil transport by tanker to various parts of the North American continent, and off-shore drilling operations, have identified the far reaching effects of these environmental hazards: the Arrow incident in Chedabucto Bay and the Standard Oil of California accident in San Francisco Bay were two preventable accidents where adequate controls were missing.

Humble Oil was one of the first major oil interests to take steps to examine possibilities of Arctic oil transportation to southern markets. The two cruises of Manhattan, a specially designed oil tanker, into the Arctic proved that ships could navigate the Arctic waters in any season. These cruises did however point out the hazards and high cost involved in such transport for north slope hydrocarbon fuels.

While Humble Oil was investigating the possibility of sea transport the Trans Alaska Pipeline System (TAPS) was formed to examine the possibility of transporting hydrocarbons by pipeline from Prudhoe Bay. Walter Hickel, then Secretary of the Interior, foresaw "great benefits to the State of Alaska by such development" and

TAPS, assuming no problem in obtaining formal authority for its operations, continued its preparations.

Meanwhile, the United States had passed the Environmental Policy Act which provides a definite routine to ensure that all aspects of development are examined before permission to operate is granted. In the course of TAPS operations, parts of this Act were contravened, and the pending settlement of aboriginal entitlement resulted in legal action to stop the TAPS development.

The Trans Alaska Pipelines Systems proposal, to be successful, must include a sea route down the west coast of North America to oil refining facilities at Puget Sound. This facet of the system is being bitterly criticized by Canadian and United States interests concerned with possible oil spill damage on the west coast.

It is thought that the United States will make a decision on the Alaskan route late this year. Rogers Morton, the new Secretary of the Interior, has stated that the decision is the most difficult one his department has ever faced. It may well be that the Department of the Interior will only make recommendations to the President's Environmental Advisory Board and that the final decision will rest with the President.

When further development of Prudhoe Bay reserves outlined the vast extent of the field, a Canadian pipeline was considered economically feasible. It would appear to offer the most convenient means of transporting the hydrocarbons to the mid-continent where the largest market exists. It should be noted in this connection that the natural gas requirements of this market are perhaps even more critical than those of oil.

Wishing to ensure logical development and to protect her public interest, Canada organized a Task Force on Northern Oil Development, headed jointly by the Minister of Energy, Mines and Resources and the Minister of Indian Affairs and Northern Development. In August 1970, they indicated the guidelines to be followed by those wishing to construct pipelines in Canada's northland. Oil and gas producers, together with major pipeline operators, then formed consortiums to examine the problems involved and to collect the information required for authority to proceed. There are now four

groups engaged in research and planning for Canadian pipelines: Mackenzie Valley Pipeline Research Limited; Northwest Project Study Group; Gas Arctic Systems Study Group; and Mountain Pacific Project.

The first consortium is studying oil pipeline problems, whereas the other three are interested in gas pipeline development. These four groups are spending approximately 25 million dollars on technical and environmental research. Research facilities to study the special problems of construction and operations inherent in northern pipelines have been constructed at Inuvik and north of Norman Wells.

The Canadian Government Task Force (whose composition is shown on the accompanying chart) is coordinating the gathering of data within the Government to ensure that applications by industry can be examined critically to assure that all aspects are thoroughly investigated. Further guidelines are expected to be given industry by the Task Force relative to environmental and social requirements and, possibly, Canadian content.

In Canada, the procedure to be followed to obtain authority to install a northern pipeline includes an application to the National Energy Board. It is the responsibility of the National Energy Board to ensure that Canadian requirements as to the technical feasibility of the proposal are satisfied, and public hearings must be held to ensure that the proposal does not create some unjust circumstance in the public sector. A further authorization required is the acquisition of a land tenure agreement for use of the proposed pipeline right-of-way. This authority is issued by the Department of Indian Affairs and Northern Development under the Territorial Lands Act and may also require public hearings before authority is issued. The National Energy Board approval of the Application entails an authority called a Certificate of Public Convenience and Necessity which may be conditioned to provide special stipulations. Land tenure agreements may also include restrictive covenants to provide special conditions for construction and operations.

Applications from industry are expected within the year but it is very doubtful whether the government will reply before 1973.

As yet, no pipeline routes through Canada have been designated although the oil and gas industry is now examining certain areas in detail. The decision of the United States on the Alaska route will have a great bearing on the possibility of an oil pipeline through Canada. The construction of a gas pipeline appears to be more probable but its justification may depend on the amount of gas the Prudhoe Bay field produces.

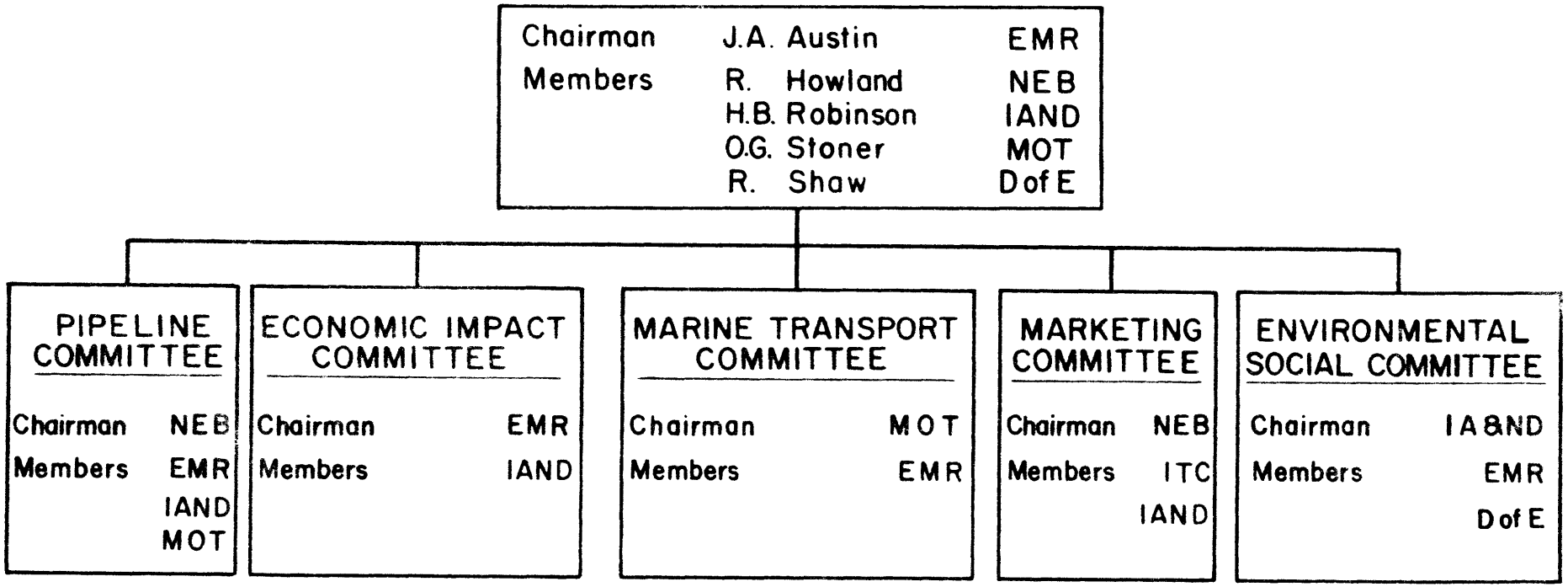
Hydrocarbon resources have not yet been discovered on the Canadian mainland in sufficient supply to justify construction of major trunk pipelines. The prospects that large hydrocarbon discoveries may be made in Canada seem good, and, with pipelines from Prudhoe Bay through the area where such discoveries would most likely be located, such oil and gas as may be found could also be transported directly to southern markets.

Arctic island gas discoveries are encouraging and the Gas Arctic Systems Study Group is initiating studies on means of transporting gas from the islands. The technical aspects are very different from those on the mainland. It may well be that the technique will involve liquefaction and ship transport although, as yet, liquefied natural gas is not competitive costwise with piped natural gas.

The Canadian economy is based in large measure on natural resources including the oil and gas contained in the thick beds of sedimentary rocks around the circumference of the Canadian Shield, particularly in the Mackenzie Valley and throughout the Arctic islands. For the past twenty years, efforts have been made to establish an economic base for northern development and it may well be that hydrocarbon production will be the key. Such development, however, must be so planned to give the necessary protection of the environment and assurance that no irreparable processes are established must be present.

The technical problems involved in construction of oil pipelines in the North are different from those of gas pipelines - and both are different from the problems of pipelines farther south. The logistics involved are difficult but the stakes are high. By careful controlled development there is a good possibility that Canada's northern territories are on the brink of a major economic development but one in which, hopefully, exploitation of resources will be balanced with protection of the environment.

TASK FORCE ON NORTHERN OIL DEVELOPMENT



EARLY KAYAKS

In the Arctic Circular, Vol. XVII, No. 2, Gert Nooter describes his search for old kayaks in Holland and his success in locating nine.

At Trinity House in Hull, England, there is a kayak that is probably older than any of those found in Holland. The kayak has a wooden frame covered with sealskin, a double paddle, and a wooden figure which was carved in Hull in 1619. Hunting equipment includes a sealskin float with a coiled line in the normal circular line-holder, and a bird dart. From an illustration in Country Life for March 25, 1971, it appears identical with kayaks used in Greenland in modern times.

The kayak was given to Trinity House in 1613 by Andrew Barker. It was presumably brought back by him from Greenland the previous year. Barker had been master of the Hart's-ease, the smaller of the two ships on Hall's fourth voyage to Greenland. Hall was slain by an Eskimo, apparently avenging a party of Eskimos killed by Hall during a previous voyage, and Barker then took over as master of the other ship, the Patience.

G.W. Rowley

NEWS ITEMS

Arctic Summer School, Inuvik,
July 11 to 30, 1971

Last year Mr. Alex Hemstock, Regional Arctic Co-ordinator for Imperial Oil Ltd., proposed an arctic summer school. The purpose as outlined in the subsequent brochure, was to "provide senior and middle management people from private industry and government organizations with an opportunity to become familiar with developments in northern Canada."

The University of Alberta, through its Boreal Institute and Extension Department, agreed to give the course, and with the co-operation of the Commissioner of the N.W.T., arrangements were made for the course at Inuvik.

The participants in the course were forty-six in all, representing the following groups:

Industry (oil, gas, construction)	19
Federal Government Departments	16
Universities	4
Territorial Government	3
Provincial "	2
Private Research	1
Committee for Original Peoples Entitlement	1

The total group of participants included one Eskimo, one Indian and one Métis resident of the N.W.T. Other residents attended the course intermittently by invitation.

Most of the participants and the instructors were housed in Grollier Hall, a school residence operated by the Oblate order. With the exception of some evening seminars held in the Hall, classes were held in the Samuel Hearne high school.

The instructors were:

Engineering

R. Alex Hemstock,	Imperial Oil
S.J. Glenn Bird,	University of Toronto

Ecology

Bill A. Fuller,	University of Alberta
Don Gill	University of Alberta

Geology

Chris J. Yorath	Dept. of Energy, Mines & Resources
Gerry S.M. Lock,	University of Alberta

Sociology

Phil T. Spaulding,	University of Calgary
Keith J. Crowe,	Dept. of Indian Affairs and Northern Development

Administration was handled by Charles M. Lockwood, University of Alberta Extension, and Robbie Jamieson, Boreal Institute. Specialists passing through Inuvik, local residents and registered participants in the course all contributed as guest speakers. The two central themes were the arctic environment vis-à-vis economic development, and the position of the native people and their cultures.

A geological "fly-over" was made over the Paulatuk-Point Atkinson area, and an ecology field trip was made by boat to the former Reindeer Station. As part of the sociology program, visits were made to Aklavik and Tuktoyaktuk, where the school group met the community councils. An engineering tour was made to various Inuvik utilities, buildings and to the experimental oil pipeline.

During the course, the Inuvik weather was warm for the most part - uncomfortably so indoors. The participants were able to see and take part in the Northern Games, to mix with northern residents, and, in some cases, to visit oil-rigs, fishing camps, the reindeer herd and so on. Mr. Jack Davies, the Minister for the environment, addressed the group and went on the river field trip, but was surprisingly taciturn on both occasions.

A mid-course banquet, and a closing party complete with satirical "skits", helped to offset the serious side of the course. In general, both students and staff were satisfied that the course was well worthwhile and should be repeated. The major changes recommended were:

a) length reduced to two weeks.
b) inclusion of more economics.
c) changes of emphasis between various fields.

For my own part, I enjoyed the whole experience, particularly the chance to exchange ideas with people right across the spectrum of industry, government and citizenry. I think that, like me, most of those at the course were shaken free of some prejudices, brought to realization of the limits of their expertise, gained a wider perspective on northern matters, and found new friends.

K.J. Crowe.

The Institute of Low Temperature Science, Hokkaido University

The Institute of Low Temperature Science of Hokkaido University, Sapporo, Japan was established towards the end of 1941 for fundamental research into the properties and behaviour of substances and organisms at low temperature, and to relate this to the life and culture of Hokkaido, a region of severe cold and heavy snowfall.

The Institute has a staff of over 90, including 42 scientists, and is organized in ten sections concerned with physics, applied physics, meteorology, oceanography, snow damage, frost heaving, snow melt, frost injury in plants, biology, and medicine.

The laboratory building, completed in 1969, has 32 cold rooms including a wind tunnel where a maximum wind of 40 m/s can be produced, and a large cold room which is being equipped with a pool and circulating water system. Temperatures in the cold rooms can be automatically maintained to within one degree of the required temperature. All cold rooms can be cooled to -40° C and two small rooms can be cooled to -60° C and -80° C.

The Institute also operates two research laboratories, each over 300 kilometers from Sapporo and each with a small cold room. The Sea Ice Research Laboratory in Mombetsu on the coast of the Sea of Okhotsk has a radar system for ice observation with three antennas at high elevations near Esashi, near Mombetsu, and near Abashiri, which cover an area 60-80 kilometers wide along the entire coast. Ice distribution charts are made every day and analysed for data on the movement and deformation of sea ice which forms towards the end of December and breaks up in April. The other laboratory is for avalanche research and is at Toikanbetsu in northern Hokkaido.

Reports are published in Japanese with English summaries in the journal "Teionkagaku", Low Temperature Science, which has both a physics and a biology series, and in English irregularly in "Contributions from the Institute of Low Temperature Science", Series A (physics and geophysics), Series B (biology and medicine). At the end of 1970 the latest issues were Volume 27 for both

series of the journal, and No. 22 in the A Series and No. 16 in the B Series of the Contributions. The Institute also published the proceedings of the International Conference on Low Temperature Science held at Sapporo in 1966 to commemorate the 25th anniversary of the Institute. These were entitled "Physics of Snow and Ice" and "Cellular Injury and Resistance in Freezing Organisms". Most of the publications of the Institute are held by the Arctic Circle.

G.W. Rowley.

Formation of a National Eskimo Organization

In a five-day conference at Carleton University during the last week of August 1971, about 20 Eskimos met to found the first exclusively Eskimo organization. It is expected that this organization, known as Innuit Tapirisat will ultimately be in a position to speak for the 12,000 Eskimos in the Northwest Territories and Northern Quebec. All discussions were conducted in Eskimo and, with the exception of one official from the Indian-Eskimo Association, only Eskimos were admitted. Tagak Curley of Churchill appeared as chief spokesman of the group. However, no statements on progress or immediate aims were made public while the meetings were in progress.

In July 1970, Eskimos from all parts of the Canadian North gathered at Coppermine, N.W.T., to discuss mutual problems, and the founding meeting of Innuit Tapirisat at Carleton University was one result of that gathering. The Indian-Eskimo Association is being asked to assist the new group until it gets established.

Northwest Project Study Group

A group of oil companies and gas pipeline transmission companies has formed a consortium, known as the Northwest Project Study Group, to build, test and research facilities at Sans Sault Rapids on the Mackenzie River in the Northwest Territories, to study the feasibility of a proposed gas pipeline to central Canada and the mid-western United States. The Arctic test facility now in operation is part of the 12 million dollar project to be undertaken by this consortium.

It is estimated that construction and operation of the facilities at Sans Sault will cost 3.5 million dollars. Under the program, engineers will:

1) Test gas pipelines in permafrost under operating conditions.

2) Test foundations for above ground structures.

3) Test the effect of a gas pipeline on surface covered.

4) Study surface drainage problems

5) Test various materials, equipment and methods of pipeline construction.

William Brothers Canada Limited of Calgary are engineers for the research project and will supervise all testing at this Arctic facility, which is expected to be in operation for at least two years.

Canadian Arctic Resources Committee

An ad hoc citizen-scientist group, tentatively called the Canadian Arctic Resources Committee, is in the process of formation. A primary objective of the Committee is to study, assess and report on the research related to northern development that is being carried out by government, other organizations and by industry. The Committee is particularly interested in what is being done to evaluate the potential effect of exploration, development and transportation of resources on the physical environment, vegetation, fisheries, wildlife and human populations of the Canadian north.

On April 30 three members of the Committee met with the Hon. Jean Chrétien, the Minister of Indian Affairs and Northern Development; the Hon. Jack Davis, the Minister of Fisheries and Forestry; and, in the absence of the Hon. J.J. Greene from the country, with a representative of the Department of Energy, Mines and Resources. The purpose of the meeting was to explain the objectives of the Committee and to seek approval of the Ministers for scientists to visit their Departments to obtain information on research programs that are related to the Arctic environment.

The initial workshop meeting of the Arctic Resources Committee will be held in early winter in Ottawa. Information on research is being sought so that the committee can begin at once to gain understanding on: (i) what the principal needs are for social and ecological research; (ii) what is known that is of value; (iii) what research is underway; (iv) what research meeds to be undertaken.

The present membership of the Founding Committee is:

Donald Chant
Ramsey Cook
Maxwell Cohen
Tagak Curley
Pierre Dansereau
John Deutsch
M.J. Dunbar
William Fuller
R.G. Williamson
Roderick Haig-Brown
Kenneth Hare
Albert Hochbaum
Trevor Lloyd
Ian McTaggart-Cowan
Eric Molson
Richard Passmore
Douglas Pimlott

The Committee expressed the hope that many citizens in different walks of life will work with it to help focus attention on social and environmental aspects of Arctic development. It hopes that government and industry will provide the information which is necessary if Canadians are to gain understanding of the issues which are at stake.

Trilingual Newspaper in the North

A periodic review of the activities of the federal government in the Yukon and Northwest Territories has just been published in newspaper format. As shown by its masthead, it publishes in three languages, English, French and Eskimo.

Its aim is to provide Eskimos with information on what is happening or about to happen in the North and to provide a means of communication between them and the federal government. With the accelerated pace of northern development it is realized more than ever before that the Eskimos must be brought into the picture and the newspaper has been found to be the most acceptable form of written communication in that area. The paper, published by the Northern Economic Development Branch, Department of Indian Affairs and Northern Development, is scheduled to appear regularly.

The Monzino Expedition

The expedition led by Guido Monzino, that set out from Cape Columbia, Ellesmere Island, to reach the North Pole by dog-team (Arctic Circular Vol. XXI. No. 1, 34-35) accomplished its objective 18 March 1971. It was photographed in the vicinity of the Pole from a Canadian Armed Forces Argus aircraft. Reconnaissance assistance flights had been made by Argus aircraft over the expedition since it left Ellesmere Island.

The return journey from the Pole was made by dog-team as far as the United States Research Station on T3. From there the expedition was evacuated by air.

The following telegram was sent by the leader of the party to the Honourable Jean Chrétien, Minister of Indian Affairs and Northern Development:

> "I have the pleasure of informing you that the Canadian flag, as well as other flags, was hoisted at the North Pole, as an expression of my thanks for all you have done for my expedition."
>
> signed,
>
> Guido Monzino.

(For those readers who may be able to see the forthcoming edition of north, one of the publications of IAND, we note it will contain an article by Mr. L.A.C.O. Hunt, Chief, Northern Co-ordination Division, IAND, containing photographs of the Monzino expedition on the ice near the Pole. Mr. Hunt contributed the Arctic Circular article referred to above).

Arctic Circle correspondence - Correspondence should be addressed to the officer concerned,

c/o The Arctic Circle,
Box 2068, Postal Station D,
Ottawa, Ontario
K1P 5W3

Arctic Circle Meetings

The regular meetings of the Arctic Circle are held on the second Tuesday of every month at 8.30 p.m. in the Officers Mess, No. 9 Transport Company, R.C.A.S.C., Catherine Street at the corner of Bank Street. The bar opens at 8 p.m., giving members half an hour for social and business discussions before the meeting begins and the guest speaker gives his address.

Out-of-town members who wish to receive notices of these meetings and, thereby, be informed in advance regarding the guest speakers and the topics to be discussed, should address their requests to the Secretary, Mr. Keith C. Arnold.

The Arctic Circular

The Arctic Circular is published three times a year - oftener if the amount of material received permits. Correspondence, papers and reports are welcomed from all members, from persons living in the North, or from anyone having information on general northern activities, research or travel, or on technological, industrial or social developments. Contributions and correspondence should be addressed to the Editor, Mrs. Margaret Montgomery Larnder.

Back issues of the Arctic Circular are available, single copies at $0.50 and complete sets (Volumes I to XX) $100.00. Requests should be addressed to Miss Mary Murphy, Publications Secretary.

Arctic Circle Ties

A few Arctic Circle ties - featuring a white narwhal on a navy blue background - are still available. The cost is $3.50 each. Members wishing to purchase ties should forward their request to the Treasurer.

THE ARCTIC CIRCULAR

VOL. XXI No. 3 Published by The Arctic Circle December, 1971
Ottawa

194th meeting of the Arctic Circle, 12 October, 1971

The speaker was Mr. Keith Crowe who, together with his wife Edna, were the official companions and translators for a group of Eskimo artists who visited Expo 70 in Japan. As he and his family have had considerable experience of living in the Canadian Arctic they were admirably suited for this role. In 1958, Mr. Crowe joined the former Department of Northern Affairs and National Resources, and is at present with the Northern Science Research Group, Department of Indian Affairs and Northern Development. The subject of his talk was "Eskimo Artists in Japan".

The speaker was introduced and thanked by the President of the Arctic Circle, and the following outline gives some idea of his delightful account of six months work at Expo 70.

"Some of you may have seen at Expo 67 in Montreal, murals carved in soapstone and plaster by two Eskimos. I will describe the techniques briefly as they were pioneered at Expo 67 and developed further at Expo 70. For the plaster plaques or bas-relief, white plaster is poured into frames about 2 inches deep with a thin surface of hard coloured plaster. By cutting through the hard surface, the artist exposes the white underlay, and a great variety of effects are obtained. Paul Toolooktook of Baker Lake, in his only attempt at plaster carving, discovered an orange hue between the green and white surfaces. This he eventually exposed to create an autumn tundra effect.

For the soapstone plaques, stone slabs 2 inches thick were cut and fitted into metal frames. Kumakula of Cape Dorset did the first of these plaques at Expo 67 and I remember one of his figures was an

Eskimo child wearing a hood of rabbit fur with the ears left on, as is often done. This "carving of a child with rabbit's ears", was later cited as proof of the artist's queerness! Anyway, the stone plaques have much in common with the stone blocks cut for print making. I believe that Frank Mayers, an art consultant and designer for the Exhibition Commission, originated the idea of the plaster and stone plaques.

Kenojuak, the artist of Cape Dorset, was invited to go to Japan, but declined. Instead, she, her husband Johnniebo, and three of their children came to Ottawa in late 1968 to produce a plaster mural on contract. The finished work comprised about 21 panels each 3 inches square, and this was mounted high on a wall at Osaka above the area where the visiting Eskimo artists worked. At the conclusion of Expo 70 this mural was presented to the Japan Museum of Fine Arts. Canada was the first country to make such a gift from her pavilion - just as we had already collected a number of "firsts" in registration and construction at Osaka.

Arrangements had been made for another employee of my department and his wife to accompany the Eskimo artists to Japan, but when he was unable to go I was invited to make the trip. For those of you who do not know me, I and my family lived in the Eastern Arctic for 4 years, and I travelled extensively among Eskimo communities for another 7 in connection with administration, economic development, adult education, and so on. I have been involved in most phases of Eskimo art, and am fairly competent in the Eskimo language. I also speak elementary Japanese, while my wife is fluent in Japanese and knows more Eskimo than she will display. Hence our invitation to go to Expo 70.

We took our three daughters out of school in February and they accompanied us, completing their grades by correspondence courses during the monsoon weeks. The six months experience was certainly worth a year of conventional schooling.

Ever since Martin Frobisher's day, Eskimos have journeyed far from their homes, and, in recent years, friends of mine have turned up in the West Indies, Australia, Africa and Europe. I believe, however, that the members of our Expo 70 group were the first Eskimos to live and work for half a year in non-Arctic Asia.

The group included seven Eskimos

The mainstays were Elijah and Ikalik Pudlat of Cape Dorset who had been at Expo in Montreal in 1967. Ikalik was only 19 when we left Canada and, a week before leaving home, she had her fourth child, who was given in adoption by Eskimo custom. Elijah and Ikalik are both good looking, tranquil and thoroughly likeable people. They took with them Noovooaliak, a $1\frac{1}{2}$ year-old boy, and Koitsak, their small daughter.

Another member of the group, Saryu Amitok, is a handsome and voluble man from Povungnituk. He is a gifted sculptor and designer of batik or stone cut prints. Although he has given brief exhibitions of carving in southern Canada, he knows little English or French. He did not bring his wife and three children to Japan, but discovered on the journey that he and Elijah were related.

Pangnerk, at 51, was the oldest of our group. Tiny and lame, he is one of the Padlei people who knew frequent starvation before they moved to Eskimo Point. His face is deeply etched by life and weather, and his stark plain-surfaced carvings are primitive, the best being tremendously expressive.

Until a few years ago, Paul Toolooktook, a 23-year-ol artist from Baker Lake, lived in a snowhouse or a tent. He has attended school, speaks a little English, but had never travelled beyond his home region. In the beginning he acted as interpreter between Pangnerk and the rest of us until we learned each others dialects. Paul often withdrew into himself when carving, lost in his private world of the Barren Lands as he created his best works, massive stone figures of his people.

The artists had been selected and invited before I came on the scene, and, before setting off for Japan, I visited each of them in their own homes - except Elijah whom I knew already. I did not think Pangnerk would be equal to the trauma of the journey and life at Expo, and, although the plans could not be changed at the outset, he did ask to return home after six weeks. His place was taken by James Pootoogook, aged 21, of Povungnituk. James speaks good English and was able to relieve me a little as "social director" for the other artists. Although he had done very little carving to my knowledge, his work at Expo was good and in the style of his father.

We gathered in Vancouver. While there we visited the aquarium and saw the killer whales as well as white whales that had, much to the interest of the Eskimos, a microphone in their tank so that we could

listen to their language of whistles. Since the Eskimos were required to have yet another medical examination, we went to the dingy old immigration buildings where we were greeted by Dr. Cyril Drabbitt, formerly of Frobisher Bay. Cyril was always a dedicated northern doctor and was excited and happy to see our gang - I had to keep reminding him to fill in the forms!

After a brief stop at Anchorage, where the artists were pleased to see an Eskimo woman, we arrived at Tokyo airport in a blizzard where a bedlam of reporters put us into a state of shock with their flashlights and barrage of questions. From Osaka airport we had our first taste of Japanese taxi-riding, a sure test for incipient heart condition!

The apartments that were to be our homes for six months were part of a new suburb created a year ago in an area formerly green with bamboo forest. Clumps of bamboo and little lakes still softened the rawness of new apartment blocks and, across the highway, a small village complete with rice paddies and temples, formed an enclave of old Japan. Inside, our apartments were furnished Western style, but had sliding paper wall panels that could be moved or removed to give space and variety. Some of the occupants "went Japanese", and replaced their furniture with Tatami straw matting, futon floor-mattresses, incense burners, lanterns, and so on. In March we were grateful for electric heaters, and later we lived to the hum of air conditioners. We gradually became accumstomed to various appliances, to the deep Japanese bath, and to the Beverly Hillbillies on television speaking formal Japanese. After some initial fun and sign language on both sides, the Eskimos became frequent shoppers at the small village centre and the modern department stores near our homes.

Our apartments were identical, with 3 bedrooms in each. Elijah's family lived across from me, and later took in a Japanese boarder; Saryu and the other men lived below Elijah. Little Koitsak, like my girls, learned to mingle the words, foods, and customs of several cultures. Above us lived four families from Thailand, very pleasant neighbours. The rest of our building housed young Canadian and Japanese hosts and hostesses working in our pavilion.

Noise was our chief problem - one that came close to wrecking our whole project. By day we heard the roar of Expo-bound road and railway traffic. Early and late, loud speakers would bellow instructions at commuters and construction workers. People of many countries,

working different hours, would honk car horns, and there were always parties. Eventually we adjusted to four or five hours sleep each night, and were not ruffled on the April evening when we sat outside, our belongings bundled in bedsheets and watched the other end of our building burn in a fire that luckily took no lives.

The western edge of the Expo site was a mile from our home, and sometimes we walked there through a park and through the neat, bright-roofed housing of middle class Japan. The subway, built especially for Expo, was convenient, but incredibly crowded during peak hours. Pangnerk was once lost for two hours at the Expo station, and Saryu, unable to push his way to the train door, was taken downtown and returned full of adventures. Sometimes, we took taxis, fairly cheap but driven with blood-curdling speed and recklessness. For longer excursions we rented a minibus complete with driver.

Each day the Eskimo sculptors worked in two or three shifts depending on their numbers, in a space about 5' x 20', separated, but not nearly far enough, from the passing crowds by a display case containing Eskimo artifacts and art. Originally, the planners had thought more in terms of the actual "human" activity on display than in terms of the art itself, but as the plaques and better three-dimensional pieces began to be given as VIP gifts for royalty and heads of state, the status or importance of the sculptors rose.

Pangnerk and Paul were reluctant to try the bas-relief panels and did mostly three-dimensional carvings. Once Pangnerk broke an arm from a figure he was carving, and after a moment's reflection, took his hatchet and whacked off the other arm to match. This "Venus de Milo" was given to Prince Charles, and I often wonder what the Royal Family did with this rather weird and primitive carving.

One of my favourite memories of Pangnerk is of him sitting, feet up on a box, cigarette at a jaunty angle, wearing a bell given him by a wandering hippy. Happily he beamed at Prince Charles who was quite unknown to him, while, all around, the area fairly seethed with protocol and security. Pangnerk, though well-loved by all, found the frantic atmosphere and physical demands of Expo too much. He returned home late in April loaded with souvenirs. Among other things, he saw his first horse, an RCMP mount, in Japan.

As many as 12,000 people would pass the artists each day, and about three-quarters of these would stop briefly to watch and to question. The great majority were Japanese, who were most interested in the soap-

stone from Quebec's Eastern Townships. Apparently it is rare or unknown in Japan. They were also intrigued by the story of how James Houston in 1957 studied Japanese hanga wood-block printing under the master Hirotsuka, and then took the techniques to Cape Dorset for adaptation to stone. In Elijah Pudlat the stream of artistic influence had come back full cycle.

Unless one has known the great space and silence of the Arctic, the vital intimacy of Eskimo family life, and the rhythm of hunting seasons, it is difficult to appreciate the tremendous achievement of the Eskimos at Expo 70. In a completely new land, amid the frenetic atmosphere of an international exposition, they daily produced art varying in quality from good average to excellent. For those prone to decry Eskimo work habits, I can report that Elijah and Saryu, the two who stayed the full 6 months, worked six days a week, six hours a day throughout, with only six days off. In addition, the men and Ikalik did occasional small sculptures and paintings at home.

One question often asked is, "How did the Eskimos adjust to the climate, food, customs and people of Japan?" As for climate, in March they shivered with the rest of us. In the hot sticky days of July and August, the men wore long trousers when I could only tolerate shorts, and in their apartments the Eskimos used air-conditioning less than my family did.

The Japanese visitors to our pavilion were perennially heard to comment on the Eskimo's physical resemblance to themselves. One old lady, stooped from years of work in the rice fields, left in a huff, convinced that we were guilty of fraud. James Pootoogook helped to confuse matters more when he worked wearing geta (the high wooden Japanese clogs), shorts, and horn rimmed glasses! One rainy day Elijah was turned back when on his way home from work by security guards who thought he was a Japanese tourist trying to jump the queue for the United States pavilion. If we went downtown to a movie, I would ask in Japanese for tickets, but invariably the cashier would reply to the Eskimos. As they stated many times, the Eskimos enjoyed the feeling of belonging physically, and of mingling with the Japanese people in a way not possible in Montreal or Toronto. It was a help to them to see policemen, taxi-drivers, shopkeepers and reporters who, for a change, looked like Eskimos.

Eskimo women who come to southern Canada usually abandon the use of the amaut or baby-carrying coat, because they feel it makes them look too different from those around them. Since a similar outfit is worn

by many Japanese mothers, Ikalik was able to carry one, and in summer she adopted the lighter Japanese nenneko. The Japanese preference for oblique statement, subjective thinking, and the avoidance of face-losing confrontations, is similar to Eskimo custom. Another aspect of life in Japan that helped morale was the habit of giving gifts. Almost daily the Eskimos would receive a souvenir from stores, business firms or individuals. We received much kindness and hospitality from Japanese firms or municipalities who arranged frequent free bus tours for us, and, in our daily problems, individual Japanese were often very helpful. These actions helped the Eskimos to feel at home. There were of course some obvious differences in character and behaviour, and in Eskimo eyes the Japanese were sometimes uimayut; like industrial peoples everywhere, they are too agitated.

I had hoped to find some links between the Eskimo language and the non-Japanese languages of the Ainu, Oroko, and Giliak peoples living in Hokkaido. Unfortunately, I had not had time to look at previous comparisons, but Mrs. Tamura, a linguist from the Tokyo Institute, came to study the Eskimo language with our group. From our brief comparison of the three minority languages and Eskimo, there seems little obvious linkage. The sound pattern and, to a lesser extent, the structure of Japanese seems more like Eskimo, and though of course no theory is implied, I list the following intriguing pairs,

Japanese			Eskimo		
Ikima	-	root form of verb to go	Ikima	-	root form of verb to ride
Niku	-	meat,	Nipku	-	dried meat,
Ani	-	older brother,	Anik	-	woman's brother,
Inu	-	dog,	Inuk	-	person, Eskimo, (a common theme in the folklore of Mongol peoples is that of man and dog related in creation myths.)
Umi	-	the sea,	Umiak	-	a boat
Ki	-	tree	Kiyuk	-	wood

Confusing and amusing were;

Kuma	-	bear	Kumak	-	louse
Ima	-	now	Imar	-	so, yes
Kami	-	hair	Kmik	-	boot

Beyond the little world of our pavilion, Expo itself was exciting and, at times, overwhelming. We saw the elephants of Thailand, the RCMP Musical Ride, the dancers and batik crafters of Indonesia. The Eskimos saw sculptors at work from the USSR and Gabon, and discussed hunting with aborigine dancers from Australia. One day a country-style Japanese fair was staged at Expo, and Paul came back to the pavilion greatly excited, carrying two baby rabbits - the first live rabbits he had ever held! On Alaska Day, only two Alaskan Eskimo dancers arrived. Jenny, an Eskimo hostess at the Alaska pavilion, was asked to dance with them to make up the number, and so were our three men. With drums borrowed from the Feux-Follets dance troupe, they rehearsed one evening in the apartment. The drums had to be dried out frequently over gas stoves as it was the rainy season and the hides sagged. Next day they danced, drummed, and sang in rain and wind, and later repeated the performance for television. The show itself, with so little rehearsal, was a disaster, but it was fun for Eskimos of lands 3,000 miles apart to meet and compare carvings, clothing, and dialects.

In their apartments the Eskimos created an atmosphere of home, playing tape-recordings of church services or dances sent by friends and family. Letters were passed around, and we received various Eskimo language publications. Another important element in successful adjustment was the sense of community and cooperation which developed among Canadian and other employees. Many young Canadians and Americans found that the Eskimos came close to their ideal of informal, simple, people who are not materialistic. Tape recordings of wonderful musical evenings with the folksingers were taken back to the Arctic. Of course, it would be untrue to paint our lives and characters as idyllic - there was illness, loneliness, homesickness, drinking and argument; but all this really very little in view of the strain and strangeness of our situation.

In our free time we ranged as far afield as we could, often by rented minibus. We stayed in Japanese inns on the sea coast and on the shores of the Inland Sea. After our day of swimming, fishing and sightseeing, we would take the Japanese bath, then stroll in Japanese clothes and clogs around the gardens. Our meals were served at low tables in our rooms by maids in kimona who came and went through the sliding doors. We all became proficient with chopsticks, and raw fish presented no problem. In general, however, Japanese meals, with their emphasis on vegetables, sauces and rice did not satisfy us.

During a tour of Osaka harbour we saw more ships anchored than the entire Arctic sees in a summer. We swam in public pools and in a small, unpolluted lake in the nearby hills. On one hot night, Elijah, Saryu, and I on our way there watched by lamplight thousands of frogs in the rice fields. Saryu was afraid of them, and a farmer's wife, disturbed by our antics put up all the shutters on her house. We visited a newspaper plant, a TV studio and baseball finals. Ikalik could not get over seeing the actors in a studio "house", playing the parts she watched nightly on TV. We saw a cherry blossom festival, spent a day at an art seminar, and saw the world's biggest fireworks display.

Pangnerk had shot hundreds of caribou in Canada, but in the temple park at Nara he was scared when tame deer jostled him to be fed. One evening James took Saryu to a sauna but Saryu is very ticklish. Every time the girl masseuse put her hands on him he would giggle, until everybody was laughing.

The parents of my wife emigrated from Hiroshima to Canada early in the 1900s and, as she had never seen her Japanese relatives, we visited Hiroshima for three days. Apart from this separation, our family and the Eskimos were always together and, after the difficult "shakedown period", the days moved swiftly. Paul left us late in July for the fall caribou hunt but, first, he went climbing in the Japan Alps with friends. James started home in September via Hawaii and in the same month, Elijah and his family and Saryu, returned via the shortest route. Saryu's homecoming was tragic - his wife died suddenly while he was still in Montreal waiting for the weekly plane north.

Since the Osaka adventure, all the artists have settled back into northern life. Elijah hasn't carved a thing, but prefers to drive the Cape Dorset water truck and to hunt. Saryu has stopped doing batiks, has demanded and received a raise in pay from his co-op, and for a few weeks after his return, I am told, his art work had a distinct oriental flavour. Last February at Povungnituk he and I had a feed of frozen seal while reminiscing about Japanese food.

Pangnerk has not been too badly shaken by his experience, and there is, I believe, an exhibition of his work in Toronto now. James was happily unemployed when I last saw him, and Paul is back at the Baker Lake craft shop. They were a grand group, and I was proud to be with them."

Following this, Keith Crowe gave a half-hour showing of slides which, as he said, gave "some substance to my compressed account of 6 months of cross-cultural shenanigans".

195th meeting of the Arctic Circle.

This was the occasion of the Annual Dinner and was held Monday, 17 November, 1971, at the RCAF Ottawa Officers' Mess, on Gloucester Street.

This event was very well attended and, following dinner, members and guests moved into the spacious lounge where Mr. Charles R. Hetherington, President of Panarctic Oils, addressed the gathering.

Mr. Hetherington, whose academic training in chemical engineering began with a B.Sc. degree at the University of Oklahoma and culminated in a Sc.D. degree from MIT, came to Canada, after nearly ten years practical experience in various United States agencies, to work with Frank McMahon on the promotion and establishment of Westcoast Transmission Company, Limited - of which he was Vice-President and Chief Engineer from 1952 to 1959. This line, from the Peace River area of Alberta and British Columbia to Vancouver, was the first large-diameter (30") gas pipeline constructed in Canada. In the course of his very active career he has been

- Managing Director of Pacific Petroleum, responsible for the well-drilling and plant-construction programs required to provide gas supply to the Westcoast project.

- Private consultant to the oil and gas industry in Alberta on matters of production, transportation and economic studies, having formed his own company, Charles R. Hetherington & Co. Ltd., of Calgary.

- Owner and director of Cancrude Oil and Gas Ltd. (to 1967).

- Advisor to various government and private companies in Australia for about three years.

- Director and Vice-President of Westcoast Transmission Company (1967-70) and of Westcoast Production Company (was the principal figure in raising $24,000,000 and establishing the concern as a public company.)

Since 1 August, 1970 he has been President of Panarctic Oils.

The following is the speaker's outline of his address to the Arctic Circle, entitled "A New Image for the Arctic".

"For a number of reasons, I am pleased and complimented to have been asked to address this Annual Dinner of the Arctic Circle, and to have this opportunity to talk to you. First, your organization and Panarctic Oils have a common interest in the Arctic and hence I will talk about a subject which is as dear to my heart as I know it is to yours. Second, all of you assembled here have a vested interest in Panarctic's venture in the Arctic Islands, because the Canadian Government is a full and active partner in this undertaking using your money. Third, I welcome this opportunity to provide such an interested forum as the Arctic Circle with a body of information designed to let you know of the new and exciting things that are happening in this nation's last remaining frontier.

I am going to let a film do most of my talking for me because even the most gifted of speakers would have great difficulty in conveying a mental image of operations in this northern frontier. First, though, a few comments.

It is understandable that the Canadian public should be uninformed or misinformed with regard to the Arctic. Many of us, including myself until recent years, held the impression that Canada's territories above the Arctic Circle were either beyond our present capabilities to develop, or were too far away from world markets to be worth the cost and effort of exploration and development. Was not this the barren wasteland that had destroyed Amundsen, Franklin and hundreds of other explorers and adventurers before and after them? It is true enough that the high north, at first glance, appears as remote and desolate as the back of the moon. It is the kind of country that gives birth to myth and legend. . . but we know now that the Canadian Arctic is not a myth; it is a reality to which we have been introduced in recent years and it is an environment we have learned to cope with, thanks to technological advances and thanks as well to the explorations alluded to previously.

Over the years during which industry showed no interest in the high Arctic, the Government of Canada undertook to conduct land surveys, take aerial photographs, prepare maps, do extensive geological and geophysical work, and measure ice conditions and water depths, all of which proved invaluable when, in the 1960s, industry awoke to the prospects of this area.

In July of this year (1971) I was privileged to be a member of the Canadian delegation of the Honourable Jean Chrétien to visit the Soviet Russian Arctic. Earlier, our Prime Minister, Mr. Trudeau, had visited Russia to see and discuss development of northern areas. Mr. Chrétien's Delegation was the first follow-up visit to initiate a technical exchange between our respective countries.

On this visit we saw vast mineral developments and booming cities of 150,000 people as far north as 69°N - that is as far north as Inuvik. We learned of huge gas fields that produce from the same geologic formations in which we have recently discovered large reserves of natural gas in the Canadian Arctic Islands. We saw pipelines laid over hundreds of miles of permafrost to bring this prized fuel to their cities and industries. We saw the vigor with which the Russians attacked problems of remoteness and harsh climate similar to ours, in order to develop their north.

So when I stand before you today to suggest that a large part of Canada's future may lie, not in the middle north, but in the high north, I am speaking to you not as a voice in the wilderness, but as one of the growing number who now realize the truth of that statement.

In Russia the discovery and large scale use of gas and oil followed after the discovery and use of other mineral and forest products. Their large cities in the far north are more the result of mineral and forest processing than of the discovery of oil and gas. Canada does not have these large mineral discoveries or forest resources in our far north and we cannot be expected to develop in the same manner. We have, however, made significant discoveries of oil and gas at a time when North American demands are rising rapidly in the face of diminishing domestic supplies. This has changed the Canadian picture.

Panarctic has made two large natural gas discoveries, one at Drake Point on Melville Island and a second at King Christian Island. Imperial Oil has made three oil discoveries on the Arctic Coast in the Mackenzie Delta.

Getting gas and oil out of the Arctic and into the hands of the consumer is going to be a major undertaking, and the established reserves are going to have to be very large indeed to justify the effort and enormous expense, taking into account as well the need to safeguard the ecosystems of the Canadian north.

Let me assure you that we are aware of the problems and that we have started early to come to grips with them. Panarctic is in the fourth year of its exploration program now. On paper, our plan is relatively simple. First we find sufficiently large reserves of gas and oil to justify their transportation to world markets; then we devise a suitable method or methods to transport these reserves safely and economically. Following that we proceed to market these vast new reserves in such a fashion as to meet all of Canada's domestic needs

the retention of Canadian control over large potential natural resources and to the reinforcement of Canadian sovereignty in the Arctic Islands. Now, as a shareholder on the same basis as the industrial participants, the Government of Canada stands to benefit financially on its investment.

Panarctic has been in the Arctic Islands for better than three years now and has learned a great deal about operational procedures in a land that is in total darkness for three months of the year, where temperatures drop to 50°F below zero and where the wind howls to 65 miles per hour. The hostile climate is part fact, part fiction, for many days are as nice as in Alberta or British Columbia, as you will see in the film soon to follow. The point is that we have developed the techniques to handle the bad days and carry on work.

Inaccessibility is more of a problem. Here Panarctic also has met the problem with respect to carrying on its operations in the Arctic Islands. You will see in the film, movements by air and shipping by water into the Arctic as far north as 80°N, within 700 miles of the Pole. I can fly nonstop from Calgary to King Christian Island in 5 hours and have enough fuel left to return to Yellowknife or Edmonton if the weather is bad. Communications are via our own small, single side band, radio transceivers with which we talk directly from Calgary to bases in the Arctic Islands. I can pick up the microphone at an Arctic base and tell my wife I will be home for dinner.

In three years of exploration in the Arctic Islands, out of 8 exploratory wells drilled, 2 resulted in major gas discoveries and 3 other wells gave encouraging but noncommercial gas or oil shows. This initial success ratio is exceptional, particularly for a new and unknown area.

To date, Panarctic has expended about $50 million. In February of this year we announced additional financing in the amount of $26 million, and stated that $76 million on exploration will have been expended by the end of 1972 to prove-up the resource in the 55-million-acre land-spread held by the Company. Since then we have been able to announce a further injection of exploration capital in the amount of $75 million through an agreement with four United States Gas Companies, this without in any way diluting or weakening Panarctic's Canadian ownership, and without in any way endangering Canada's future oil and gas reserve position.

first, and then to make Canada a net petroleum exporter and elevate this nation to a major position in world oil and gas production.

Not so many years ago a plan of this sort was considered a pipe dream. Canada could not sell the oil that it had in Alberta and British Columbia and there were limited markets for gas in Canada. Surplus gas could not command a decent price in the United States. Why then would anyone go to the Arctic Islands, "within the shadow of the North Pole", to look for more oil and gas?

Like so many areas of business, the supply-demand pendulum often swings in the other direction and, despite our supposed intelligence, the pendulum swings before many realize it.

This was the situation in the Canadian Arctic Islands. Geologists knew of the tremendous geologic structural features in the Arctic that had the potential to contain immense reserves of fossil fuels. Many companies, mostly Canadian independents and mining companies, filed on large land spreads, presumably as speculations, because none of these companies was capable individually of mounting the required effort to undertake proper exploration.

Dr. J.C. Sproule, an eminent Canadian geologist, perceived the great potential for oil and gas in the Arctic Islands and the opportunity for Canadians to develop it. Arising out of his initial efforts, Panarctic Oils Ltd., was formed as a consortium of 19 industrial companies and the Government of Canada at a time when no other company or group of companies would take the risk to invest the huge sums of money required. The timing could hardly have been more ideal for, just as Panarctic got started, oil was discovered on the North Slope of Alaska. Had this Alaskan discovery been made much earlier, the individual companies owning lands in the Arctic Islands would not have come into the consortium. Had the Alaskan discovery not been made, continued financing of Panarctic could have been much more difficult.

Now today the discovery of oil at Prudhoe Bay, followed by the discovery of gas in the Arctic Islands and more recently by the discovery of oil in the Mackenzie Delta, proves that the geologists were right in predicting large reserves of fossil fuels in the Far North. The industrial companies which participated in Panarctic will benefit as additional reserves of gas and oil are proved up and put into production.

At the time the Government of Canada made its investment in Panarctic, its incentives were directed more to the development of the north, to

Other oil and gas companies that did not obtain land positions in the Arctic Islands have shown great interest in the oil and gas prospects on Panarctic lands and, in order to get additional exploration work done at an earlier date, certain limited acreages have been farmed out to Sun Oil Company, British Petroleums, the West German oil company Deminex, Imperial Oil Limited and Gulf Oil Canada Limited. These farm-outs will produce $40 to $60 million of additional work. In the result, the work to be conducted on Panarctic's lands, considering a continuation of Panarctic's own program, is expected to be well over $200 million over the next five years.

What this additional financing does is to expedite our exploration program and enable us to determine our oil and gas reserve position sooner than had been originally contemplated.

Panarctic presently has 4 drilling rigs operating in the Arctic Islands and a 5th rig is being taken under contract. There are 4 other drilling rigs in the Arctic Islands and this fall all 9 will be drilling on Panarctic lands.

In terms of obstacles we have learned to overcome in the Arctic Islands, the extinguishing of the King Christian Island gas blowout in January of this year is probably the most dramatic, but not untypical of problems we have to contend with on a smaller scale.

The King Christian well blew out in October, 1970. The 250-foot flame consumed 100 million cubic feet of gas every day until January when the first attempt succeeded in extinguishing the flame and controlling the well. To do this we had to airlift a total of 6 million pounds of equipment and materials, and devise methods never used before to kill a wild well. Our personnel did this entirely in the Arctic night at temperatures dropping to 50°F below zero. The film you are about to see will give you some impression of the working conditions.

But Panarctic's investment in the Arctic goes beyond money, equipment and human endeavour and ingenuity. It must, of necessity, reach out to the ecology of the Arctic terrain and the welfare of the northern peoples. Operations in the Arctic Islands are strictly policed by a task force set up by Panarctic, including outside consultants, to assure that the company leaves the land in the same condition that it found it. With these precautionary procedures it is fully expected that Panarctic will comply with the regulations for land use set up by the Federal Government.

As far as the northern peoples are concerned, it is simply a matter of enlightened self-interest to help them to emerge with the Arctic into the Twentieth Century. The new industries of the north are going to need these people, and they have got to be assisted out of a marginal hunter's existence where the mere act of survival was, for centuries, a 24-hour-a-day task and introduced into a new way of life with the same opportunities available to all Canadians.

Panarctic's operations are much farther north than any Eskimo or Indian settlement, so difficulties have been encountered in inducing native northerners to fit into the bachelor camp type of operation presently being used. Eventually when oil and gas go into production, it is hoped to employ largely native northerners in permanent settlements and, in preparation for this time, Panarctic is attempting to acquire and train northerners for these jobs."

Following this address, Mr. Hetherington showed a superb film dealing with aspects of oil and gas operations in the Arctic above 72°N, including building, housing, surveying, transport and loading by land, sea and air, as well as views of blow-out fires and their extinction (see also Arctic Circular, Vol. XXI, No. 1, 28-33).

Following the showing of the film, Mr. Hetherington very graciously answered a number of questions that it and his address had raised. He indicated briefly

- he considered pipelines the main means of transporting gas - and possibly oil - from the high Arctic. Whether the lines would be above, below, or on the surface would have to be determined by research and by local conditions.

- he indicated that Panarctic had plans - and already some experience - for clean-up of possible oil spills.

- clothing used at present was whatever was commercially available. The greatest problem is with seismic crews working in the open; drilling crews are more protected by walls and some heating.

- on the matter of what ships and crews Panarctic has used, he indicated Canadian ships, Newfoundland crews.

The speaker was introduced by the President of the Arctic Circle, Brigadier-General Keith R. Greenaway, and was thanked by the Secretary, Mr. Keith Arnold.

196th meeting of the Arctic Circle, Monday, 13 December, 1971.

Instead of the usual "second Tuesday", this meeting was held on Monday in order to have as guest speaker, Dr. Joseph MacInnis of Toronto who was in Ottawa for only that one day. Dr. MacInnis is a physician, an expert diver, a pioneer in underwater research in Canada and leader of the first team anywhere in the world to carry out underwater research under ice - in the Great Lakes and at Resolute Bay, N.W.T. He has provided medical and technical support for some of the deepest and longest manned dives in history. In 1968, he formed a consulting firm - Underwater Research Ltd., Toronto - which has had as clients the United States Navy, Smithsonian Institute, and the Canadian Government, to name a few. He is the author of many scientific papers and has two published books: "Underwater Image" (1971) and "Aquarius Descends" (1972).

The title of Dr. MacInnis's talk was "Beneath Canyons of Ice" and it took the form of a running commentary to accompany a most interesting selection of coloured slides on the underwater experimentation and research he and his colleagues have carried out up to the present. He expressed his gratitude to those members of the Arctic Circle and others like them whose exploits and publications had inspired him to undertake diving and underwater research in the north and whose practical assistance had helped make the experimentation possible. He reviewed his group's Great Lakes research which had served as a springboard for the arctic work, discussed the two Resolute expeditions, and mentioned some future plans.

The following is a summary of the speaker's commentary. It is unfortunate for our readers that the excellent slides with their interesting and informative details cannot be reproduced here.

"Dr. MacInnis pointed out that the story of how is underwater expeditions got started begins a long way from the Arctic. He reminded his audience that man had long been aware that some 71% of the surface of this planet was covered with water, but, not until the United States' Space program, was it possible to take photographs of the Earth from a great enough distance to obtain a view of an entire hemisphere in one picture. Such pictures, in colour, really brought home to people in an extraordinarily vivid manner how much of the earth's surface was covered with water. In fact, our world is really a water and not an earth planet.

The sea is a very difficult subject to discuss because it is not familiar to everyone. Most of us, however, know of some of the underwater exploration that has gone on, especially the work involving

nuclear submarines. A great deal of other work has also been carried out [here the speaker showed a series of relevant slides concerning dives from that of the Trieste to a more recent one near Guam that reached 35,000 feet below the surface. It was interesting to discover that there was life at this 7 mile depth.]

Jacques Cousteau, with whose work you are all familiar, brought the ocean into our living rooms and onto our theatre screens by his series of underwater-living experiments in the sixties - for example, the Conch Shell III expedition whose members lived for a month at 100 metres below the surface. Another milestone in the series of underwater steps was reached in 1965 when an H-bomb, lost off the coast of Spain, was recovered seven months later [one of the slides showed the bomb being supported by two submarines.] This was a big step, but it was a "crisis step" and unfortunately this has been the way progress in underwater research has advanced in the last decade or so.

The quest for off-shore oil was another development that spurred underwater research. If wells were to be drilled and the off-shore resources tapped, man's presence was required right on the seafloor, next to the stack or blow-out preventer, as it was called. [A most interesting slide, showing a sketch of a diving system 432 feet down in the North Sea in 1967, gave some small idea of this type of undertaking.]

Another milestone in the continuing research underwater was passed in 1968 when Link - the inventor of the Link Trainer - put two men out of his "Deep Diver" submarine at a depth of 700 feet. To date, this was the deepest "dive" ever made by man exposed directly to the water and it demonstrated his ability to stand the incredible cold and pressure at these depths. These two divers collected, to their surprise, algae - which is not supposed to grow at such depths.

The speaker then turned his attention to the Continental Shelf and its importance to Canada. Throughout the world the Shelf stretches seaward from tidewater for an average of 42 miles, its offshore edge lying at an average depth of 432 feet. For legal purposes it has been defined as stretching out to a depth of 200 metres.

It not only contains incredible renewable and nonrenewable resources, but also offers possibilities for "farming" and "fish cultivation areas". So this is the area where underwater-man was developing his capabilities in the 1960s. A slide of Canada emphasizing the Continental Shelf and the submerged freshwater areas showed vividly that almost 50% of Canada is covered by water. Yet, as the speaker pointed out, in spite of this

vast underwater territory, Canada at present has no program for manned underwater research. We have, in Canada, an incredible marine science capability, with some of the best marine scientists in the world, yet these scientists are largely limited to operating at the surface. We are today essentially an underwater country without an underwater program.

Describing it as "a very modest attempt to canalize underwater activity by man in this country", Dr. MacInnis then discussed the "SUBLIMNOS" project in the Great Lakes. About $2\frac{1}{2}$ years ago he and some colleagues concluded that as there was no manned underwater program in Canada, it would make sense to begin one. They decided to start with an underwater habitat of very simple design, essentially a working chamber at the top and a ballast chamber below. The working chamber was provided with heat, power, air, communications and four observation windows. This habitat was placed in 32 feet of water off Tobermory, Ontario, in June 1969.

The researchers had several objectives in mind:

1. To begin a study of the equipment required by divers to work underwater, particularly in conditions of extreme cold.

2. To study the performance of the divers in this environment.

3. To undertake a dynamic ecosystem survey of the bay in which the habitat was located, using the habitat not as a place to live but as a workshop or small laboratory.

Since they did not believe that science should work in a vacuum they wished to encourage interest and participation by non-scientists in this underwater activity; they, therefore, invited any artists, sculptors, or writers who could dive to participate and record their impressions.

Diving was done both by day and by night, and, in December 1969, they celebrated their first Christmas underwater, aided by a small Christmas tree and a little rum! By this time the water was extremely cold, down to about 34^{o}F.

They were very interested in the biological aspects of the environment, and for the first time they were able to operate on a day and night cycle. In a sense, they became part of the environment. They were also able to operate throughout seasonal cycles, and the speaker described several of their experiments, including some to determine the

effect of pollutants. They built artificial reefs to attract fish, and, in fact, tried to integrate themselves into the environment as much as possible. In January 1970 they had to operate under ice all the time, and it was necessary to open a hole in the surface ice daily in order to get below. Of necessity they became interested in overcoming the cold, and various pieces of equipment that might keep the diver warm were tried out. One suit that poured hot water over the body of the diver kept him very warm indeed, but they were concerned that this warm water, when discharged into the outside waters would upset their biological studies.

They were able to continue their biological studies through late January, knowing full well that nobody else in the world had ever been able to overcome the hostile barrier presented by the ice cover.

One interesting piece of equipment that they developed in the interests of safety was a micro-habitat, or "sea shell", as it became known. This is essentially a bubble of air trapped in an inverted hemisphere. If trouble develops in his breathing system a diver urgently needs somewhere to go, and these "sea shells", several of which would be located in the diving area, provide the necessary safe retreat.

The researchers established the fact that a habitat is absolutely essential for continuous underwater work under the ice. It provides that most necessary haven for resting, communication, and other activities. Otherwise the diver must find one small hole through the ice after each sortie or in the event that his breathing system breaks down.

From the experience gained in the Great Lakes, the group has designed a new form of habitat suitable for two-man operation, which, by the use of plastic hemisphere eight feet in diameter, will provide a far better view for study of the bottom or of the undersurface of the ice. They hope to be able to use this new habitat on their third arctic expedition in May 1972. Dr. MacInnis illustrated the ideas for the new habitat by means of slides, referring to it as a small portable two-man hydrosphere, and acknowledged the valuable contributions made by Chemico and the Aluminum Company of Canada in its fabrication.

At this point in his presentation Dr. MacInnis made reference to the cost of a voluntary, nonprofit, program of this nature. The cost of their first habitat was some $8,000.00 whereas that of the one just described was some $15,000.00. Added to these figures was the cost of the Great Lakes program and of the two arctic expeditions described

below, making a total of $53,000.00. He felt this showed what could be accomplished for a very reasonable amount if one adopted the "Volkswagen approach"!

The first expedition to the high Arctic took place in August 1970. The team consisted of four members: Dr MacInnis, interested in human and equipment performance; Dr. Allen Henry, a biologist; Dr. Lee Summers of the University of Michigan, a geologist; and a photographer to help document the expedition. All members of the team are superb divers. The primary purpose of the expedition was to undertake a multi-disciplinary study of the problems of working underwater in Arctic conditions. They flew to Resolute and, on arrival there, decided to camp beside the sea since they wished to determine whether low cost expeditions were possible if the team operated on a minimal subsistence way of life. They found it was difficult to get dried in a tent and that the going was hard, but it was possible.

Never had they seen ice like this before, and most certainly never from below the surface. They took many pictures and were very impressed with its underwater appearance. From below they noted the strange mixing effect near the surface as fresh water flowing in from the river mixed with the salt water. The quality and quantity of saltwater life amazed them. Due to the cold temperature of the water, 28.5°F, many species were so slow-moving that the biologist was able to collect them by hand or net! They also discovered that certain strange markings on the bottom were, in fact, "footprints of the moving ice". Further, this moving ice presented a hazard they had never experienced before. The members of the expedition felt they were seeing things no one had ever seen before, and that under water in the high Arctic is a whole new world. They came away very excited by the experiences of this first expedition.

They had taken two types of suits for underwater trial. The one that proved to be the better was a Swedish suit that gave up to one hour's performance before the onset of shivering. By comparison, they found the standard "wet suit" gave only up to about 30 minutes diving time. At these water temperatures, about 28.5°F, without suits, muscles would shut down and coordination cease in something less than two minutes.

After this first Arctic expedition, when they discovered they still had a small amount of money left over, they decided to ask further backing from their friends in Ottawa and to go back to the same site in order

to study the difference between summer and the winter operations. In February 1971 they returned to Resolute and carried out further work in temperatures of -30°F, -40°F, and even -50°F.

This time they were better equipped and had added extra photographers to the crew. An account of this second expedition will be published in the March 1972 edition of the National Geographic and, as a result, Dr. MacInnis was unable to show slides for this part of this talk.

The surface ice at Resolute was five feet thick at the time of the second expedition and was covered with eight inches of snow. These more stringent conditions made a support shack near their diving hole a necessity as a tent was no longer a practical shelter for changing, drying, and all other operations. It was also necessary, as a rule, to use lights below the surface for guidance and to assist in the work, and techniques were evolved for installing and positioning these lights. The "sea shells" used on this occasion could accommodate two divers at a time, and the divers could communicate clearly with each other, with other "sea shells", and, of course, with those above ice.

Again the group was amazed at the submarine life they found, and, this time, they used hydrophones to record submarine noises. It was interesting to note that although the expedition took place at the end of the Arctic winter and, in spite of the depth of ice and snow, if the lights were turned off, the men could still operate in a "twilight zone"."

Dr. MacInnis concluded his talk as follows:

"The thesis is a very simple one, if we are to understand the underwater Arctic we are going to have to support underwater-man's activities. We must put the ecologist down there so that he can study the underwater conditions - he could use a submarine or a habitat. Whatever the tool, we must give it to him so that he can establish free-pollution base-lines and determine what are the biological resources, in order that we can at last come to grips with this critical and strategically important part of this county, which, as far as I can see, has been virtually ignored."

Some of the points which came out, in no particular order, during the question period, included the following:

- The need facing Canada is to develop her ability to carry out underwater operations to the edge of the Continental Shelf. If we do not develop this capability ourselves, someone else (unnamed) will -

and could do it tomorrow. Yesterday Canada had a commitment to go north, today she has the commitment to go underwater to the edge of the Continental Shelf.

- Transparency in the arctic waters is the best this group had ever seen, greater than 200 feet. It was infinitely better than the very poor conditions at Tuktoyaktuk.

- Navigation underwater is one of the most serious problems, essentially one is going blind. A grid was laid out under water to help guide these free-swimming researchers and this, coupled with the lights, were the individual's best guides to the safety of the "sea shells" when needed. Only here in the "phone booth" could there be communication with the surface or with others on the bottom.

- Thermal equalibrium is the main stressor. Gases become more dense, breathing can become difficult, narcosis can develop due to the gases and act like an anaesthetic. Yet the French experiments have shown men can safely spend up to eight days at depths of 1000 feet in proper conditions. There is a great need for improved bio-engineered systems (suits, breathing apparatus, etc.)

- There was discussion and comment on the deepest dives made to date both in the open and in submerged-laboratory conditions.

- No seals were seen under the ice. Dr. MacInnis was the first to see Harp seals under water in the Gulf of St. Lawrence (with the CBC). "If you think they are playful on the surface, they are delightful in their kingdom under water." He hopes in future to meet other marine animals underwater.

- The group chose salt water for their northern experiments as the ocean is the primary water area. Its ice presents a totally new hazard. The speaker noted that research in this field has been begun in the vicinity of T3.

- The group lived on high-caloric diets. It did not matter much what was included so long as the calorie count was high. Alcohol was good - in fact necessary after a dive.

Following the question period, Dr. MacInnis requested the all-too-willingly-given indulgence of his audience for the showing of a delightful short film he had created. Its theme is the parallelism of man's adventuring out into space and down into the depths of this planet's waters.

The speaker was introduced and thanked by the Club President, Brigadier-General Keith R. Greenaway.

WINTER RESEARCH ON THE MUSKOX (OVIBOS MOSCHATUS WARDI) ON BATHURST ISLAND, 1970-71

by

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In the November 1969 issue of the Arctic Circular (Vol. XIX, No. 3, 55-57) it was reported that plans were being made for a study of muskox behaviour during the 1970-71 winter season on Bathurst Island (Gray 1969). The present report describes briefly some aspects of that winter study. Detailed observations will appear in the reports to be submitted to the supporting agencies.

David Gray and Don Cockerton, his companion and assistant for the winter, arrived on Bathurst Island in mid-August 1970 and departed mid-June 1971. Their home for the ten months was the High Arctic Research Station of the National Museum of Natural Sciences, located between Goodsir and Bracebridge inlets (75° 43'N, 98° 25'N). The research station consists at present of two 16x16 Parcoll Huts and one 16 ft. fibre-glass, storage igloo.

It was hoped to discover where the muskoxen winter, how the population and individual herd size and structure vary with the change in seaons, and what differences occur in the behaviour during the darker and colder periods of the year.

Weather

The period of observations on the island covered three of the four climatic divisions outlined by Thompson (1967), extending through the autumn, winter and spring divisions of southern regions.

September-November This period of decreasing daylight featured many snowstorms and many days of blowing snow. Although the sun rose and set for the last time in early November, the light remained adequate for a full day's work until very late in November.

December-April December proved to be the least productive month of the year. The combination of low light intensity and high frequency of snow and blowing snow resulted in poor to zero visibility for al-

most 2/3 of the month. However, the low light intensity at midday, even on 21 December, was sufficient to carry out camp chores without the aid of lights. On clear days, starlight provided enough illumination for travel on foot. For about one week both before and after full moon, land forms five miles distant could easily be seen, and the spotting scope could be used to see objects up to 1/2 mile away.

January, February, and March Though remaining cold, these months provided many days of good weather for travel and observation. Unfortunately, minor medical problems curtailed activities during part of this time. The sun rose again 7 February, but its influence on the temperature was not felt until April. After five months below zero, the temperature rose to 13°F. on 17 April. Ice fog was common during this month.

May-June With the advent of 24 hours of daylight, temperatures rose steadily. May featured many cloudy, snowy, white-out days. Only a few of the beautiful, clear days anticipated at this time of year materialized.

Methods

Daily counts of the muskoxen in the study area were made from camp, using 15x60 and 25x60 spotting scopes. The light of midday was sufficient to see about six miles with the scope up to 26 November and after 15 January. Between early December and mid-January, surveys of the area were made on skis, using the scope or binoculars whenever possible.

Cross-country skis and skidoos were the major means of transportation. With the onset of the colder weather, the skis proved more reliable and much less frustrating to operate. It was possible to carry most of the necessary equipment while skiing. However, greater skill and more experience with the skidoos in very cold weather would have saved a great deal of time and expanded the working radius.

Fairly lengthy observation periods were maintained, even in times of extreme cold, by the usual techniques of keeping the observer's extremities moving and by alternating periods of notetaking with intervals of intense activity. Photography, both still and ciné, was not generally feasible during the four coldest months.

The program of tagging muskoxen on Bathurst Island (Jonkel 1971) was continued in May 1971. C. Jonkel of the Canadian Wildlife Service, pilot Gene Vinct and David Gray immobilized and tagged six bull muskoxen; a radio-transmitter collar was attached to each.

Observations of temperature, wind, precipitation, cloud cover and visibility on Bathurst Island were taken twice daily. A summary of these observations for the period Sept. 1970 - May 1971 is given in the following table.

Month	Temperature Extremes (°F)		Mean Temp.	Total ppt.	No. of days visibility less than 2 miles
	Highest	Lowest	(°F)	(inches)	
Sept. 70	33	1	23.1	0.16	8
Oct. 70	30	-19	1.1	0.26	13
Nov. 70	26	-45	-16.8	0.10	16
Dec. 70	-8	-47	-29.2	0.09	19
Jan. 71	0	-52	-33.3	tr.	11
Feb. 71	-10	-46	-31.5	0.05	9
Mar. 71	-2	-40	-21.8	0.04	5
Apr. 71	25	-42	- 9.3	0.05	10
May 71	26	- 8	10.9	0.09	3

Results

As was expected from the trend shown in previous years, the number of muskoxen in the study area increased steadily from late August through early October. The highest numbers seen each month were: August, 28; September, 101; October, 121; November, 90; December, 0; January, 0; February, 51; March, 53; April, 53; May, 59; and June, 42. Associated with the increase in the valley population was an increase in the number of herds and the mean herd size. After the high of early October, herds gradually began to move out of the study area until, by 12 November, only one herd was left. On 13 November, it, too, moved out. Two smaller herds were observed briefly on 18 and 26 November, both about five miles from camp. No muskoxen were seen from 27 November,1970, until 4 February, 1971. The larger herds seen in early February showed a great deal of day to day fluctuation in size. These muskoxen were seen in groups of from 10 to 53 animals, with the average herd size being about 40. The late-winter population size remained fairly high until May, then dropped to the usual summer low during June.

The first calves seen during this 3 year study were observed on 1 May and 2 May, during a helicopter survey of southern Bathurst. Ten calves were seen in a total of 308 muskoxen.

During September and October, when several herds could be observed simultaneously, emphasis was placed on recording the movements and activity pattern of individuals and herds. In terms of feeding-resting-rumination periods, the muskoxen within a herd are generally in synchrony, but the information collected indicates that different herds, in the same area, at the same time, are not synchronized in their activity patterns.

An important aspect of the winter behaviour of muskoxen is the digging of feeding craters in the snow. Snow cover is removed from the vegetation by a pawing motion of the forelegs. A hard crust is broken by lifting and dropping the head onto the crust. The displacing of one muskox from a crater by another provides one method of determining the position of each animal in the herd's dominance heirarchy. The subordinate animal gives up the crater to the dominant without any physical contact occurring. In herds studied by the author over long periods of time, a linear heirarchy existed among the bulls, and bulls were dominant over cows (Gray 1970a).

To test the hypothesis that cows or subordinate bulls may be expending more energy in obtaining food than a dominant bull, the following information was recorded during certain observation periods; the number and frequency of displacements, the individual involved (where known), whether or not the displacing muskox used the crater already dug, and whether the displaced muskox moved to a new area or returned to an area previously cratered. These data have not yet been analysed.

Several kinds of male-female interactions were noted, but no copulations were seen.

During September and October small herds joined together to form larger herds. The circumstances included: simple merging while feeding, with little or no interaction; one herd running toward another and joining, after being investigated by the herd bull of the stationary herd; and members of two herds joining after the defeat of one herd bull by the other.

Predation

Two groups of arctic wolves were seen, a pack of 5 to 6 in September, and a male-female pair seen periodically throughout the winter. The pack approached herds three times but only once did they actually attack, and then unsuccessfully. The pair attacked herds twice while under observation and in both cases killed a female. One cow, killed on March 4, was pregnant and fell behind as the herd ran from the wolves. The second, killed on 24 March, was left behind as the herd stampeded. These two kills took longer to achieve than the killing of a bull muskox in 1968 by what may be the same male wolf (Gray 1970b). No other carcasses of wolf- or winter-killed muskoxen were found in the study area.

Disturbance

Many observations were made on the effect of human activities on the muskoxen. These activities include close and distant flying by aircraft, approach by man on foot or skidoo, seismic blasts and other man-made sounds.

Some herds in the study area were easily "frightened" into stampeding. A herd, feeding one mile from camp on a calm day, reacted to the sound of the sawing of plywood by running several miles. Seismic blasts made at a distance of approximately four miles from another herd, caused no noticeable response. Approaching a herd on foot or skidoo could result in the herd galloping off in a tight group. This makes the marking of animals with the paint pistol very difficult, and one must choose between the desirability of marking animals and the disruption or possible loss of the herd being studied.

Buzzing or circling by helicopters and fixed-wing aircraft seems to be the most harmful of man's activities. Although the herd will often stand in a tight group when the aircraft is overhead, in many cases it will run as the aircraft approaches. At such times herds may split up, individuals stumble, fall or flounder in soft snow and may fall behind the rest of the herd. This type of disturbance must have a deleterious effect on the weaker animals in a herd - old bulls, pregnant cows or those in poor condition. Pilots do not usually realize that although a herd may stand its ground while the aircraft is close, it may run from the area after the disturbing stimulus has departed. This movement is usually not as "frantic" as when they are closely pressed, but may involve alternate walking and galloping for several miles. This, too, can have undesirable effects on certain individuals.

Author's acknowledgements

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PROGLACIAL LAKE STUDIES
BARNES ICE CAP, BAFFIN ISLAND - PROGRESS REPORT

by

G. Holdsworth *, and P. McLaren **

Introduction. In 1970 glaciological observations were made of the ice margin of Barnes Ice Cap at proglacial Generator Lake (Fig.1). Surface flow rates were measured and depth soundings of the lake were made in an attempt to construct the cross-section through the ice front.

Measurements of dirt content in the basal ice were also made with the object of obtaining rates of moraine supply from the submerged ice front. The calving of a projecting tapered ice lobe in July 1970, due to an unusually high rise of the lake level, forms the basis for studying the mechanics of calving and for studying the environment in which the sublacustrine moraines are known to form.

In addition, some of the now-exposed moraines in the ancient, partly drained lake basin were studied for morphology and till fabric.

Seismic and sonar depth soundings were made in 1971 at the ice margin, providing further data on which to base the reconstruction of the ice/lake water/moraine boundary.

Observations at the ice front 1969-71

The present ice front is characterized by cliffs and ramps (semi-floating tapered lobes of ice) in the ratio of about 49% to 51% respectively. In water shallower than about 30 m, cliffs predominate, whereas in water deeper than about 30 m, ramps predominate. Typically, depths of 50 m occur just off the ends of the ramps.

Observations of crumbling and sagging of those parts of the cliff that rise 20-24 m above the surface of the water (1969) indicate that the cliff is undercut below water level. However, because of the danger of working in the immediate proximity of the cliffs, galciological work was concentrated on the three main ramps.

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** Department of Geology, University of Calgary

Seismic sounding through the ice and sonic sounding (profiling) through the lake water, combined with the 1970 observation of the calving of the largest ramp, has led to the reconstruction of the cross-section through the ice margin at T1 (Fig.2). The location of T1 and the other poles is shown in Fig.3 together with contours of the horizontal component of flow rate, which are based on surveys made from 1969 to 1970.

Using Nye's model (Nye 1957), surface movements and strain rates have been used to calculate subsurface flow rates within the ice. For the grounded ice, an unknown contribution to the surface flow is through basal sliding which may not be zero.

The extrapolation of a partial temperature profile indicates that, at least in one locality, the basal temperature is at $0^{o}C$, even assuming that the basal temperature gradient is as low as 1^{o} per 44 m (Ward(1952) - gives a value of 1^{o} per 20 m). Because the ice here is at least 45 m thick - and this below the level of seasonal fluctuation - temperatures at the base must be at melting point the whole year. The temperature profile is shown in Fig.2.

The location of the temperature profile is just down glacier from the zone of crevasses, the upper one of which acts as a conduit for melt water from a surface stream that flows for nearly three months of the year. That the water runs out into the lake subglacially has been confirmed by dye experiments. The size of the dyed area of lake water and the time taken for it to appear at the lake surface (D.M. Barnett, personal communication) indicates that the zone of subglacial seepage must be restricted. However, at least three active moulins are known to exist. The implication is that the heat supplied by the lake water (temperature approximately $1^{o}C$ at the bottom near the ice front) is sufficient to thaw the subglacial material back several hundred meters from the ice front. The basal melting must be reinforced in summer by the transmission of melt water down to the base. Further, the intervening ice is warmed by the "stationary" crevasse zone which is caused by a subglacial rise. It is concluded from these observations that at least some of the crevasses must be open down to bedrock or till.

If there is a certain thickness of unfrozen subglacial till where the ice is grounded, one would expect that, should any subsidence of the ice occur, it would likely be a slow process, taking place throughout the year. In any case, no significant vertical drops of the ice surface were indicated in the 1970-71 survey data.

The average dirt content of the basal ice has been calculated on the basis of the dirt content measured in the ice of an exposed flow fold (see FF on Fig.1), together with a knowledge of the approximate grading curve for moraine. The thickness of dirty basal ice is deduced from the present geometry of the flow fold by reverting it to a pre-fold single layer. The thickness works out to be about 8 m. Therefore, an average debris content of 8±2% by volume (based on a till density of 2.2 g. cm^{-3}) would give a basis for determining the probable rate of supply of moraine within the wedge-shaped space beneath the ramp, provided our estimates of ice flow rate at depth are reliable.

The rate of supply of debris under a steady state lower surface is:

8 M x 17 (±3) $m.yr^{-1}$ x 8 (±2%) per m width 11±5 $m^3.\ yr^1.\ m^{-1}$.

This figure would probably be a lower-limit value under the present flow regime.

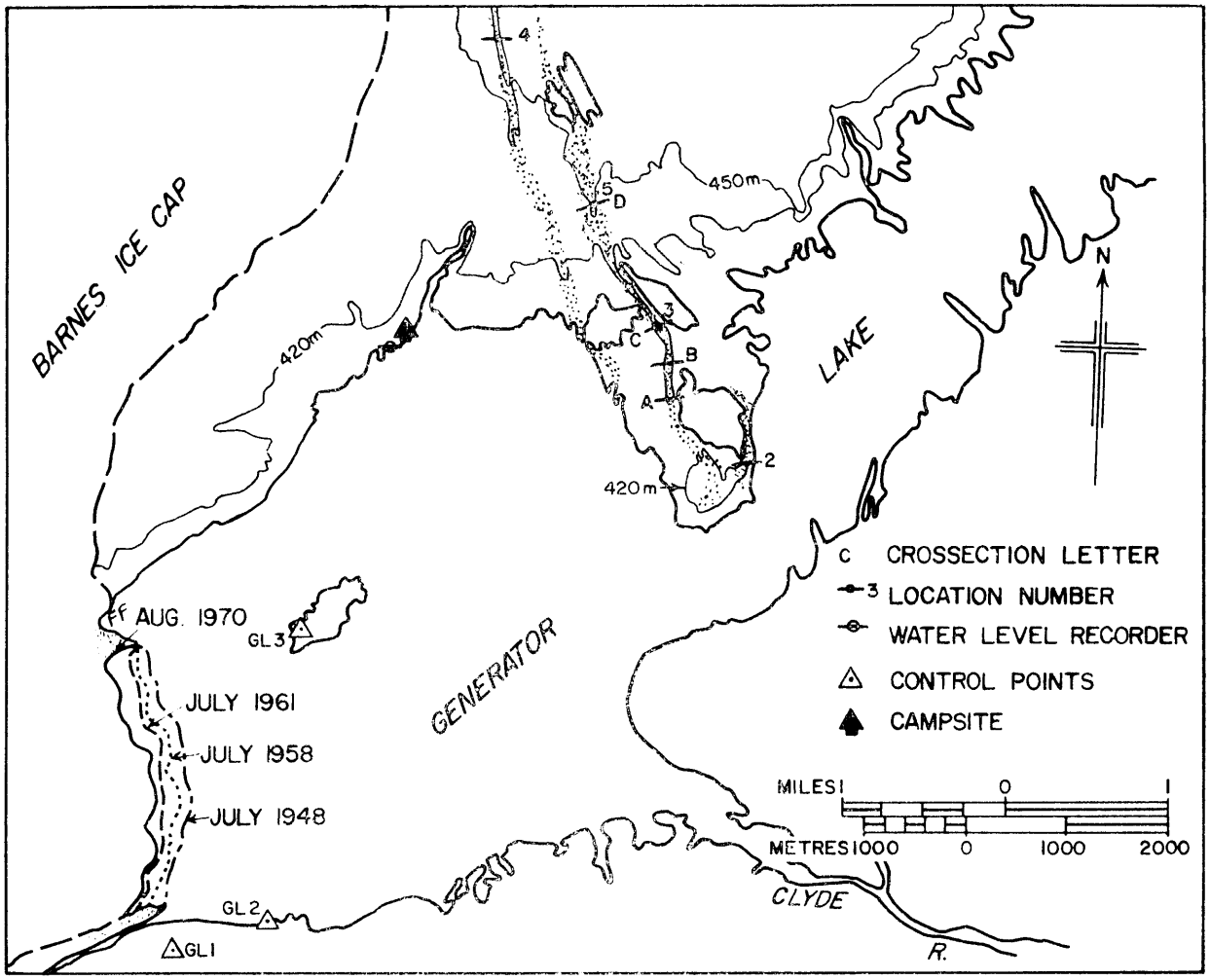
From aerial photographs it is possible to estimate that before calving, the T1 ramp had been in existence in the same general form for a period of up to 9 years. In this time a moraine of volume up to

100±45 $m^3.\ yr^{-1}$ per m width could form by direct deposition from the ice.

Observations of exposed moraines in the ancient lake basin

Andrews and Smithson (1966) give descriptions of cross valley moraines, which are considered identical with the present moraines, and for which the more appropriate term sublacustrine moraines is used (see also Goldthwait 1951). In cross-section these moraines are distincly assymetrial being less steep on the proximal slopes than on the distal slopes which tend toward the angle of repose of moraine (34^{o}).

The exposed moraines, formed in a previously more extensive, deeper lake with a water level about 77 m above the present level, show a gradual increase in spacing and size (height) as the lake area increased contemporaneously with the withdrawal of the ice margin. Moraine crest heights reach about 20 m above the former lake bottom, and moraine spacings reach several hundred meters. In some cases, overlapping (superposition) of individual moraines within a group can be observed.



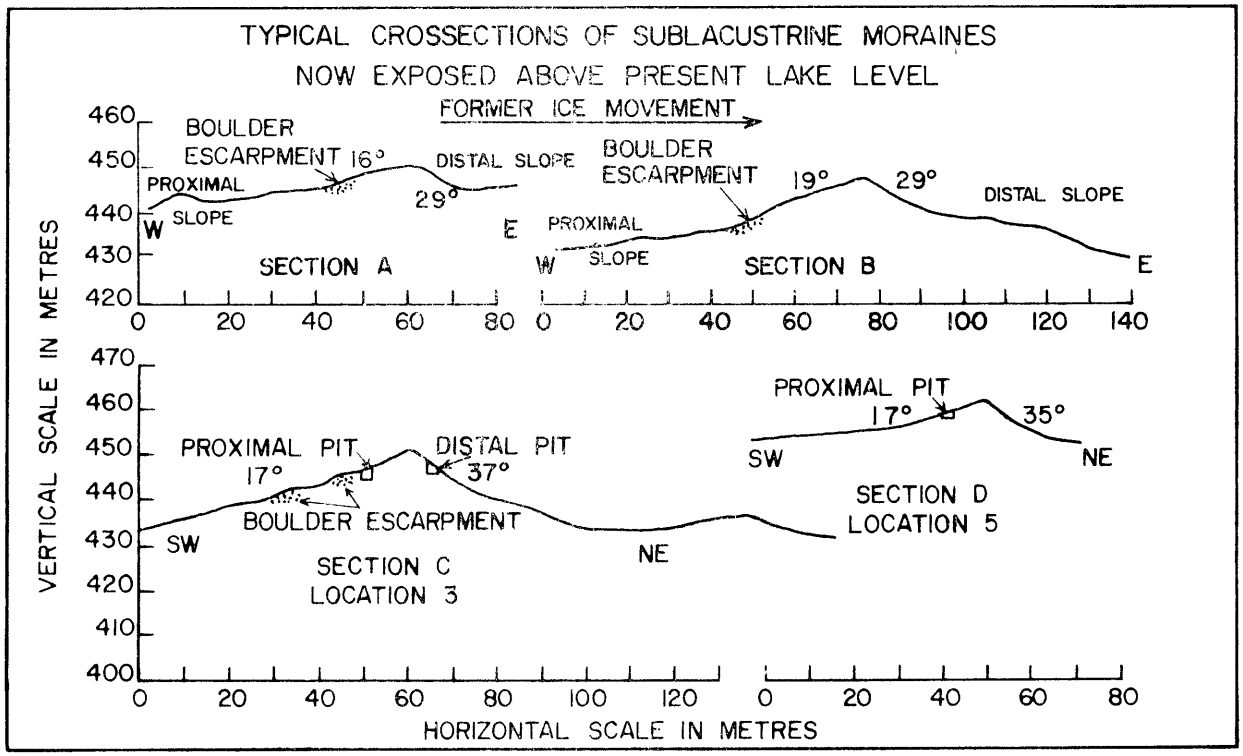


Fig. 1 Upper: Map of Barnes Ice Cap and Generator Lake.
Lower: Cross-sections through typical sublacustrine moraines in the ancient lake basin.

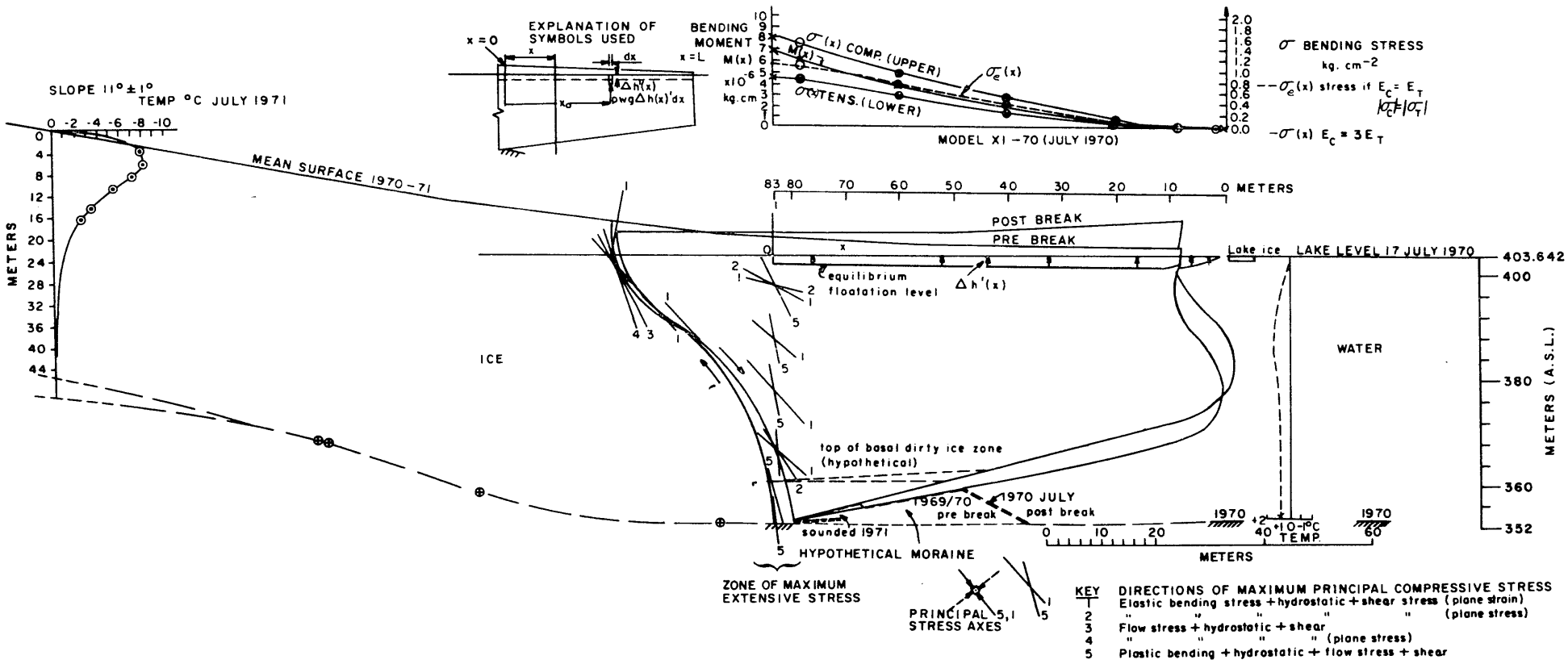


Fig. 2 Cross-section through the ice front at T1.

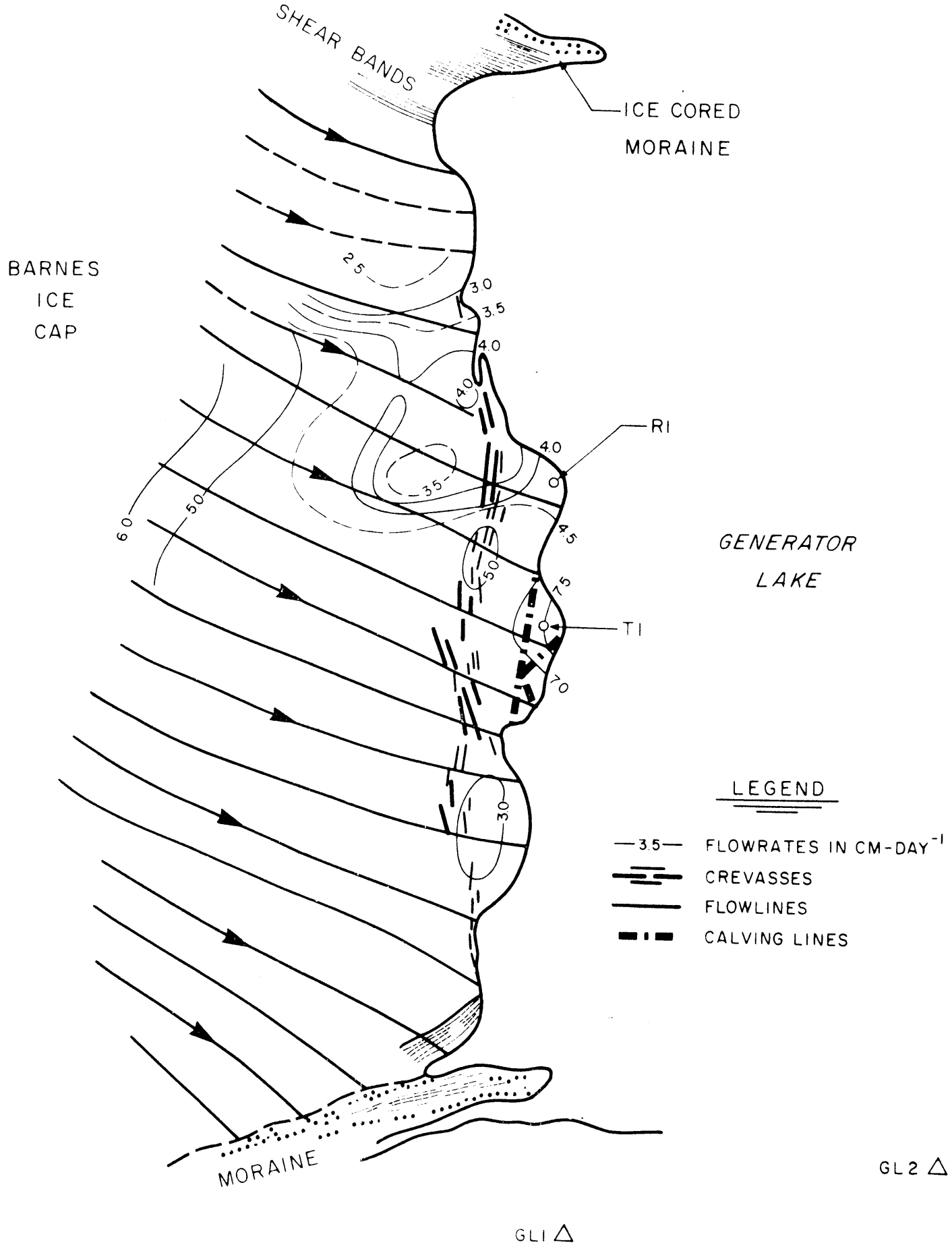
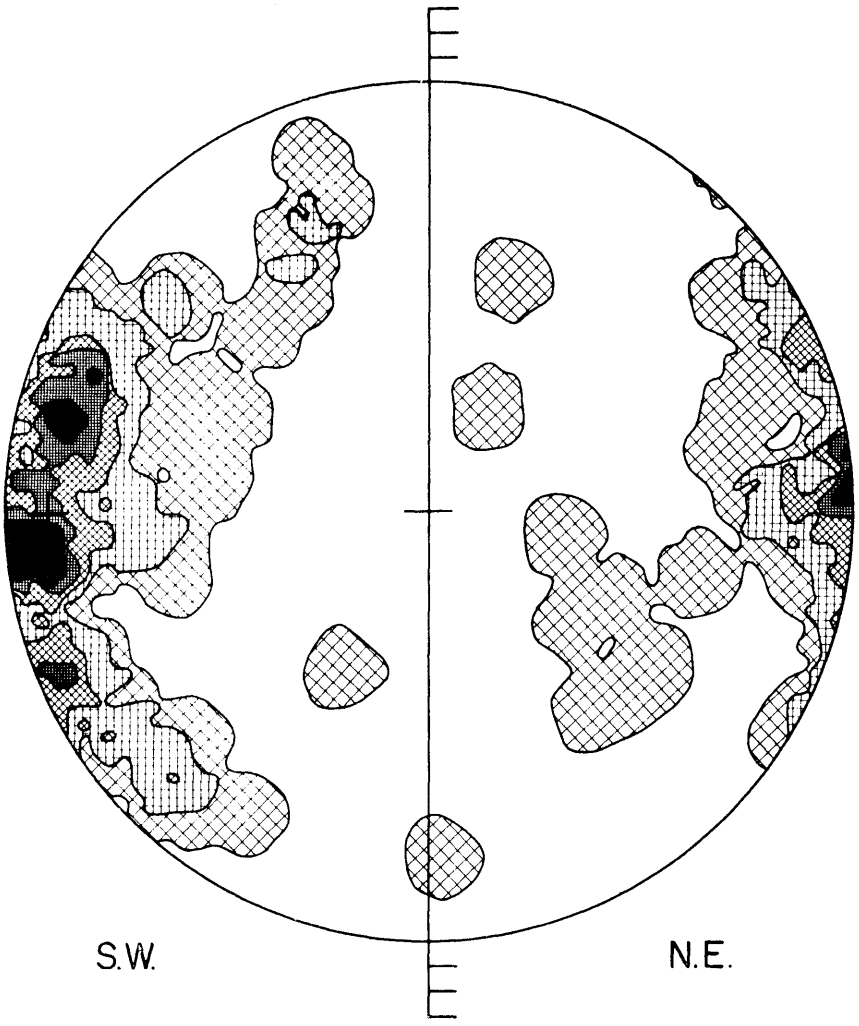


Fig. 3 Map of the ice front showing the 1970 position.



LOCATION 5
PROXIMAL PIT
PIT DEPTH 100 CM.
100 PEBBLES, BELOW PERMAFROST

KEY
PROXIMAL SLOPE 10°
RIDGE CREST LINE
0
1–2
3–4
5–6
7–8
>9
NO. POINTS PER 1% AREA OF NET

Fig. 4 Till fabric diagram for typical proximal moraine slope (for location see Fig. 1). Equi-area stereographic projection.

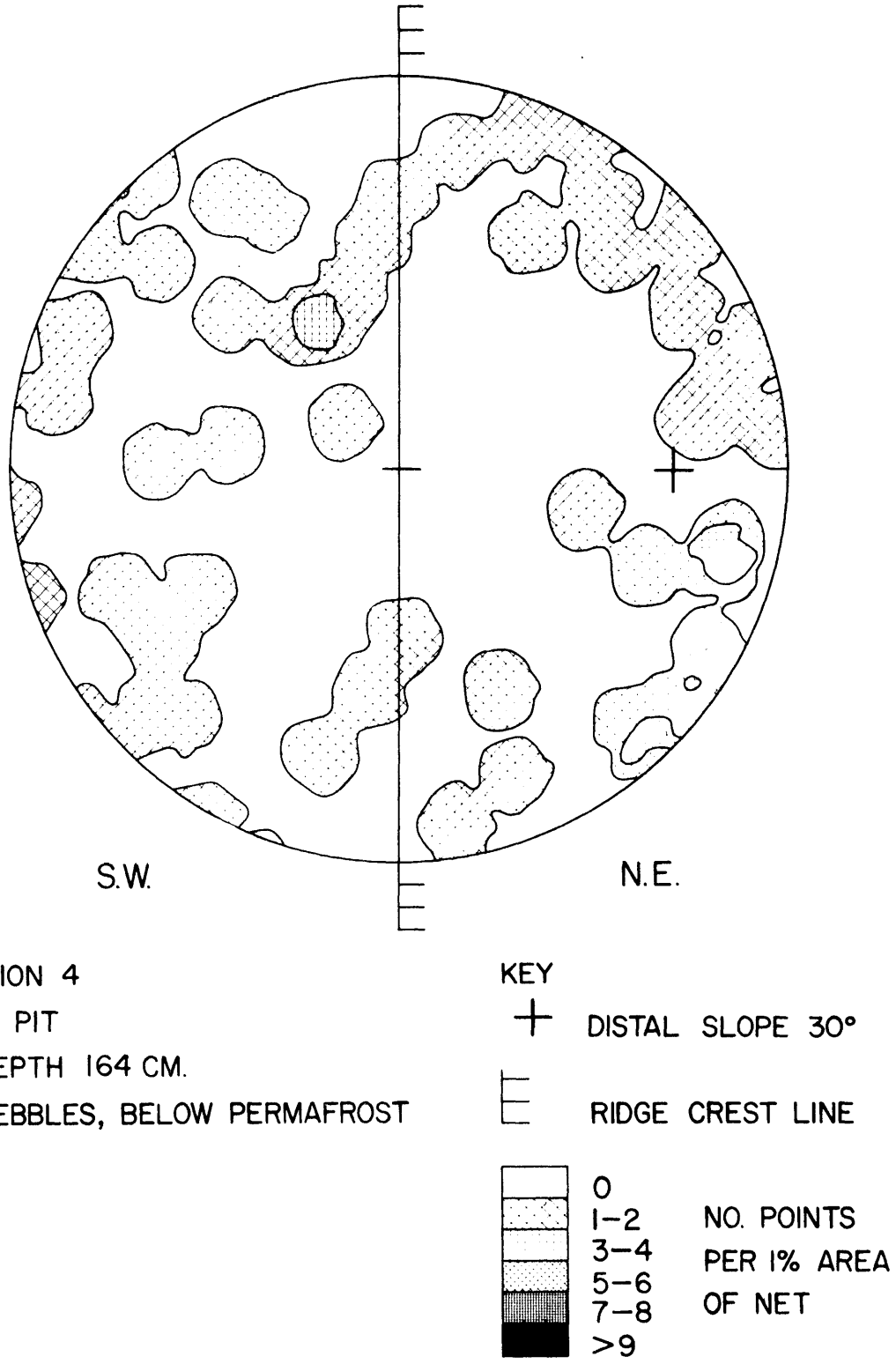


Fig. 5 Till fabric diagram for typical distal moraine slope. (for location see Fig. 1).

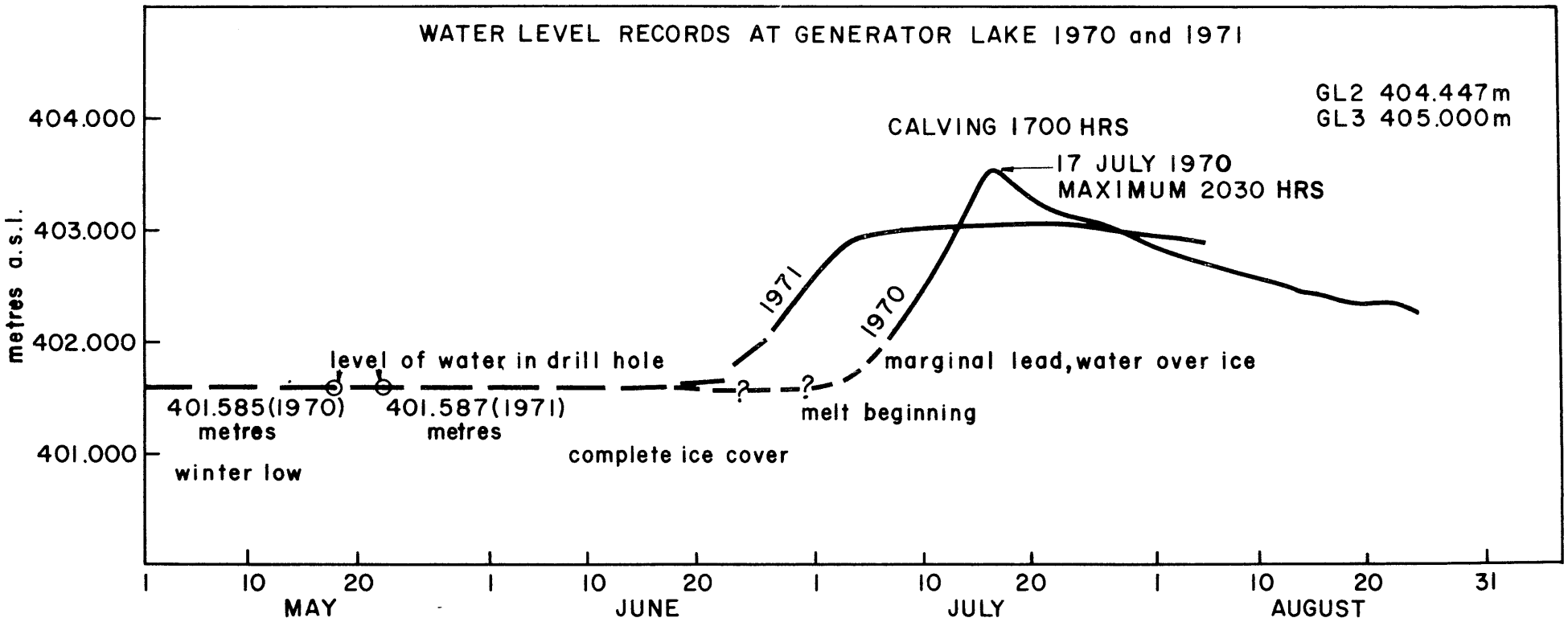


Fig. 6 Water level curves for Generator Lake, 1970 and 1971.

In order to study the fabric of the till, pits were dug at locations that sampled laterally as much of the moraines as possible. Pit depths were 100-64 cm, - substantially below the August permafrost level which lies approximately 50 cm below the surface. From the digging operations it was apparent that the distal slope till was less compacted and more bouldery than that of the proximal slope. This is of significance to the possible modes of moraine formation discussed in sections (1) and (2) below.

Pebble long-axis orientations were measured in 7 pits at 4 locations. Figures 4 and 5 are equi-area stereographic projections showing typical fabrics for the proximal and distal sides of the moraines respectively. Proximal fabrics are generally characterized by the development of a single maximum tending to be at right angles to the moraine crest. In some cases, weak second maxima are apparent but they are usually close to the main maxima. The dip of the maxima is not significantly different from the angle of the proximal slope itself. On the other hand, distal fabrics are less strong and, typically, display a near random character.

Till fabric and moraine morphology are apparently consistent with several possible modes of formation of these moraines:

1. Primary deposition in a wedge-shaped space beneath a semifloating tapered ice ramp with the proximal side of the moraine being an ice contact surface or very nearly so.

2. Formation of molding (squeezing) and forward thrusting under pressure exerted by the lower sloping ice surface.

3. A combination of (1) and (2).

4. For moraines with a steeper than average proximal slope (up to a maximum of the angle of repose) (1) may be modified by specifying an essentially grounded but undercut ice cliff, provided that the cliff position remained about the same long enough for a moraine to develop.

Observations of calving

On 17 July 1970, a large section of the T1 ramp broke away (see Fig.3 for fracture). The time of calving correlated directly with the attainment of a critical water level (Fig.6). Water level records for 1968-71 show that the 1970 summer rise, due to runoff from the ice cap, was by far the greatest (2.08 m rise from the winter low level), being 31% above the average for the four years.

Since the rise in lake level of 16 cm. day^{-1} from July 6 to 17, 1970, was much greater than the adjustment by floatation of the slab under buoyancy forces, an upward acting thrust was applied along the whole length of the slab (Fig.2) equal to

$$\rho_w \, g \, \Delta h'(x) \, dx \quad \text{per unit width}$$

where ρ_w = density of sea water (g. cm^{-3})

g = acceleration of gravity,

$\Delta h'(x)$ = difference in height between the actual water level and the "equilibrium" or free floating level of the slab for the element dx, where x is measured along the length of the slab parallel to the water line, with the origin vertically above the hingeline.

The free floating level for an element of the slab is determined from the relation

$$h(x) = \left(1 - \frac{\bar{\rho}_i}{\rho_w}\right) H(x)$$

where h = distance below the top of the slab, where a vertical column of width dx and height H would free-float.

$\bar{\rho}_i$ = density of the ice (0.905 g. cm^{-3}).

The distributed load causes a bending moment

$$M(x) = \rho_w g \int_x^L \Delta h(x) \, (x_o - x) \, dx$$

to act at a distance x from the origin. $M(x)$ is plotted in Fig.2

The next step, the calculation of the stresses, becomes complicated as there are elastic and plastic stresses due to bending, shear, hydrostatic pressure, and flow (associated with longitudinal strain rate.) Only the elastic stresses due to bending will be specified here and these are shown in Fig.2 for

(1) centrally located neutral axis, or E_c-E_t (strain modulus in compression and tension equal) and

(2) displaced neutral axis ($E_c = 3 \, E_t$) as determined from the fracture geometry.

The second is considered to be the more likely case. If so, then the

stresses are of the order $\geq$1.6 Kg. cm^{-2} compression on the upper surface and about 1 Kg. cm^{-2} tension on the lower surface, where, at the same time, the ice is stretching as it adjusts from a grounded to a frictionless base.

Depth sounding, July 1971

A portable ELAC depth sounder was used to obtain continuous profiles of the bottom topography out from the ice front. As the calved block moved out from the position it had occupied for 12 months, it was possible to sound bottom that had previously been covered by the berg. As might be expected the profiles were usually disturbed, for the rear end of the berg was calculated to be touching the bottom. There is sufficient data, however, from which to estimate the moraine volume to be 150 ± 20 $m^3 . m^{-1}$. This figure can be compared with the previous estimate of 100 ± 45 $m^3 . m^{-1}$. determined from the flow rate and the dirt content of the ice.

Conclusions

The study of the ice margin at a proglacial lake can provide an opportunity for investigating several interesting and important phenomena. In this particular instance, two interrelated problems - the process of calving and the process of formation of sublacustrine moraines have been studied together. It is seen that the study of either one requires a sound knowledge of the glaciological and hydrological conditions existing at the ice front. Detailed papers on each phenomenon are being prepared.

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THE NORTHWEST TERRITORIES HISTORICAL ADVISORY BOARD

(Summarized from reports by Mr. A. Stevenson, Chairman of the Board)

On 4 January 1969, at the 38th Session of the Council of the Northwest Territories, the Commissioner, Mr. Stuart Hodgson, announced the formation of the Northwest Territories Historical Advisory Board and the Council endorsed the need for such a body. The aim of the Board is the preservation of the wealth of historical relics in the Territories, endangered in many areas today both by ignorance and by modern economic exploitation and development. Duties of the Board include the drafting of proposals for Territorial legislation to protect historic and archaeological sites and the handling of matters dealing with museums, artifacts, documents and archives. The creation of such a body reflects the growing awareness throughout the Northwest Territories of the importance of the history and the pre-history of the area; hence the need to preserve, not only its Eskimo and Indian folklore, but also the sites, buildings and documents related to all the activities that have shaped its history, such as exploration, fur trade, missions, mining, transportation and communications.

The Board consists of 10 members and a permanent secretary appointed by the Commissioner and it acts in an advisory capacity to the Commissioner on matters of historical importance to the Territories. Its first meeting, April 1969, dealt mainly with organization, terms of reference and procedures with which to implement them. The second meeting, April 1970, reviewed the work of the previous twelve months, in particular the draft of proposed legislation to be submitted to the 42nd Session of the Northwest Territories Council. As Bill 27-42 - an Ordinance relating to Historic Sites and Museums and Archives - this legislation was approved by the Council in June 1970.

At its second meeting the Board also gave consideration to the N.W.T. Tourist Bureau's general study of the area, especially the "Historical Resources" section. Two students had already been employed by the Council to gather, from the National Museum of Canada and the Historic Sites Service in Ottawa, information on historic sites and other material relative to the N.W.T., and it was proposed at this meeting that members of the Board should also assist by making a general inventory of historical resources, according to selected themes. This inventory was known as the "Over-view Study".

Early in 1971, the Honourable Jean Chrétien, Minister of Indian Affairs and Northern Development, delegated to the Commissioner of the Northwest Territories authority to administer and issue archaeological permits under the Archaeological Sites Regulations (Northwest Territories Act). The Territories also has a representative who, in the capacity of observer, is present at meetings of the National Sites and Monuments Board. A close working arrangement established with the National Museum of Man allows the Territorial Government to obtain advice as to the professional or technical competence of each applicant, and, in the issuing of permits at Yellowknife, enables it to integrate the administration of the Archaeological Sites Regulations with Territorial legislation dealing with other historical matters. Under the new procedure five permits had been issued by late August 1971 for excavations and research in various parts of the Territories. During the same summer, the N.W.T. Historical Advisory Board also gave financial assistance and support to a number of research and historical projects. By the end of 1971 the Territorial Government hopes to have initiated a program commemorating and marking a number of historic sites. A distinctive Northwest Territories plaque has been designed and approved.

At the request of the Commissioner, an ad hoc committee met in May 1971 to lay the groundwork for a Territorial Museums Policy. This committee included Dr. W. E. Taylor, Director, National Museum of Man; Miss B. Tyler of the National Museum; Mr. L. Martin, Director of the Nova Scotia Museum in Halifax; and members of the Territorial Government and the N.W.T. Historical Advisory Board. A draft proposal outlining aims and policy for a central museum at Yellowknife was drawn up and presented to the Commissioner for consideration by him and the Board. It outlined the administrative and financial responsibilities involved, considered the programs to be set up, and discussed the desirability and feasibility of establishing other museums throughout the Territories. If all goes as planned, the new, central museum will be opened by mid-1973, replacing and absorbing the small "Museum of the North" in Yellowknife. This museum has been turned over to the Territorial Government and is operated at present through the office of the Secretary of the Board. Two students from Sir John Franklin Vocational High School look after the exhibits and collect the token fee of 25 cents from each visitor. Along with the items belonging to the Museum, the Territorial Department of Industry and Development (Arts and Crafts Division) occupies two rooms so as to display an exhibit of Eskimo sculpture and a small collection of Indian handicrafts that were shown during the 1970 northern tour of Her Majesty, Queen Elizabeth. Also, through the cooperation of the National Museum of Man, a collection of 14 Eskimo drawings was made available for exhibition during the summer.

A travelling exhibition of Eskimo history was assembled by Dr. R. J. McGhee of the National Museum, who worked out a design that permits easy handling of the exhibits for display in as many northern communities as possible. The layout gives an outline of Eskimo pre-history, explaining how the Canadian Eskimo culture developed and how the people adapted to the various Arctic conditions. The story is told in graphics and supported with artifacts from the National Museum collection. There is a description in English and in Eskimo syllabics, and a hand-out pamphlet accompanying the display gives additional detailed information. The Northwest Territories Historical Advisory Board is coordinating, scheduling and transporting this excellent exhibition and is assisting financially.

The initial phase of the "Over-view Study" relating to "Historical Resources" was completed in the fall of 1970. The results of this survey form an inventory consisting of an ever-growing collection of maps and of information filed on cards. It is kept in the office of the Secretary of the N.W.T. Historical Advisory Board in Yellowknife.

With the administration and responsibility for programs formerly carried out by the Federal Government being transferred to the Territorial Government, many files were retained in the North. It has been arranged that the Records Manager of the Department of Indian Affairs and Northern Development and an officer of the Public Archives visit Yellowknife to evaluate the remaining old files still in the possession of the Territorial Government. The year 1966 will be the date separating those files that are to be considered Federal responsibility from those that will remain Territorial responsibility. A filing system for publications and reports has been created in the office of the Secretary of the N.W.T. Historical Board; old and new photographs are being listed and filed; newspaper clippings are being mounted and filed in chronological order; some books and recent publications have been catalogued. In addition to material in the Records Office of the Government of the Northwest Territories, items being recorded by the Board Secretary are forming a nucleus of archival material. Plans are underway for one or two members of the Territorial Government to spend some time in the Public Archives and, possibly, to take courses recommended by Dr. William I. Smith, Dominion Archivist. Dr. Smith has given much valued assistance in the setting up of proper records and archives, and, on his invitation, a representative of the Territorial Government attended the meeting of the Provincial Archivists held in Ottawa in 1971.

In June 1970, as part of the Northwest Territories Centennial celebrations, the National Historic Sites and Monuments Board of Canada visited Fort Smith, Fort Simpson, and Yellowknife. A historic plaque commemorating the Slave River Portage was unveiled at Fort Smith (Chairman of the ceremony was Allan R. Turner, Saskatchewan Provincial Archivist and Chairman, Historic Sites and Monuments Board of Canada). At a ceremony on 13 June, Fort Simpson, the oldest continuously occupied site on the Mackenzie River, was similarly honoured as a national historic site; and on 9 July, at Fort Providence, Her Majesty, the Queen, unveiled a plaque to the memory of Sir Alexander Mackenzie.

In the planning for the centennial celebrations, the new Historical Advisory Board and the Centennial Historical Committee worked closely together. Much-appreciated help was also received from the National Museums and the National Historic Sites and Monuments services in Ottawa.

During Centennial year a "Historical Series" was launched with the publication of two pamphlets: "Retracing Franklin's First Expedition" by Eric Morse, and "Pages from the Polar Past" by a member of the N.W.T. Board. The "Historical Series" will publish reprints and new articles with, it is hoped, contributions from an increasing number of the northern communities.

The N.W.T. Historical Advisory Board makes recommendations to the Commissioner on historical, Indian, Eskimo, or other names considered suitable for geographic features in the region. These will then be submitted to the Canadian Permanent Committee on Geographical Names for approval. In recent months, Chief Cazon of Fort Simpson, a member of the Board, has submitted a number of names for the Upper Mackenzie River district, and Chief Hardistry of Wrigley has sent in names in the Slavey dialect of the Athapaskan Indians for features in his area. These submissions are very timely as new maps of the area are presently being compiled.

Films of the Netsilik Eskimos

Ten years ago the Education Development Centre of Cambridge, Mass. decided to make a series of films showing in detail the traditional life of an Eskimo group. At the suggestion of the Northern Co-ordination and Research Centre of the then Department of Northern Affairs and National Resources, they chose the Netsilik Eskimos. The Netsiliks had been less influenced by modern ways than most Canadian Eskimos, and the memory of old times would be sufficiently strong for any necessary reconstruction to be achieved without difficulty. Grants were obtained from the Ford Foundation and the U.S. National Science Foundation, and work was begun in the summer of 1963. The resulting films have been produced by Quentin Brown, and directed by Dr. Asen Balikci and Father Guy Mary-Rousselière, O.M.I. The National Film Board of Canada has been responsible for the sound track and has undertaken the distribution of the films in all countries except the United States. The series consists of nine 16 mm. colour films and is divided into 21 parts, each lasting about half an hour.

Each episode is shown in great detail and without haste. The series presents an intimate and well-balanced account of the life of the Eskimos and the ways in which they managed to survive under extreme conditions using the meagre resources of the Arctic. No written account could provide a comparable description. If a picture is worth a thousand words, how much is $10\frac{1}{2}$ hours of film worth?

The only language spoken in the films is Eskimo. There is no explanation in English, nor is any needed. The films are too good and too detailed for that. The Educational Development Centre has performed a real service to the world in providing such an excellent record of traditional ways before it is too late. Both artistically and anthropologically the series is an outstanding success.

Details of the films are as follows:

Film		Time	Cost
At the Caribou Crossing Place	Part 1	30 mins. 15 secs.	$260
	Part 2	29 mins. 21 secs.	$260

Film		Time	Cost
At the Autumn River Camp	Part 1	26 mins. 18 secs.	$220
	Part 2	33 " 06 "	260
At the Winter Sea Ice Camp	Part 1	35 " 40 "	300
	Part 2	36 " 16 "	300
	Part 3	30 " 16 "	260
	Part 4	34 " 40 "	260
Jigging for Lake Trout		31 " 56 "	260
At the Spring Sea Ice Camp	Part 1	26 " 40 "	220
	Part 2	26 " 36 "	220
	Part 3	26 " 35 "	220
Group Hunting on the Spring Ice	Part 1	34 " 13 "	260
	Part 2	27 " 55 "	220
	Part 3	33 " 01 "	260
Stalking Seal on the Spring Ice	Part 1	24 " 31 "	220
	Part 2	33 " 45 "	260
Building a Kayak	Part 1	33 " 00 "	260
	Part 2	32 " 46 "	260
Fishing on the Stone Weir	Part 1	30 " 20 "	260
	Part 2	26 " 52 "	220
		10 hrs. 24 mins. 02 sec.	$5,260

The total cost of the individual films is $5,260 with a 10% discount on the complete series, or a 5% discount on the purchase of any number of these films exceeding $2,000. A description of the content of each film is available. Details can be obtained from the National Film Board, Box 6100, Montreal 101, Quebec, or from any of the Film Board's regional offices in Canada or abroad. In the United States enquiries should be addressed to Universal Education and Visual Arts, 221 Park Avenue South, New York, N.Y. 10003, or to Modern Learning Aids, 1212 Avenue of the Americas, New York, N.Y. 10036.

G.W. Rowley

REVIEW

PITSEOLAK: PICTURES OUT OF MY LIFE

Edited by Dorothy Eber

Published by Design Collaborative Books, Montreal, in association with Oxford University Press, Toronto. $9.95

Reviewed by W. T. Larmour
Eskimo Art Specialist, Northern Services Division,
Department of Indian Affairs and Northern Development.

The book, "Pitseolak: Pictures out of my life", is the autobiography of Pitseolak, an artist whose work also illustrates the publication. English and Eskimo syllabics printed side-by-side tell the Eskimo woman's life-story.

Pitseolak is a resident of Cape Dorset on Baffin Island who has "lost the time when I was born.....my sons say maybe I am 70". A talented artist, she has produced a variety of engravings, stone cuts, and drawings in colour and black and white, more than 90 of which illustrate the book brought out September 30, 1971 by Design Collaborative Montreal Limited in association with Oxford University Press of Toronto.

In her autobiography, Pitseolak recounts her childhood, life in the old Eskimo way, and the changes brought with the arrival of strangers from the south. She also describes games she played while young, the fearsome powers of the Eskimo shamans, old hunting trips and the coming of James Houston, the first civil administrator for Cape Dorset, who asked her and others to draw pictures and to produce other art depicting their life style and environment.

Pitseolak is very aware of the significance of the period in which she has lived for her people. In her words: "I know I have had an unusual life, being born in a skin tent and living to hear on the radio that two men have landed on the moon. I think the new times started for Eskimos after the white men's war, when the white men began to make many houses in the Arctic."

Pitseolak - her name means "sea pigeon" - was born on Nottingham Island in Hudson Bay. In the year she was born her family left their camp at Sugluk in what is now Nouveau-Québec to set out for Baffin Island. They travelled to the Foxe Peninsula and then went on to Frobisher Bay.

Early travels of her family were made in sealskin boats but she recalls the time when her father decided to buy a wooden boat in Lake Harbour, Baffin Island. On that occasion, the little Pitseolsk burst into tears with fright when she saw her first white man.

When she was still young, Pitseolak married her childhood friend Ashoona and was the mother of 17 children, four of whom survive today. The family lived in igloos and summer tent-huts while on hunting trips in the region. Her husband who had a reputation as a fine hunter, died while the family was on one of these hunting and fishing trips.

Pitseolak was interviewed and tape-recorded in Cape Dorset by Dorothy Harley Eber, with the help of interpreters, and the tapes were edited by Mrs. Eber into a narrative that tells Pitseolak's life story. The Eskimo text was prepared with the assistance of the Department of Indian Affairs and Northern Development, in particular with the aid of Sarah Ekoomiak and Harriet Ruston, two Eskimo girls who work for the Department in Ottawa.

Two copies of Pitseolak's book were presented to the National Library by the Honourable Jean Chrétien, Minister of Indian Affairs and Northern Development with the author in attendance at the presentation.

Commenting on the publication of the book, Mr. Chrétien observed: "I am most pleased this book has been added to the growing number of books by Eskimo and Indian authors. Last year we witnessed the publishing of "Harpoon of the Hunter" by another Eskimo, Markoosie, a talented young man who is also an airline pilot. Now we have a book of memoirs and wonderful artwork by Pitseolak, a lady who has preserved for us in a vivid fashion times back to the turn of the century when the Eskimo people were much less affected by the white man's society.

Both authors have made outstanding contributions to the cultural heritage of the native people and to all Canadians. It is indeed interesting for us to find out about 'the old way'."

FROM OUR READERS

From Dr. Kou Kusunoki,
Chief, Department of
Research and Information,
Polar Research Center,
National Science Museum,
Kaga 1-9-10, Itabashi-ku,
Tokyo, Japan.

I am a reader of the "Arctic Circular" and have read your recent article on "Monzino Polar Expedition" with. . . great. . . interest.

If you could inform me (of) the later news of that expedition, I should be very grateful to you. Here in Japan I have never heard of that expedition. Since I was on Arlis II in May 1964 when Bjoern Staib's party gave up their dash to the Pole, I am still interested in the arctic expeditions.

Would you be kind enough to inform the editor of the Arctic Circular about the error in the article of "Tokai University Canadian Arctic Research Expedition (TUCARE)" in page 36, No. 1, Vol. XXI.

It is not Tokyo University but Tokai University. University of Tokyo is governmental university and Tokai University is private one. (University of Tokyo is the official English name for TOKYO-DAIGAKU in Tokyo, not spelled Tokyo University; Daigaku stands for university).

In the address of the Committee, Hiratpuka should be read Hiratsuka. (Headquarters of the Tokai University is located in Tokyo).

With very best wishes.

NOTE: The Editor's thanks to Dr. Kusunoki for this correction.

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Dr. Noel Odell of Clare College, Cambridge, has forwarded us a copy of the special number of the newpaper LO SCARPONE of Milan, dated 1 July,

1971. It contains more than four pages of text and photographs of the Monzino expedition to the North Pole (See Arctic Circular, Vol. XXI, No. 1, 34-35, and No. 2, 132). Dr. Odell had received this copy from Guido Monzino himself, whom he had met some years ago in Switzerland, both being avid members of the mountaineering fraternity.

The photographs are superb, showing ice conditions encountered and the efforts of the dogs and men to overcome the obstacles they presented. In addition to pictures of members of the expedition, there are photos of equipment, living and travel conditions, and of the camp at 88°N. There is also a very fine view of the Canadian Armed Services "Argus" making a reconnaissance survey over the party. This service by the Canadian government was very much appreciated.

The text is, naturally, an enthusiastic account of the success of the undertaking and relates aspects of the experience as seen through the eyes of several of those involved. It also includes reference to the audience granted by the Pope to members of the expedition, the congratulations of the President of the Republic who received them at the Quirinal Palace, and their reception by senior members of the Cabinet and other government agencies.

We are grateful to Dr. Odell for bringing this issue of the paper to our attention.

Arctic Circle correspondence - Correspondence should be addressed to the officer concerned,

c/o The Arctic Circle,
Box 2068, Postal Station D,
Ottawa, Ontario
K1P 5W3

Arctic Circle Meetings

The regular meetings of the Arctic Circle are held on the second Tuesday of every month at 8.30 p.m. in the Officers Mess, No. 9 Transport Company, R.C.A.S.C., Catherine Street at the corner of Bank Street. The bar opens at 8 p.m., giving members half an hour for social and business discussions before the meeting begins and the guest speaker gives his address.

Out-of-town members who wish to receive notices of these meetings and, thereby, be informed in advance regarding the guest speakers and the topics to be discussed, should address their requests to the Secretary, Mr. Keith C. Arnold.

The Arctic Circular

The Arctic Circular is published three times a year - oftener if the amount of material received permits. Correspondence, papers and reports are welcomed from all members, from persons living in the North, or from anyone having in formation on general northern activities, research or travel, or on technological, industrial or social developments. Contributions and correspondence should be addressed to the Editor, Mrs. Margaret Montgomery Larnder.

Back issues of the Arctic Circular are available, single copies at $0.50 and complete sets (Volumes I to XX) $100.00. Requests should be addressed to Miss Mary Murphy, Publications Secretary.