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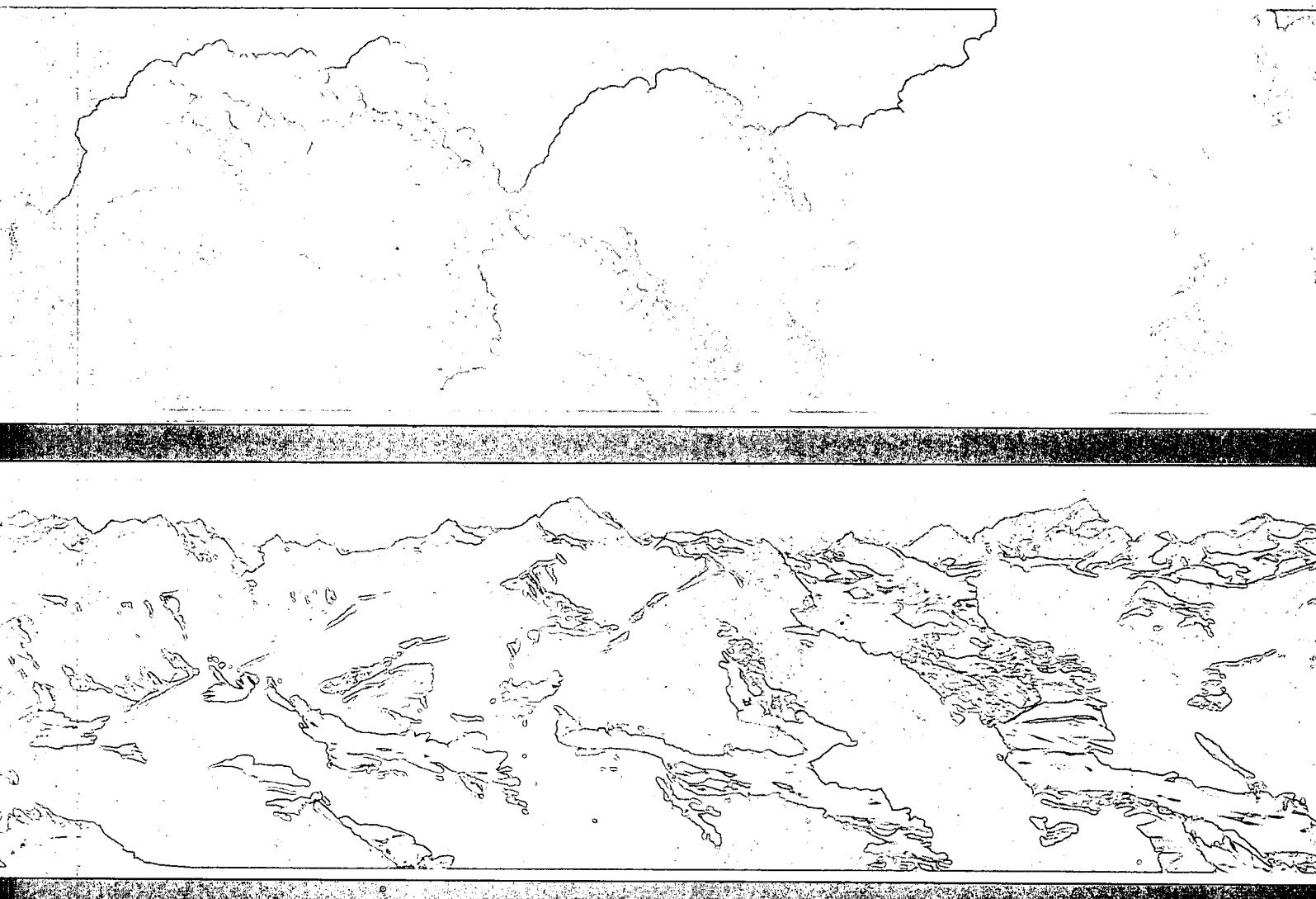
Research Projects in Glaciology – 1974



REPORT SERIES NO. 36

INLAND WATERS DIRECTORATE,
WATER RESOURCES BRANCH,
OTTAWA, CANADA, 1974.

Environment Canada
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PREFACE

This report is the fifth in a series outlining the glaciological research program in what is now the Water Resources Branch, of the Department of the Environment. The earlier reports are:

1) "Research Projects in Glaciology, 1968"
Inland Waters Branch, Department of Energy
Mines and Resources, 1968

2) "Ice Studies in the Department of Energy Mines and Resources, 1968"
Report Series No. 7, Inland Waters Branch
Department of Energy Mines and Resources, 1968

3) "Research Projects in Glaciology, 1971"
Report Series No. 15, Inland Waters Branch
Department of Energy Mines and Resources, 1971

4) "Research Projects in Glaciology, 1972"
Report Series No. 23, Inland Waters Branch
Department of the Environment, 1972.

It is apparent from the list that the glaciological program has been affected by several reorganizations and indeed, the program itself has changed in response to changing government priorities. However, the basic objective of maintaining a centre of glaciological expertise within the Federal Government has been retained. The reports are written so that the starting of new, and termination of existing projects can be easily identified. In this way the reports provide a record of the changes which have occurred.

The present report has two parts, 1) an introduction outlining the objectives and organization of the group, and the significant changes that have taken place and, 2) a catalogue providing details on the individual projects. Each project description has been fitted on one page and to facilitate this, only short references have been included. For full details of publications and reports see the consolidated list of publications at the end of the introductory section.

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1. DIVISION OBJECTIVES AND ORGANIZATION

The objective of the GLACIOLOGY DIVISION is to maintain within the Federal Government a centre of expertise in basic and applied studies of snow and ice in relation to our inland water resources. The Division is divided into six sections (see chart) in order to achieve this objective:

ARCTIC HYDROLOGY SECTION - carries out basic and applied research in Northern Canada. Basic research involves all components of the hydrologic cycle and is emphasized in research basin studies. Applied research is directed towards the needs of northern resource and transportation developments; water supply systems for settlements and the assessment of the environmental impact of highway and oil/gas pipeline development (Mackenzie Valley and Arctic Islands).

REMOTE SENSING AND INSTRUMENTATION SECTION - is responsible for the provision of technical and advisory services in areas of instrumentation and remote sensing by instrument development and construction, identification and evaluation of new technology, and by demonstration of feasibility of new techniques and instrumentation.

PERENNIAL SNOW AND ICE SECTION - embraces all Divisional programs related to the study of perennial snow and ice on the land surface, in particular, glaciers. There are three main thrusts to the current program:

Investigation of mass, energy and water balances for selected glaciers to determine the contribution of glacier meltwater to stream flow and the laws governing its variability; the nature of past and present glacier fluctuations and their relationship to climatic change.

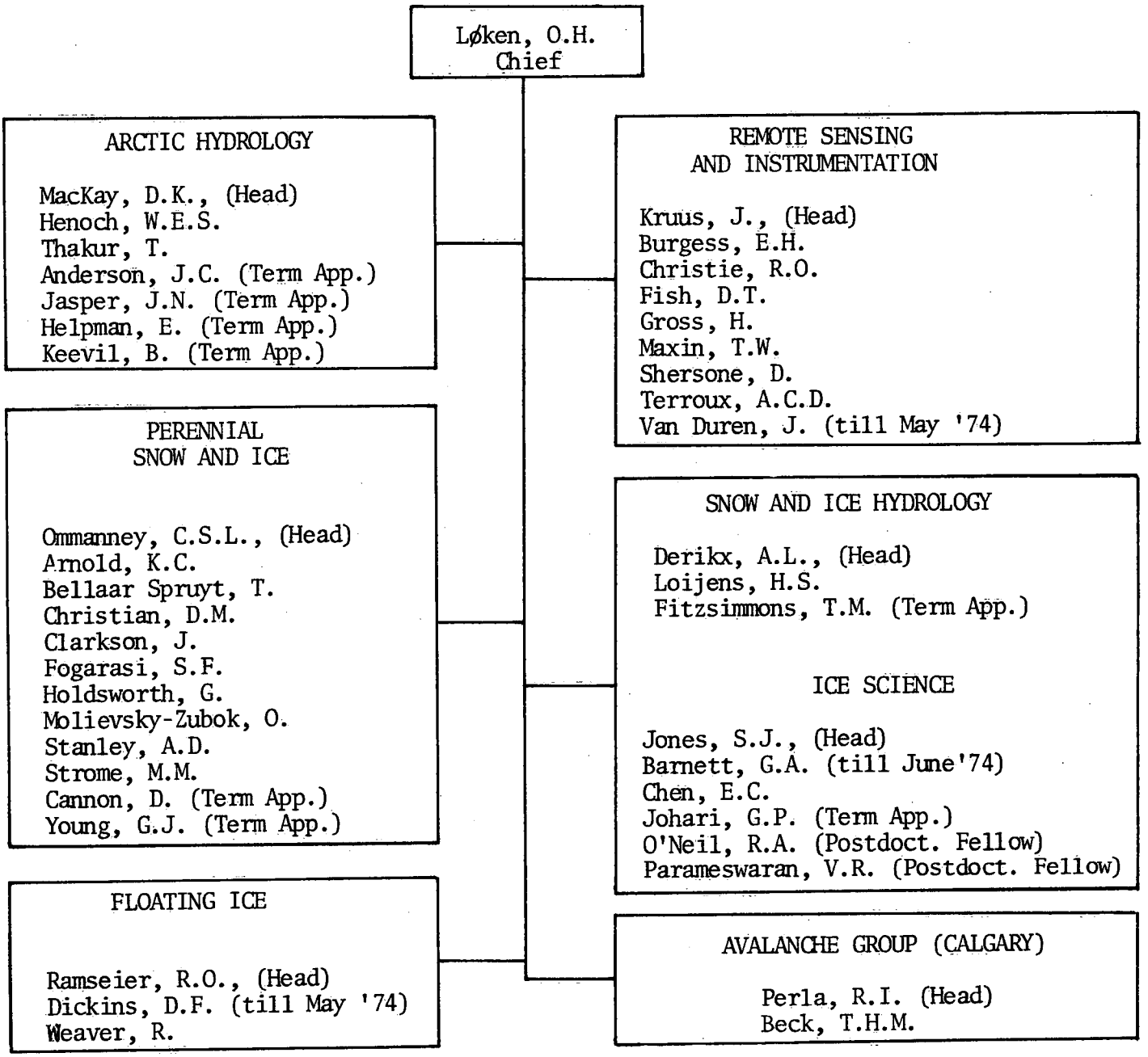
Research into the physical properties of glaciers to permit a better assessment of environmental hazards related to glaciers such as jökulhlaups and surges and investigations of the flow characteristics of glaciers to assess large scale mass losses by calving with its concomitant threats to activities in the coastal zone.

Development of a comprehensive information system on snow and ice resources in Canada to maximize the usage of all existing glacier data and information and to identify all glacierized areas potentially hazardous to human activity.

SNOW AND ICE HYDROLOGY SECTION - is responsible for detail site-specific, as well as process oriented studies of snow metamorphosis with particular emphasis on the movement of meltwater through the snowpack and the underlying soil or ice. Remote sensing techniques are used, and further developed, to extrapolate site-specific data to river basins. Hydrological forecast models may require modification to incorporate the additional snow pack information.

ICE SCIENCE SECTION - basic properties of ice are studied under controlled laboratory conditions. The mechanical and electrical properties of ice are typical examples of studies carried out in close cooperation with field

GLACIOLOGY DIVISION



Reid, I.A.
(Applied Hydrology Div.)

oriented studies, e.g., radio echo-sounding of glaciers. The interaction between ice and hydrocarbon oils is of particular interest in connection with current petroleum developments in Arctic Canada and the behaviour of the oil-water-ice system is being investigated under field and laboratory conditions.

FLOATING ICE SECTION - engineering glaciology in relation to floating ice forms the core programs in this Section, and current emphasis is on problems relating to navigation (e.g. on the St. Lawrence Seaway), oil pollution in ice infested waters, and on the application of remote sensing techniques for ice studies.

An Avalanche Group has recently been established in Calgary to carry out glaciological research related to snow and ice mechanisms of avalanche problems.

2. RECENT CHANGES IN THE GLACIOLOGY PROGRAM

The previous reports in this series show that continuous change has taken place in the glaciology program and this has also been the case in the two years since the preceding report was published. This reflects the continuing need for retaining flexibility in the research program to ensure timeliness and applicability of the research in providing solutions to problems as they arise. A research program must always try to anticipate problems, and while it is important to focus on developments in the near future, its success can only be protected by also giving attention to the more distant future (five or more years from now) i.e., by also pursuing basic research.

In the activities of the Arctic Hydrology Section, the Mackenzie Valley Pipeline studies continue to play a dominating role, but since the start of the environmental assessment of the Mackenzie Highway, our involvement has broadened to include the Highway as well. With the possible commencement of a pipeline from the Arctic Islands to Southern Canada, studies of the hydrologic conditions in the Eastern Arctic have been accelerated. Basin studies, including studies of the soil moisture conditions in the active layer and the behaviour of ice dammed lakes, have started on Ellesmere Island.

In the Perennial Snow and Ice Section, studies of the physical characteristics of ice masses have been extended to include a study of the deformation of ice islands floating at sea, (such ice bodies deform at very low stresses) and a study of the surging Tweedsmuir Glacier, British Columbia, started in October 1973 to determine the future trend of this surge which was first reported in September 1973. Improved computerized methods for analyzing mass balance data have been developed, and it has been possible to reduce the number of actual field measurements necessary to achieve the desired accuracy of the annual glacier mass balance. This stepping down of field activities in the mass balance work coincides with the termination of the International Hydrologic Decade, at the end of 1974. The future scope of the mass balance investigations will partly depend on the planning for the International Hydrological Program and the new GEMS (Global Environmental Monitoring System) program of United Nations. Some IHD projects, e.g. the Glacier Inventory of Canada, will not be completed during the Decade and will continue for at least a couple of years.

The Snow and Ice Hydrology Section has continued data collection and analysis of new and existing data from the Mer Bleu experimental plot near Ottawa. In order to assess the usefulness of gamma-ray radiation for use in snow surveys an extensive airborne experiment has been carried out over Southern Ontario. The results are now being analyzed and similar surveys are planned for other parts of the country, e.g. the Prairies and the Western Cordillera.

The Ice Science Section has put increasing emphasis on the study of the electrical properties of ice, an important part of the overall effort in remote sensing, particularly in the microwave regions. Additional studies of ice at low temperature have been initiated.

The Floating Ice Section has given increased emphasis to the use of remote sensing techniques, particularly passive and active microwave systems in the study of ice. The availability of imagery from ERTS and from the SKYLAB missions has prompted investigations of their practical use for operational purposes. Ice thickness measurements using a new radar instrumentation is being developed and will be used in connection with the Beaufort Sea environmental studies. The section participates in the monitoring of the Ice Drilling Platform constructed by Panarctic Oil Ltd., for use in its first major off-shore drilling project in the Arctic Archipelago. The section also participated in the Hover-craft ice-breaking trials. Our involvement in these two last activities resulted from the requests of two different federal departments and this shows that our expertise is both recognized and relevant.

The Remote Sensing and Instrumentation Section has given much attention to studies of ERTS imagery and an assessment of its possible application to hydrologic investigation. The work has to a large extent been carried out by outside groups, working under contract. The use of satellites as communication links to transmit data from remote observing stations is also under investigation. The instrumentation group has continued to provide specialized service to a broad range of research projects.

One of the most significant changes in the program is the recent establishment of an avalanche research group in Calgary. This development is taking place in cooperation with National Research Council and it is hoped that we jointly will strengthen the Canadian research effort in this field.

The Glaciology research program is national in scope and field investigations have been carried out in many regions of the country, but since its inception the program has been carried out from the headquarters in the National Capital Region. With the establishment of the group in Calgary, we will for the first time have staff permanently located outside the Ottawa-Hull area.

Ottawa
July 1974

O. H. Løken
Chief
Glaciology Division

3. TECHNICAL AND SCIENTIFIC REPORTS 1972-1974

The following list contains the publications written or co-authored by members of the Glaciology Division since the previous Project Catalogue was printed in 1972. Reports which have been written under contract agreements between the Division and individual scientists or companies are listed under the name of the author(s), and are marked with an asterisk (*).

Note that the report "Hydrologic Aspects of Northern Pipeline Development" is listed under "MacKay et. al. (1973)". This report consists of 16 individual contributions which are listed separately under their respective authors, but referred to as "In" MacKay et. al. (1973)".

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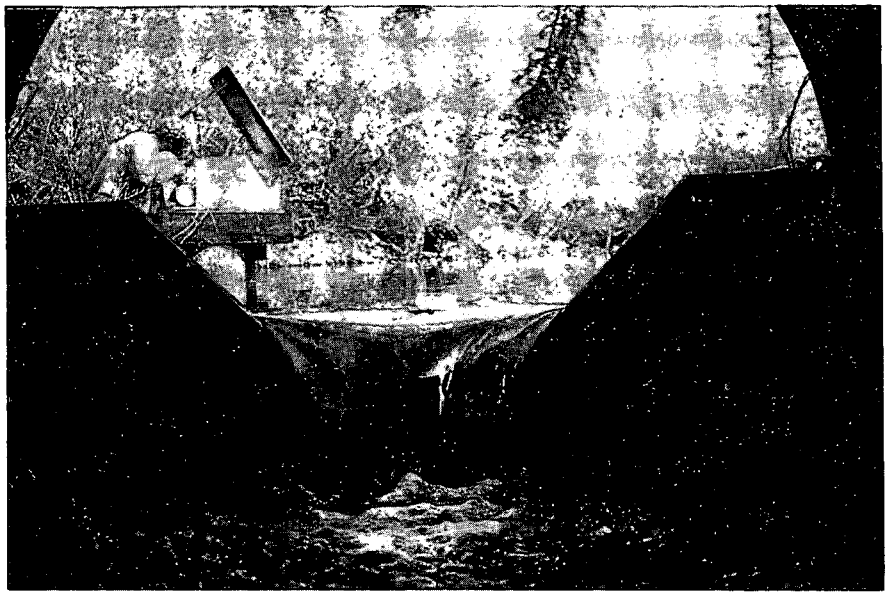
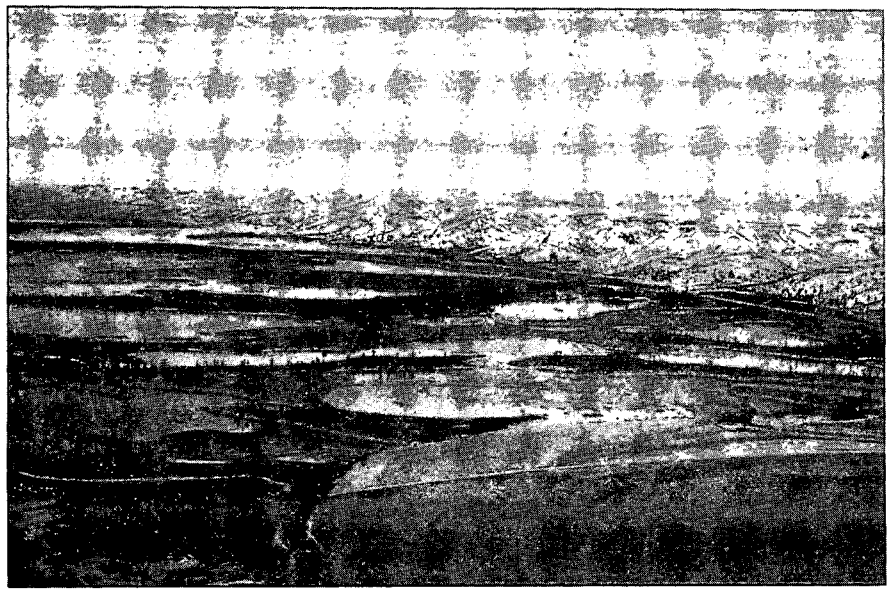
Project Catalogue

Arctic Hydrology



Discharge measurements
Boot Creek
(G-73-4)

Ground ice exposed by
river bank erosion
(G-72-19)



Mackenzie Delta
channel system
(G-70-1)

PROJECT: G-70-1

MACKENZIE VALLEY STUDIES

PRINCIPAL INVESTIGATOR: D. K. MacKay

COOPERATIVE AGENCIES: University of British Columbia (Dr. J. R. Mackay)
Geological Survey of Canada, Water Survey of Canada

OBJECTIVES: To conduct hydrologic-geomorphic studies in the Mackenzie basin aimed at providing:

1. Information against which the environmental impact of a possible Mackenzie Valley Pipeline can be assessed;
2. Improved knowledge about Canada's largest river basin, by investigating: (a) Ice shove and ice jamming on the Mackenzie River, (b) The seasonal distribution of flow in the Mackenzie Delta, (c) Temperature characteristics of the river water, (d) Distribution of aufeis, (e) The significance of cryostatic pressure caused during freeze-back of the active layer, (f) Effects of snow cover on ground temperatures, (g) Katabatic winds at Paulatuk, N.W.T.

LOCATION: Mackenzie basin and the Delta region, N.W.T.

PREVIOUS WORK: A broad range of data has been collected for varying periods from several locations since 1967 to the present.

Data on cryostatic pressures, katabatic winds, snow cover, snow and ground temperatures, ice shove and ice jamming, aufeis, seasonal flood distribution in delta channels, etc., are available.

For results see: MacKay, et. al., (1973), Sherstone, (1973a), Swami, (1973b), Thakur and MacKay, (1973), Williams and MacKay, (1973).

WORK IN PROGRESS: Continuation of measurements and evaluation of results.

FUTURE WORK: Phasing out of some projects and introduction of new ones as progress warrants.

PROJECT: G-70-4

EXTREME SUMMER STORM CONDITION IN THE TRIBUTARY HEADWATERS OF THE LOWER MACKENZIE, N.W.T.

PRINCIPAL INVESTIGATORS: D. K. MacKay, S. Fogarasi and M. Spitzer

PUBLICATION: MacKay, Fogarasi and Spitzer (1973).

PROJECT COMPLETED

PROJECT: G-70-5

REGIONAL HYDROLOGIC CHARACTERISTICS OF MACKENZIE RIVER BASIN

PRINCIPAL INVESTIGATOR: T. Thakur

COOPERATING AGENCY: None

OBJECTIVES:

1) To collect data and study complete basin morphometry from all available sources.
2) To evaluate and mathematically analyze the available geomorphic and hydrometric data.
3) To estimate selected stream flow characteristics of the gauged Mackenzie watersheds.
4) To develop mathematical models to estimate stream-flow characteristics of ungauged basins.
5) To carry out statistical analysis to measure influence of geomorphic parameters on stream flow.

LOCATION: Mackenzie River Basin

PREVIOUS WORK: For results see: Thakur and Lindeijer (1973)

WORK IN PROGRESS: Data Collection, Processing and mathematical analyses are being continued.

FUTURE WORK:

1) Further improvement of the mathematical model.
2) Application of the model to different watersheds in Northern regions.
3) Testing applicability of the model to different types of hydrologic data.

PROJECT: G-72-7

MORPHOMETRIC ANALYSIS OF MACKENZIE DRAINAGE BASIN NETWORKS

PRINCIPAL INVESTIGATOR: T. Thakur

PROJECT COMBINED WITH G-70-5

PROJECT: G-72-16

HYDROLOGIC RECONNAISSANCE - MACKINSON INLET AREA,
ELLESMERE ISLAND, N.W.T.

PRINCIPAL INVESTIGATOR: O. H. Løken - work done under contract with McMaster University - Professor S. B. McCann

COOPERATING AGENCIES: Polar Continental Shelf Project

OBJECTIVES: To carry out a hydrological reconnaissance in the area near the head of Mackinson Inlet and northward to the head of Bay Fiord, Ellesmere Island, with particular emphasis on ice problems and hydrologic problems which may arise in connection with possible pipeline and/or marine terminal construction in this area.

LOCATION: Ellesmere Island, N.W.T.

REPORT: McCann, James, Cogley and Taylor (1972)

PROJECT COMPLETED

PROJECT: G-72-18

HYDROLOGICAL STUDIES, VENDOM FIORD AREA, ELLESMERE ISLAND, N.W.T.

PRINCIPAL INVESTIGATORS: D. K. MacKay - work done under contract with Profs. S. B. McCann and M-K Woo, McMaster University.

COOPERATING AGENCY: Polar Continental Shelf Project (EMR)

OBJECTIVES: To study the present and past hydrologic regime of the major streams that reach the head of Vendom Fiord, with particular emphasis on extreme events such as those caused by sudden draining of ice dammed lakes. To investigate soil moisture conditions in the active layer and their dependence on time of year, slope and meteorological conditions.

LOCATION: Vendom Fiord, Ellesmere Island ($78^{o}10'$N. 82^{o}W)

PREVIOUS WORK: Following reconnaissance in 1972, a major field project was started in 1973. For results see: McCann, Cogley, Woo and Blachut (1974)

WORK IN PROGRESS: Summer field work (1974) has started with increased emphasis on studies of the hydrology of the ice dammed lakes and on soil moisture conditions.

FUTURE WORK: Field program is expected to continue in 1975;final report will then be written.

PROJECT: G-72-19

BANK EROSION IN THE MACKENZIE DELTA

PRINCIPAL INVESTIGATOR: D. Outhet (D. K. MacKay)

COOPERATING AGENCY: Dept. of Geography, University of Alberta

OBJECTIVES: To study the causes and rates of erosion of channel banks in the Mackenzie Delta (south of 68°N), on bi-weekly and yearly time scales; to categorize bank profiles and erosion rates for each type.

LOCATION: Mackenzie Delta, N.W.T.

PREVIOUS WORK: Field - Preliminary reconnaissance of bank erosion sites (1972) and detailed field studies (1973)

WORK IN PROGRESS: Study of past bank erosion using old air photographs, and preparation of report.

FUTURE WORK: Analysis of data to assess relative importance of factors influencing bank erosion. Further field measurements of bank erosion rates for various bank types and preparation of a final report.

PROJECT: G-72-20

LAKE CHARACTERISTICS IN THE MACKENZIE BASIN

PRINCIPAL INVESTIGATOR: D. K. MacKay

COOPERATING AGENCY: Dr. J. R. Mackay, University of British Columbia

OBJECTIVES: A number of lakes in the Mackenzie basin which emphasize the range of physical and limnological conditions along the pipeline routes have been selected to:

1) describe the permafrost distribution under lakes. (In cooperation with J. R. Mackay, University of British Columbia), and,
2) study and document lake thermal regimes in different environments within the Mackenzie basin.

LOCATION: Mackenzie basin

PREVIOUS WORK: Field: Instrumentation of several lakes to collect water temperature data.

WORK IN PROGRESS: Continuation of data collection and analysis of results.

FUTURE WORK: Data collection to continue.

PROJECT: G-72-27

PHYSICAL CHARACTERISTICS OF SNOWBED COMMUNITIES IN THE RICHARDSON MOUNTAINS, N.W.T.

PRINCIPAL INVESTIGATOR: N.J.K. Peterson (on contract-D.K. MacKay)

COOPERATING AGENCY: Geography and Biology Depts., Carleton University.

OBJECTIVES: To investigate distribution and ablation of snow banks and their effects upon ground temperature, soil moisture regime, active layer development, ice content of underlying soils, the annual temperature regime and the energy flux at the air-snow and snow-ground surface interfaces.

LOCATION: Canoe Lake, Richardson Mts., N.W.T. ($68^{o}4'N$, $135^{o}30'W$)

PREVIOUS WORK: Field: During the summers of 1971 and 1972, the ecology of snowbeds, and the distribution of snow cover in the vicinity of Canoe Lake were studied. Physical characteristics of snowbeds, including their distribution, depth, accumulation and melt rates and albedo were observed and measured. Meteorological parameters such as air temperature, relative humidity, precipitation, wind and solar radiation were monitored in snowbank regions. Ground temperatures and soil water contents were obtained, and topography and snow cover mapped for three study sites.

WORK IN PROGRESS:

1) Continuation of collection of hydrometeorological and energy budget data.
2) Surveying of a 15 by 15 mile area to study distribution and characteristics of snowbeds.
3) Analysis of data to test hypotheses.

FUTURE WORK:

1) Analysis of data.
2) Preparation of a report on the findings.

PROJECT: G-73-4 - formerly part of G-70-1

BOOT CREEK AND PETER LAKE RESEARCH WATERSHEDS, N.W.T.

PRINCIPAL INVESTIGATOR: J. C. Anderson

COOPERATIVE AGENCIES: Atmospheric Environment Service; Water Survey of Canada; Fisheries Research Board

OBJECTIVES: To measure the components of the water balance in a tundra (Peter Lake) and a tundra-taiga (Boot Creek) watershed, in the Mackenzie Delta region, N.W.T., and to apply the results of this research to other watersheds in the lower Mackenzie which may be crossed by pipelines and highways. To obtain and provide information on water supply, for towns such as Inuvik.

LOCATION: Mackenzie Delta Region: Boot Creek basin ($68^{o}22'N$, $133^{o}33'W$); Peter Lake basin ($68^{o}45'N$, $134^{o}8'W$)

PREVIOUS WORK: Data collection at Boot Creek began in 1967, under D. K. MacKay. Project discontinued in 1968, resumed in 1970. Data collection at Peter Lake since 1970. Emphasis has been on the measurement of precipitation and runoff, and the establishment of relationships between these two variables.

For recent results see: Anderson and MacKay (1973)

WORK IN PROGRESS: Continued data collection: precipitation, runoff, latent evaporation, wind, temperature, humidity, global radiation.

FUTURE WORK:

1) Continued data collection and analysis.
2) Collection of soil and snowpack temperature data at Boot Creek during snowmelt period.
3) Extension of snowmelt flood monitoring to larger basins in Inuvik area which are crossed by Mackenzie Highway.

PROJECT: G-73-5 - formerly part of G-70-1

TWISTY CREEK WATERSHED STUDY

PRINCIPAL INVESTIGATOR: J. N. Jasper

COOPERATING AGENCIES: None

OBJECTIVES: To obtain data on precipitation and runoff events and to develop a mathematical model of basin runoff; to determine bed mobility and basin sediment yield through measurement of dissolved material, suspended sediment and bed load, for a small watershed in the headwaters of the Arctic Red River, N.W.T.

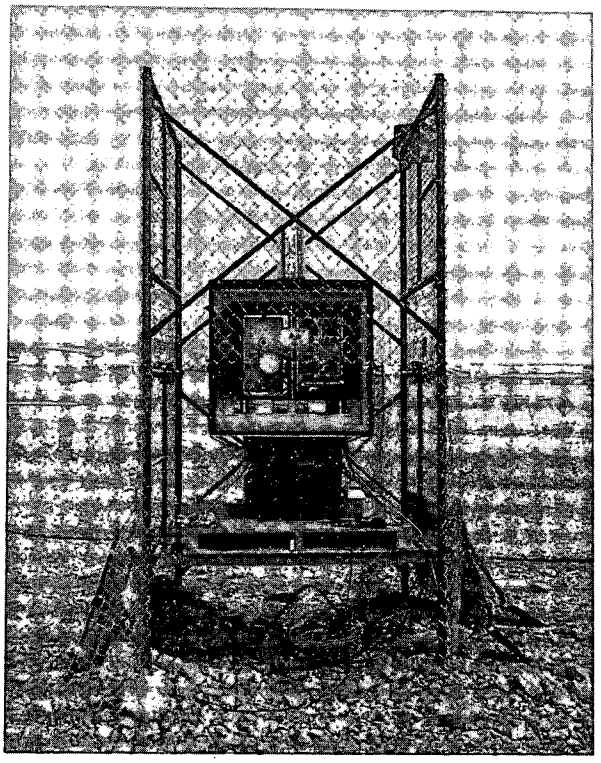
LOCATION: Mackenzie Mountains, N.W.T. ($65^{o}23'N, 131^{o}16'W$)

PREVIOUS WORK: Recording of temperature and humidity at 3 sites, precipitation at 6, water levels at 2, and collection of water chemistry and suspended sediment samples since 1972. Bed load sediment sampling was added in 1973 and continuation of above plus bed load sampling and basin surveying to allow construction of an accurate map from aerial photographs has been completed.

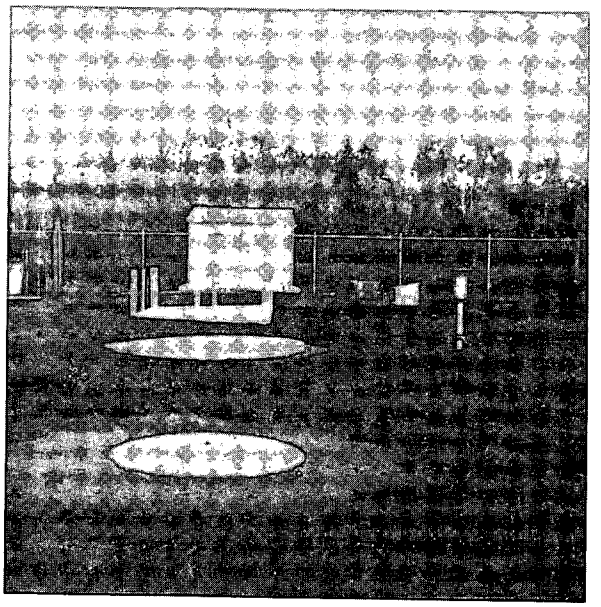
For recent results see: Jasper (1973) and Sellars (1973).

WORK IN PROGRESS: Computation of total sediment yield for 1972, 1973 field seasons, derivation of basin unit hydrograph and analysis of relationships between meteorologic data and stream flow recession.

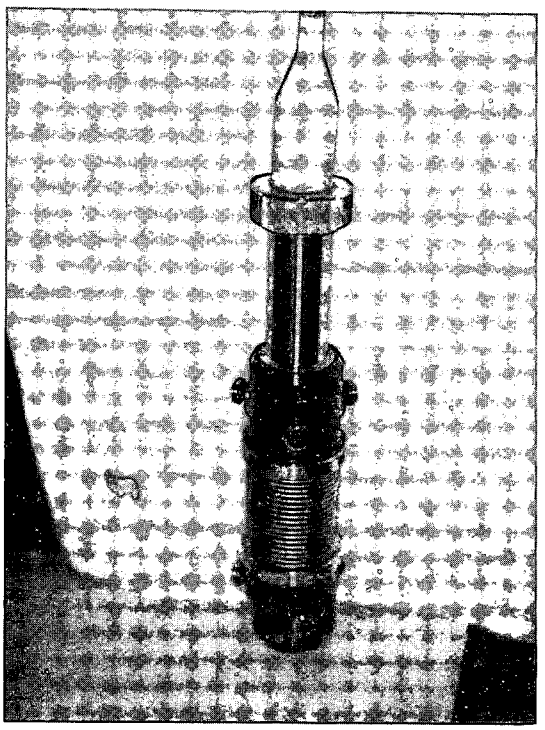
FUTURE WORK: Completion of field program in the summer of 1974, and final data analysis and summary for 1972, 1973 and 1974.



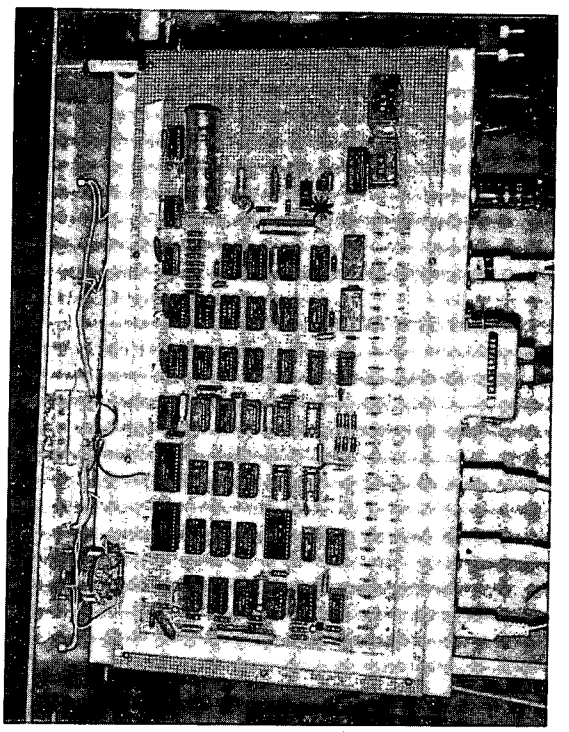
Isotope-fuelled automatic weather station under test in Resolute Bay (cover removed). (G-71-6)



Part of installation at Mer Bleue (G-69-8)



Fracture Deformation Gauge for Hydrology Research Division.



Controller for automated precision density measurements.

PROJECT: G-71-6

APPRAISAL OF LONG TERM METEOROLOGICAL RECORDERS

PRINCIPAL INVESTIGATORS: J. Kruus, A.C.D. Terroux

COOPERATING AGENCY: Atmospheric Environment Service, Atomic Energy of Canada Limited.

OBJECTIVES: Obtain, modify and develop long term meteorological recorder capable of operating unattended under winter conditions in the Arctic and Cordillera.

LOCATION: Resolute, N.W.T. (Also Churchill, Man. and Arctic Red River, N.W.T.)

PREVIOUS WORK: After a market survey in 1969, two Ott instruments were purchased. One has been operating in Resolute, N.W.T. since 1971, powered and heated by a thermo-nuclear generator produced by Atomic Energy of Canada Ltd. The other, using a wind generator and nickel-cadmium batteries has been operating at Churchill, Man. and recently at a site on Arctic Red River. Several modifications have been made to both systems to determine causes of failures.

WORK IN PROGRESS: The Arctic Red River Station and Resolute Station data are being analyzed and compared with data from neighbouring weather station.

FUTURE WORK: The Arctic Red Station was recently decommissioned. One Channel on the Resolute station will be used to estimate times of any failure. Data analysis will continue until the end of the lease for the isotope power supply in 1976.

PROJECT: G-71-7

APPLICATIONS OF REMOTE SENSING TO GLACIOLOGY

PRINCIPAL INVESTIGATORS: A.C.D. Terroux and A. D. Stanley

COOPERATING AGENCY: U.S. Geological Survey, B.C. Water Investigation Branch B.C. Hydro.

OBJECTIVES: To determine the area of application of ERTS and airborne imagery in the study of snow and ice, particularly with respect to:

1) Distribution of snow over large areas.
2) Assessment of snow depletion during the spring runoff.
3) Variation of glacier mass balance based on snow line levels at the end of the summer.

LOCATION: Western Cordillera between 46^{o}N and 64^{o}W

PREVIOUS WORK: Examination of existing Federal and Provincial photography from the Canadian Cordillera. Acquisition of ERTS imagery and infra-red photography (Banff-Jasper area).

WORK IN PROGRESS: Monitoring snow depletion using ERTS microfiche imagery. Acquisition of ground truth information from selected glacier basins and hydrologic basins. B.C. Hydro is conducting an operational trial in the spring of 1974 in estimation of snow line from computer-compatible ERTS images.

FUTURE WORK: B.C. Hydro will continue development of methods and applications for hydro power generation optimization.

PROJECT: G-72-9

EXTRACTION OF HYDROLOGIC INFORMATION FROM ERTS IMAGERY

PRINCIPAL INVESTIGATOR: J. Kruus

COOPERATING AGENCY: Operations and Research Coordination Branch (ORCD)

OBJECTIVES: To conduct research into methods which may be used to extract information from images received from the Earth Resources Technology Satellite, and to attempt an evaluation of the costs and benefits of obtaining this information by means of polar-orbiting satellites as compared to other means.

LOCATION: Ottawa

PREVIOUS WORK: Three contracts were funded by ORCD to meet the objectives of the program. All have been completed. See: Howarth (1973); Howarth and Woo (1973); Mollard, (1973), Solomon (1974).

WORK IN PROGRESS: The reports are being evaluated and the future direction of the project defined.

FUTURE WORK: Not yet defined.

PROJECT: G-72-10

RETRANSMISSION OF HYDROLOGIC DATA

PRINCIPAL INVESTIGATORS: J. Kruus, A.C.D. Terroux

COOPERATING AGENCIES: Water Resources Branch, Water Quality Branch, Canadian Centre for Remote Sensing.

OBJECTIVES: To gain experience with the operation of a data retransmission system based on the ERTS polar orbiting satellites and to evaluate the advantage of short-time data acquisition from a site with both hydrologic and water quality instruments.

LOCATION: Ottawa, Ontario and Centreville, N.B.

PREVIOUS WORK: A Data Collection Platform was operated on the Rideau River in Ottawa for eight months. Since June 1973 it has been operating in Centreville, New Brunswick. From the Rideau River location, water level data was transmitted. At the Centreville site, water quality parameters are being transmitted. For results see: Kruus (1973 a and b).

WORK IN PROGRESS: Preparation of a final report required as a part of the NASA agreement and tests to isolate causes for differences between land-line and ERTS data transmissions.

FUTURE WORK: Cooperation with Canada Centre for Inland Waters in operating the transmitter on a tower in Lake Winnipeg.

PROJECT: G-72-11

OPERATION OF INSTRUMENT SHOP

PRINCIPAL OFFICER: J. Kruus

COOPERATING AGENCY: None

OBJECTIVES: To provide technical advice and assistance to laboratory and field investigations.

LOCATION: Shop at Pte-Gatineau

PUBLICATION: Adams, Yank, Christie, and Kruus (1974).

PROJECT: G-72-24

APPLICATION OF THERMAL INFRARED TECHNIQUES TO DETECTION OF MELTING SNOW

PRINCIPAL INVESTIGATOR: A.C.D. Terroux

COOPERATING AGENCY: Geography Department, University of Michigan.

OBJECTIVES: To investigate if areas of melting snow can be determined by uncalibrated infrared line scan and radiometric techniques for both flat and glaciated areas.

LOCATION: Calgary, Lake Louise and Saskatchewan Glacier, Alberta.

PREVIOUS WORK: Thermal infrared line scan imagery was acquired outside Calgary in spring, 1972. Thermal infrared radiometer data was collected in Lake Louise for three days during the same period. Three IRLS flights were conducted over the Saskatchewan Glacier in June 1972 during a single day. Preliminary analysis of these three sets of data is complete.

WORK IN PROGRESS: Final analysis is presently underway using a Spatial Data colour densitometer. The project will be completed by the end of 1974.

PROJECT: G-72-25

PROVISION OF TECHNICAL ASSISTANCE IN REMOTE SENSING

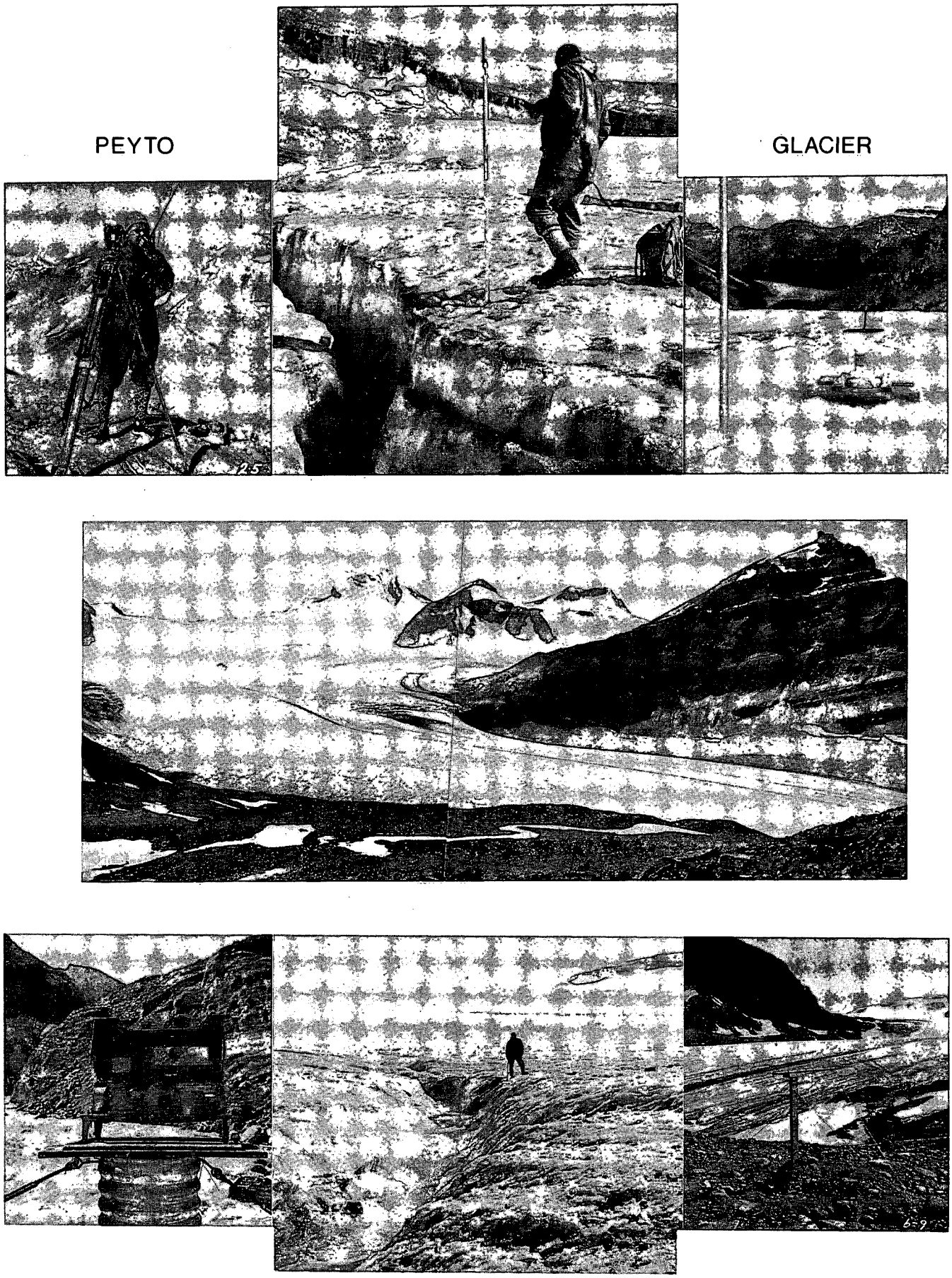
PRINCIPAL INVESTIGATORS: J. Van Duren, D. Sherstone, A.C.D. Terroux, H. Gross

OBJECTIVES: To provide technical assistance to Inland Waters Directorate in support of projects involving remote sensing.

REPORTS: For results see: Gross, Davis, Kruus (1971); Kruus, Davis, Gross (1973); O'Neil, Davis, Gross, Kruus (1973); Sherstone (1973a and b).

Perennial Snow and Ice

PERENNIAL SNOW AND ICE SECTION



PROJECT: G-67-1 MASS AND WATER BALANCE MEASUREMENTS AT PLACE GLACIER

PROJECT: G-67-2 DISCHARGE COMPONENTS OF A MELTWATER STREAM FROM DRAINAGE BASIN OF SENTINEL GLACIER

PROJECT: G-67-3 MASS AND WATER BALANCE MEASUREMENTS AT WOOLSEY GLACIER

PROJECT: G-67-4 MASS AND WATER BALANCE MEASUREMENTS AT PEYTO GLACIER

PROJECT: G-67-5 MASS AND WATER BALANCE MEASUREMENTS AT RAM RIVER GLACIER

SEE PROJECT: G-73-12

PROJECT: G-67-6

GLACIOLOGICAL INVESTIGATIONS IN THE AREA OF BERENDON GLACIER

PRINCIPAL INVESTIGATOR: A. D. Stanley

COOPERATING AGENCY: Granduc Operating Company Ltd.

OBJECTIVES: Berendon Glacier was selected for long-term investigations as part of IHD programs to determine the mass balance of selected glaciers. The investigations include surveys to determine the minimum of annual observations needed to predict changes in surface velocity and terminus position. Any advance of the terminus may be hazardous to a large-scale mining operation located near the terminus.

LOCATION: Coast Mountains (56° 15'N, 130°10'W), 35 km north of Stewart, B. C.

PREVIOUS WORK: Some glaciological information was obtained in 1956-57, but it was not until Granduc Mining Company became active in the area that additional information became available. Dr. W. H. Mathews of the University of British Columbia has been instrumental in obtaining data for the Berendon, North Leduc and Frank Mackie Glaciers. Since 1966 the mass balance has been obtained for Berendon Glacier, together with records of meltwater discharge and meteorological conditions.

PRESENT WORK: Standard glaciological measurements are being made to determine the winter accumulation to mid-May and observation of ablation at several markers on the glacier surface. These markers are resurveyed each year.

FUTURE WORK: Measurement of the net balance will be obtained in mid-August, together with a survey of the markers.

PROJECT: G-67-7

GLACIER SURGES

PRINCIPAL INVESTIGATOR: A. D. STANLEY

COOPERATING AGENCIES: Surveys & Mapping Branch; Polar Continental Shelf Project; Icefield Ranges Research Project (Arctic Institute of North America and the American Geographical Society).

OBJECTIVES: To obtain information on glacier surges and to evaluate existing theories.

PREVIOUS WORK: As a result of interest in the surges of Steele Glacier in 1966, the Glaciology Sub-Division contributed to a number of studies in the Icefield Ranges. In cooperation with a number of agencies aerial photographs were obtained during the surge of 1966, 1967 and 1969. Field studies were also undertaken on the "Rusty Glacier" which were considered to be in a pre-surge condition.

WORK IN PROGRESS: Preparation of a large-scale map showing the Steele Glacier and associated features.

PROJECT: G-67-8

PEYTO GLACIER AREA MAP

PRINCIPAL INVESTIGATOR: W.E.S. Henoch

COOPERATING AGENCIES: Surveys and Mapping Branch; National and Historic Parks Branch, (Department of Indian and Northern Affairs).

OBJECTIVES: To prepare a final edition, multicoloured, map of the Peyto Glacier area (scale 1:10,000) using Swiss cartographic techniques to portray a glacier in an Alpine environment. The map will have marginal notes about the local environment thus providing map users of diverse interests with a map of high technical and artistic value.

LOCATION: Peyto Glacier ($51^{o}40'N$, $116^{o}34'W$), 45 km northwest of Lake Louise, Alberta.

WORK IN PROGRESS: Compilation for the final edition of Peyto Glacier Map 1:10,000. The engraving of overlay with bedrock portrayal is nearing completion, the drawing of the overlay with shading of the relief will follow. All overlays will be finished and ready for printing before the end of 1974.

PROJECT: G-67-11

BARNES ICE CAP STUDIES

PRINCIPAL INVESTIGATOR: G. Holdsworth

COOPERATING AGENCIES: Surveys and Mapping Branch, Geodetic Survey (EMR), University of Minnesota, University of British Columbia, University of Victoria, B.C.

OBJECTIVES: To determine the thermal and flow regimes and the mass balance of the South Dome area of the Barnes Ice Cap. To identify significant parameters connected with the surge area on the south part of the South Dome and to construct a surge model for an ice cap with cold edges.

LOCATION: Barnes Ice Cap, Baffin Island ($70^{o}10'N$, $73^{o}30'W$)

PREVIOUS WORK: In 1970 and 1971 measurements of strain rate and velocity were made on the South Dome that contributed to the study of a postulated surge, Holdsworth (1973a, b and c); Barnett and Holdsworth (1974). Ice depths have been determined with a 35 MHz echo sounder at accurately determined points by S. J. Jones (1972).

WORK IN PROGRESS:

1) Assessment of the mass balance of the South Dome up to 1974 is being completed. Deformation data for the 1970-71 period have been prepared for publication.

2) Further measurements of ice depths on the South Dome are being undertaken by S. J. Jones and R. O'Neil with a variety of echo sounders.

3) Surface movement and strain rates are being measured on the southern part of the ice cap. Two localities are undergoing detailed study; the margin which flows into Generator Lake, and a land-based margin with and without ice-perched moraine development. (See Hooke, R. Le B. "Structure and Flow in the Margin of the Barnes Ice Cap, Baffin Island, NWT, Canada," Journ. of Glac., Vol. 12, #66 pp. 423-438).

4) Temperature profiles to a 30m depth in the ice cap (on the divide and margines) are being measured.

FUTURE WORK: A line of poles will be established along the central flowline of the surge area for measurement of flow rates, mass balance and for use as control in the echo sounding measurements. Deep drilling and expansion of the ice temperature program is planned.

PROJECT: G-67-13

DECADE GLACIER STUDIES

PRINCIPAL INVESTIGATOR: A. D. Stanley

COOPERATING AGENCY: None

OBJECTIVES: To study the mass, water and energy balance of a small well defined glacier basin in an Arctic environment, in order to determine the role of glaciers in the hydrologic cycle by:

1) Measuring accumulation and ablation;
2) Recording meltwater discharge and meteorological data;
3) Relating glacier variations to recent climatic trends;
4) Comparing glacier runoff to the regime of an adjacent unglaciated basin.

The glacier belongs to the worldwide network of glacier basins selected for detailed mass, water and energy balance measurements under the International Hydrological Decade program.

LOCATION: Central Baffin Island ($69^{o}38'$N, $69^{o}48'$W), 70 km southwest of Clyde River, N.W.T.

PREVIOUS WORK: Glaciological, hydrological and meteorological data collected since 1965. The observations have varied in intensity and scope from year to year. Data reports available.

For recent results see: Løken (1972a).

WORK IN PROGRESS: Analysis of data.

FUTURE WORK:

1) Continuation of spring and fall surveys.
2) Installation of long-term meteorological recorders for all year operation.

PROJECT: G-67-14

PER ARDUA GLACIER STUDIES

PRINCIPAL INVESTIGATOR: A. D. Stanley

COOPERATING AGENCY: Defence Research Board

OBJECTIVES: To investigate the mass and energy balance of a small, well-defined glacier in a high-Arctic environment and study the role of glaciers in the hydrologic cycle by:

1) Measurement of mass balance.
2) Relating glacier variations to recent climatic trends.

The mass balance data are related to surface movement determined each year by terrestrial photogrammetry.

LOCATION: At head of Tanquary Fiord, Ellesmere Island ($76^{o}35'$W, $81^{o}32'$N), 240 km northeast of Eureka, N.W.T.

PREVIOUS WORK: Glaciological data collected since 1964 (by Defence Research Board) and since 1968 by Glaciology Division.

WORK IN PROGRESS: Analysis of field data.

FUTURE WORK: No further field work planned.

PROJECT: G-67-15

GLACIER INVENTORY

PRINCIPAL INVESTIGATOR: C.S.L. Ommanney

COOPERATING AGENCIES: None

OBJECTIVES:

1) To prepare an inventory of perennial ice and snow masses on and beneath the land surfaces in accordance with the International Hydrological Decade recommendations.
2) To develop the necessary computer programs for storage, analysis and reduction of the glacier inventory data.
3) To investigate, on the basis of the collected data, factors that influence the geographical distribution and types of ice masses, the role of perennial ice in the Canadian water balance and changes over time caused by climatic change and environmental degradation.

LOCATION: Hull, P.Q.

PREVIOUS WORK: The progress of the Canadian Glacier Inventory has been summarised by Müller and Ommanney (1971) and by Ommanney (1971b and 1974b). The procedures manual for the glacier inventory was revised in 1973 (Ommanney et. al., 1973).

A computer program for obtaining totals, averages, weighted averages and histograms from the data so far collected (Axel Heiberg Island and Vancouver Island) has been converted to run on a CDC 6400 computer.

WORK IN PROGRESS: A procedures manual describing the data acquisition system is in the final stages of preparation. This system consists of a D-Mac Pencil Follower interfaced with a PDP 8-I mini computer and will be used for abstracting all the quantitative data from the work maps.

FUTURE WORK: The inventory will be extended to include all perennial ice areas in Canada. Analysis of data and selection of suitable benchmarks for continuous monitoring will follow. All data will be published in a series of Glacier Inventory of Canada reports. Consideration will be given to undertaking a ground ice and permafrost inventory.

PROJECT: G-67-16

DETERMINATION OF ICE ABLATION BY TERRESTRIAL PHOTOGRAMMETRY

PRINCIPAL INVESTIGATOR: K. C. Arnold

COOPERATING AGENCY: McGill University; Polar Continental Shelf Project, Department of Energy, Mines and Resources.

OBJECTIVES: To measure ice ablation by photogrammetric methods which have an accuracy of approximately ± 10 cm in order to:

1) Examine criteria by which ablation stakes should be distributed over a surface with respect to parameters that influence ablation, with special reference to albedo.
2) Develop an economic data gathering system.
3) Examine some criteria by which benchmark glaciers may be selected, with special reference to those in Arctic Canada.

LOCATION: White Glacier, Axel Heiberg Island (79°28'N, 90°45'W), N.W.T.

PREVIOUS WORK: Terrestrial photography of Peyto Glacier, Alta., (1966-68) Per Ardua Glacier, Ellesmere Island, (1964, 1966-68) and White Glacier, Axel Heiberg Island (1969-70).

Analysis of data by plotting accurate sequential glacier maps and comparing seasonal changes with glacier movement and mass balance data. Emphasis on White Glacier data.

FUTURE WORK: Dependent on final result of present studies.

PROJECT: G-68-2

FLUCTUATIONS OF GLACIERS IN THE ROCKY MOUNTAINS

PRINCIPAL INVESTIGATOR: W.E.S. Henoch

COOPERATING AGENCY: Western Forest Products Laboratory, Vancouver, B. C.

OBJECTIVES: To study secular glacier fluctuations in selected areas of the Rocky Mountains and examine glacier fluctuations, correlation with climatic parameters, river discharge and dedrochronological records.

WORK IN PROGRESS: Fluctuation of Glaciers temporarily restricted to study of literature.

PROJECT: G-69-1

GLACIER ATLAS OF CANADA

PRINCIPAL INVESTIGATOR: C.S.L. Ommanney

COOPERATING AGENCIES: Surveys and Mapping Branch, Department of Energy, Mines and Resources

OBJECTIVES: To compile and publish index maps showing the location and identification of every glacier in Canada, as part of the national IHD program for an inventory of perennial ice and snow masses.

LOCATION: Hull, P. Q.

PREVIOUS WORK: 46 maps covering Axel Heiberg Island, Devon Island, Baffin and Bylot islands, the Nelson River drainage basin and Vancouver Island have been published. Recently the first two maps of Ellesmere Island have been published.

WORK IN PROGRESS: A French language edition of the Glacier Atlas of Canada maps sheets compiled to date is in preparation. Maps covering the southern half of Ellesmere Island are in the final stages of compilation and preparation for publication. Basic mapping and identification has been completed for most of the glaciers in the Canadian portion of the St. Elias Range, Yukon Territory.

FUTURE WORK: Index maps for all the glaciers in Canada will be compiled and printed at a scale of 1:500,000. Maps will be issued individually when completed, will be included with the glacier inventory reports and, at the termination of the project, will be presented as a complete Glacier Atlas of Canada.

PROJECT: G-69-2

GLACIOLOGICAL ARCHIVE

PRINCIPAL INVESTIGATOR: C.S.L. Ommanney

COOPERATING AGENCIES: Archives of the Canadian Rockies, American Geographical Society, World Data Centre A, Glaciology, Tacoma.

OBJECTIVES: To develop a glaciological archives, references to the glacier inventory index numbers (Project G-69-1), for filing all available information on individual ice masses in Canada in the form of data sheets, maps, photographs, published and unpublished literature.

LOCATION: Hull, P.Q.

PREVIOUS WORK: Photographic and related material in a number of archives and institutions has been identified and indexed. Material has also been received from individuals and agencies for deposit.

WORK IN PROGRESS: An exchange program with the American Geographical Society is presently underway covering material collected during the International Boundary surveys and some private material in the United States.

Records in the Archives of the Canadian Rockies in Banff were identified in the summer of 1973 and this material is presently being processed.

Glacier survey data obtained by the Water Survey of Canada is being compiled and published.

The mountaineering literature is being reviewed in order to identify individuals who may have suitable material for deposit in the archive.

FUTURE WORK: All glacier information obtained or kept with Federal, Provincial, Municipal and private sources will be identified. When possible, foreign sources of information on Canadian glaciers will also be identified.

Individuals will be encouraged to observe glaciers and photograph them, depositing the records in the archive.

PROJECT: G-70-2

ICEBERG PRODUCTION SURVEY IN ARCTIC CANADA

PRINCIPAL INVESTIGATORS: C.S.L. Ommanney and K. C. Arnold

COOPERATING AGENCIES: Polar Continental Shelf Project and Department of National Defence.

OBJECTIVES: To investigate the distribution of tidal glaciers in Arctic Canada, the present rate and volume of iceberg production and variations during the past 25 - 30 years.

LOCATION: Queen Elizabeth Islands, N.W.T. and Hull, P.Q.

PREVIOUS WORK ON THIS PROJECT: Calving glaciers in Baffin, Bylot, Devon, Axel Heiberg, Coburg and southern Ellesmere islands have been identified through the glacier inventory project. Since 1971 aerial photography of most of the calving glaciers in the High Arctic has been obtained, (Løken et. al., 1972).

WORK IN PROGRESS: Calving glaciers in the remaining parts of Ellesmere Island are being identified. The aerial photography program is being continued.

FUTURE WORK: The identification of all calving glaciers will be completed based on the 1960 aerial photography. The present aerial survey program will be continued and comparisons made between the 1960 photography being used as a datum and earlier and later photography to assess changes in calving activity, flow rates etc. Time lapse mapping of selected glaciers will be carried out for quantitative determination of fluctuations and rate of ice-discharge.

PROJECT: G-70-7

BAFFIN ISLAND CLIMATOLOGY

PRINCIPAL INVESTIGATOR: S. Fogarasi

COOPERATING AGENCIES: Institute of Arctic and Alpine Research, Boulder, Colo.

OBJECTIVES: To develop a physical model that will relate short-term atmospheric parameters to glacier mass and water balance observations and to in-shore ice conditions.

LOCATION: Inugsuin Fiord, Baffin Island and Hull, P.Q.

PREVIOUS WORK: Statistical studies of the distribution and flux of atmospheric moisture have been completed for the period 1961-1965. A computerized Arctic weather type classification for the 1968 summer season has been developed. Horizontal velocity divergence, total vertical velocity and precipitation patterns were calculated for selected weather conditions over the Canadian Arctic Archipelago for the summer of 1968. Atmospheric water balance components were estimated for intermediate points using a grid system. (Fogarasi, 1972).

The synoptic climatology at the head of Inugsuin Fiord has been investigated and the effects of cloudiness on incoming global radiation determined for the summer of 1968. (Fogarasi and Boakes, 1973).

WORK IN PROGRESS: The cloud climate at the head of Inugsuin Fiord is being analyzed with a view to the prediction of the lowest possible ceiling and hence the effect of cloudiness on air transport and air pollution potentials in an arctic fiord.

FUTURE WORK: Using available data the effects of the short-term atmospheric energy budget on discharges from glacier fed streams will be determined. Extreme weather events that may result in severe flooding will be analyzed and the relationships between coastal winds, cyclonic outflows, fog and in-shore ice distributions investigated.

PROJECT: G-71-5

REGIONAL MASS BALANCE MEASUREMENTS IN THE QUEEN ELIZABETH ISLANDS BY USING AERIAL PHOTOGRAMMETRY

PRINCIPAL INVESTIGATOR: K. C. Arnold

COOPERATING AGENCY: Polar Continental Shelf Project, Department of Energy, Mines and Resources.

OBJECTIVES: To extend the limited number of conventional mass balance measurements to a larger number of locations by the use of aerial photogrammetry. Regional and altitudinal variations in mass balance will be determined, and the concept of representative glaciers will be tested. At first dynamically simple ice masses will be chosen for study, so that height changes can be easily related to mass balance changes. Air photography will be taken from low altitude at the end of each budget year at all sites, and at the onset on the melt season at a limited number of sites.

LOCATION: Queen Elizabeth Islands.

PREVIOUS WORK: Selected glaciers and ice caps have been photographed annually since 1971, some more than once a year.

WORK IN PROGRESS: Further air photography, and setting up ground survey control.

FUTURE WORK: The number of sites will be extended by five to ten each year over a period of five years.

PROJECT: G-72-1

ICEBERG PROJECT - LEFFERT GLACIER

PRINCIPAL INVESTIGATOR: G. Holdsworth

COOPERATING AGENCIES: Polar Continental Shelf Project, Marine Sciences Directorate and Ministry of Transport

OBJECTIVES: To determine discharge rates of selected tide-water glaciers on the South East Ellesmere Island; to understand the glaciological/oceanographic processes influencing iceberg calving and hence to develop models of this process, by:

1) estimating glacier velocities, rates of ice discharge and significant changes in iceberg production by continuous aerial survey through Project G-70-2,
2) determination of the flow regime, marginal deformation and calving rates for a selected glacier,
3) investigation of calving processes on a selected glacier.

LOCATION: Leffert Glacier, Ellesmere Island ($78^{o}40'N$, $75^{o}15'W$) and Hull, P. Q.

PREVIOUS WORK: Field investigations were carried out on Leffert Glacier in 1972.

WORK IN PROGRESS: Field data are being reduced and analysis is underway. A detailed map of the glacier is in preparation and present changes of the ice margin is monitored by air photography.

PROJECT: G-72-2

BIBLIOGRAPHY OF CANADIAN GLACIERS (ICEREF)

PRINCIPAL INVESTIGATOR: C.S.L. Ommanney

COOPERATING AGENCIES: Computer Science Centre, Department of Energy, Mines and Resources

OBJECTIVES: To make available a computerized reference system for all bibliographic material on Canadian glaciers.

LOCATION: Hull, P.Q.

PREVIOUS WORK: The project is designed around the RAID system used for storage and retrieval of geological information. An initial input of 1200 references has been made. A procedures manual for coding references has been published, (Ommanney and Clarkson, 1973).

WORK IN PROGRESS: References in the following journals - Arctic, Canadian Alpine Journal, Canadian Geographer, Alpine Journal, Arctic and Alpine Research and Geographical Bulletin - are being systematically processed for inclusion in ICEREF.

FUTURE WORK:

1) The estimated 4,000 references related to Canadian glaciers and neighbouring mountain topography will be key-worded for input to ICEREF.

2) A cross-referenced thesaurus of acceptable key-words will be produced.

2) Photographic records will be coded for input so that photographic and literature references for individual glaciers can be retrieved together.

PROJECT: G-72-3

GLACIATION LEVELS AND EQUILIBRIUM LINE ELEVATIONS IN THE CANADIAN HIGH ARCTIC

PRINCIPAL INVESTIGATOR: C.S.L. Ommanney - work done on contract by J. T. Andrews, Institute of Arctic and Alpine Research, Boulder, Colorado.

COOPERATING AGENCIES: University of Colorado, INSTAAR

OBJECTIVES: To map the glaciation levels and equilibrium lines between latitudes 74° and 84°N and between longitudes 60° and 120°W and thus to provide a fundamental measure of the present state of glacierization; information on the sensitivity of the region to climatic change, a measure of the relationship of the present glaciation level to the contemporary climate and an integrated, regional, climatic picture to supplement that obtained from existing weather stations.

LOCATION: Hull, P.Q. and Boulder, Colorado.

PREVIOUS WORK: The final contract report on the glaciation levels and equilibrium lines in the High Arctic, as well as for Labrador, has been submitted, (Miller, Bradley and Andrews, (1974)). A map showing the glaciation levels and equilibrium lines has been printed.

WORK IN PROGRESS: A paper, based on the final contract report, is being prepared for publication; it will include the printed map.

FUTURE WORK: The basic objectives have been fulfilled so no further work is anticipated on this project.

PROJECT: G-72-4

IRRP GLACIER INVENTORY PROGRAM, ST. ELIAS MOUNTAINS

PRINCIPAL INVESTIGATOR: C.S.L. Ommanney - work done on contract through the Arctic Institute of North America by R. H. Ragle and S. G. Collins.

COOPERATING AGENCIES: Arctic Institute of North American, American Geographical Society.

OBJECTIVES: To complete an inventory of glaciers in the St. Elias Mountains in accordance with International and Canadian specifications for glacier inventory studies.

LOCATION: Hull and Montreal, P.Q., New York and Washington, D.C., St. Elias Mountains, Yukon and British Columbia.

PREVIOUS WORK: All glaciers falling within drainage basins situated exclusively in the Canadian part of the St. Elias Range have been inventoried since 1972. Data collected consists of all basic data required except for areas. Source materials have been identified.

WORK IN PROGRESS: Inventory investigations are being extended to basins such as that of the Tweedsmuir Glacier which partly drain glaciers originating in Alaska.

FUTURE WORK: By March 1976 all the glaciers in the St. Elias Mountain Range, excluding the Alaskan basins, will have been inventoried. Studies will also encompass the basins draining into Kluane Lake from the east. All data and bibliographic and photographic source materials will be listed and published.

PROJECT: G-72-6

PRECIPITATION-CLIMATE AT SOME OF THE BRITISH COLUMBIAN GLACIERS

PRINCIPAL INVESTIGATOR: S. Foragasi

COOPERATING AGENCIES: None

OBJECTIVES: To design a model for the estimation of precipitation patterns at selected glacier basins in British Columbia by:

1) deriving precipitation patterns through statistical classification of the daily totals of precipitation measured at standard weather stations,

2) relating large-, and meso-scale meteorological and topographical parameters to known precipitation values,

3) developing weighting factors on a grid network for interpolation of precipitation values between measuring points.

LOCATION: Hull, P. Q.

WORK IN PROGRESS: Daily total precipitation values have been obtained from 12 weather stations for the summer of 1971. Precipitation values for each day are being correlated with the daily total precipitation of other days. Eight types of precipitation distributions have been recognized.

ESSA 8 satellite photographs are being used to relate cloud patterns to known types of precipitation distributions.

FUTURE WORK: Using an operational precipitation forecasting model a program will be developed to calculate large- and meso-scale meteorological parameters over a grid network. Weighting factors will be derived for each point in the grid and the determined precipitation patterns mapped.

Project G-72-23

COMPUTER REDUCTION OF GLACIER MASS - BALANCE DATA

PRINCIPAL INVESTIGATOR: G. J. Young

COOPERATING AGENCIES: None

OBJECTIVES: To develop a computerized data reduction system for glacier mass-balance measurements.

LOCATION: Ottawa, Ontario

PREVIOUS WORK: Data collection was initiated in 1965, but computerized data processing started in 1970. The project uses data collected on projects G-67-1, G-67-2, G-67-3, G-67-4, G-67-5.

WORK IN PROGRESS: A computer program to describe terrain characteristics in a drainage basin using a grid square technique has been written and published, Young, (1973). This program was used in previous studies related to the project, Young, (1971a and b, 1972a). Data banks of non-changing terrain features have been compiled for each of Place, Sentinel, Woolsey, Peyto and Ram Glaciers.

A second program has been written utilizing these data banks along with variable data on snow depth/melt at point locations, to produce maps and tabulations of accumulation/melt at any given time over a glacier surface.

The programs and data banks have been used to evaluate existing stake networks and to generate new sampling locations, see Young, (1974a and b).

FUTURE WORK: The programs will be used and continually developed for:

1) Reducing data for the I.H.D. glaciers.
2) Generating new sampling networks on existing and on new study glaciers.
3) Investigating recurrence of snow patterns on glacier surfaces.
4) Comparing results produced by the standard mass-balance data reduction procedure.
5) Linking programs under development to elucidate energy transfers at the glacier surfaces.

PROJECT: G-72-26

FLUVIAL AND CRYOGENIC PROCESSES IN THE MACKENZIE RIVER BASIN

PRINCIPAL INVESTIGATOR: W.E.S. Henoch

COOPERATING AGENCIES: Western Forest Products Laboratory, Vancouver, B. C., and Faculty of Forestry University of British Columbia

OBJECTIVES: By the use of dendrochronology, to investigate past floods and ice jams on Liard River; landslides along Liard and Mackenzie Rivers; and rates of sedimentation in the Mackenzie Delta. Study of cryogenic processes in forested areas.

PREVIOUS WORK: Three field trips were undertaken in selected areas in the Mackenzie River basin in 1971, 1972 and 1973 for the above stated objectives. For results see: Henoch (1973 and 1974), Parker and Jozsa (1973) and Parker, Jozsa and Bruce (1973).

FUTURE WORK:

1) Study of ice lensing and related ground forms in the Mackenzie Delta.

2) Further samples of tree trunks and stumps collected during 1971, 1972, 1973 field seasons are being processed for x-ray densitometry and data computerized in the Western Forest Products Laboratory, Vancouver, B. C. Interpretation of results in preparation as data become available.

PROJECT: G-73-1

ARCTIC ICE ISLAND AND RELATED STUDIES

PRINCIPAL INVESTIGATOR: G. Holdsworth

COOPERATING AGENCIES: Polar Continental Shelf Project, AIDJEX, N.A.R.L.

OBJECTIVES: To establish the level of strain rates existing on ice islands and in the pack ice for determining the creep law of ice plates and the levels of stresses needed to cause pressure ridging.

LOCATION: Ice Island T-3, Beaufort Sea and Hull, P.Q.

PREVIOUS WORK: Field investigations of Ice Island T-3 in the summer of 1973,(Holdsworth and Traetteberg, 1974)

WORK IN PROGRESS: Report based on analysis of 1973 field data.

FUTURE WORK: Measurement of strain rates in pack ice floes under conditions of ridging.

PROJECT: G-73-6

ICE SHELF STUDIES

PRINCIPAL INVESTIGATOR: G. Holdsworth

COOPERATING AGENCIES: Department of Civil Engineering, University of Calgary

OBJECTIVES: 1) To establish a calving model for the northern Ellesmere Island ice shelves and to predict the size of ice islands.

2) To examine the break-up of ice islands.

LOCATION: Ward Hunt Ice Shelf, Ellesmere Island ($83^{o}10'N, 75^{o}W$) and Hull, P.Q.

PREVIOUS WORK ON THIS PROJECT: Holdsworth (1971a)

WORK IN PROGRESS: Theoretical work on the vibration of elastic plates.

FUTURE WORK: 1) Re-measurement of the thickness of the Ward Hunt Ice Shelf and its position to determine growth rates.

2) Measurement of the dynamic parameters of the ice shelf (period of oscillation and strain rates).

PROJECT: G-73-7

SURGING GLACIER STUDIES - TWEEDSMUIR GLACIER

PRINCIPAL INVESTIGATOR: G. Holdsworth

COOPERATING AGENCIES: Water Survey of Canada; U.S. Geological Survey; Canada Centre for Remote Sensing.

OBJECTIVES: To monitor selected surging of potential surging glaciers in British Columbia or the Yukon Territory. To determine the effects of a surge and to develop theoretical surge models.

LOCATION: Tweedsmuir Glacier, British Columbia ($59^{o}45'N, 138^{o}W$) and environs.

PREVIOUS WORK:

1) Terrestrial photogrammetry of the Tweedsmuir Glacier on three occasions in late 1973.
2) Investigation of the surge response characteristics.
3) Interpretation of ERTS imagery of the Tweedsmuir Glacier surge.

WORK IN PROGRESS: A map of the Tweedsmuir Glacier and neighbouring Alsek River Valley is being compiled at a scale of 1:50,000. Larger scale maps are being plotted from the terrestrial photographs. ERTS satellite imagery is being studied with a view to monitoring the surge and the infilling of the glacier dammed lake.

FUTURE WORK: Aerial photography for detailed photogrammetric mapping is planned for 1974. Other potential surge glaciers along the Alsek Valley, at present in a quiescent stage will be examined.

PROJECT: G-73-8

TESTING A PORTABLE PROFILING SNOW DENSITY GAUGE

PRINCIPAL INVESTIGATOR: G. J. Young

COOPERATING AGENCY: None

OBJECTIVES: To field test a new portable snow profiling densitometer. The instrument, a 'Digiray' manufactured by General Nuclearics of Poma, California, is a single probe type instrument working on a gamma back-scatter principle. It has been designed for deep snow-packs and utilizes a standard Mt. Rose snow sampler to bore into the snow.

LOCATION: Peyto Glacier (Banff National Park, Alberta), and Sentinel Glacier (Garibaldi Provincial Park, B.C.).

PREVIOUS WORK: None

WORK IN PROGRESS: The instrument is being linked to a portable X-Y recorder so that direct graphical output can be achieved.

FUTURE WORK: When testing has been satisfactorily completed it is hoped to use the instrument within the glacier mass-balance program in place of digging density pits.

PROJECT: G-73-12

MASS AND WATER BALANCE STUDIES OF GLACIERS ALONG A TRANSECT ACROSS THE CANADIAN CORDILLERA

PRINCIPAL INVESTIGATORS: A. D. Stanley and O. Mokievsky-Zubok

COOPERATING AGENCIES: Water Survey of Canada and Applied Hydrology Division

OBJECTIVES: As part of the International Hydrological Decade program, a series of 5 glaciers along a transect of the southern part of the Canadian Cordillera were selected for detailed studies, under varying climatological conditions, of:

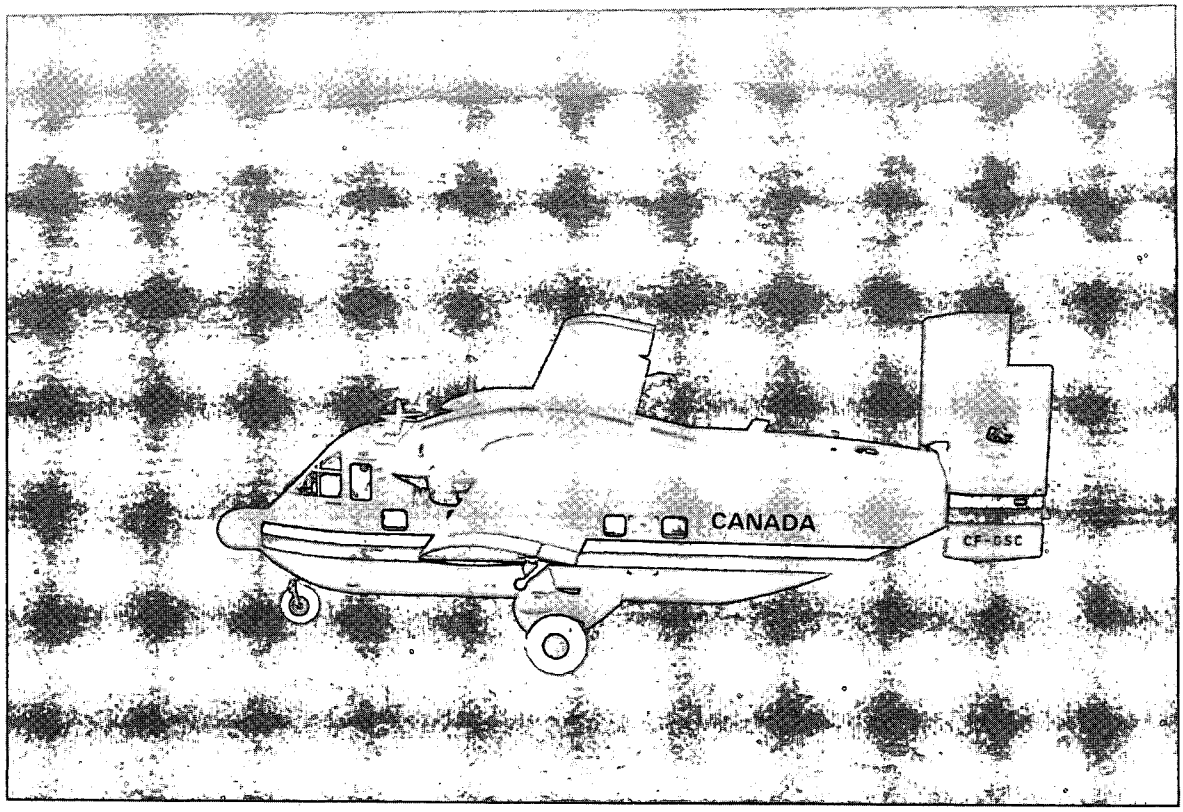
1) the annual mass balance,
2) the role of the glaciers in the hydrologic cycle, and
3) the long term changes of these factors.

LOCATIONS: Place Glacier, (50°18'N,122°48'W), 120 km north of Vancouver, B.C.
Sentinel Glacier, (49°50'N,122°55'W), 70 km north of Vancouver, B.C.
Woolsey Glacier, (50°00'N,118°13'W), 15 km northeast of Revelstoke, B.C.
Peyto Glacier, (51°40'N,116°34'W), 45 km northwest of Lake Louise, Alta.
Ram River Glacier, (51°51'N,116°12'W), 45 km north of Lake Louise, Alta.

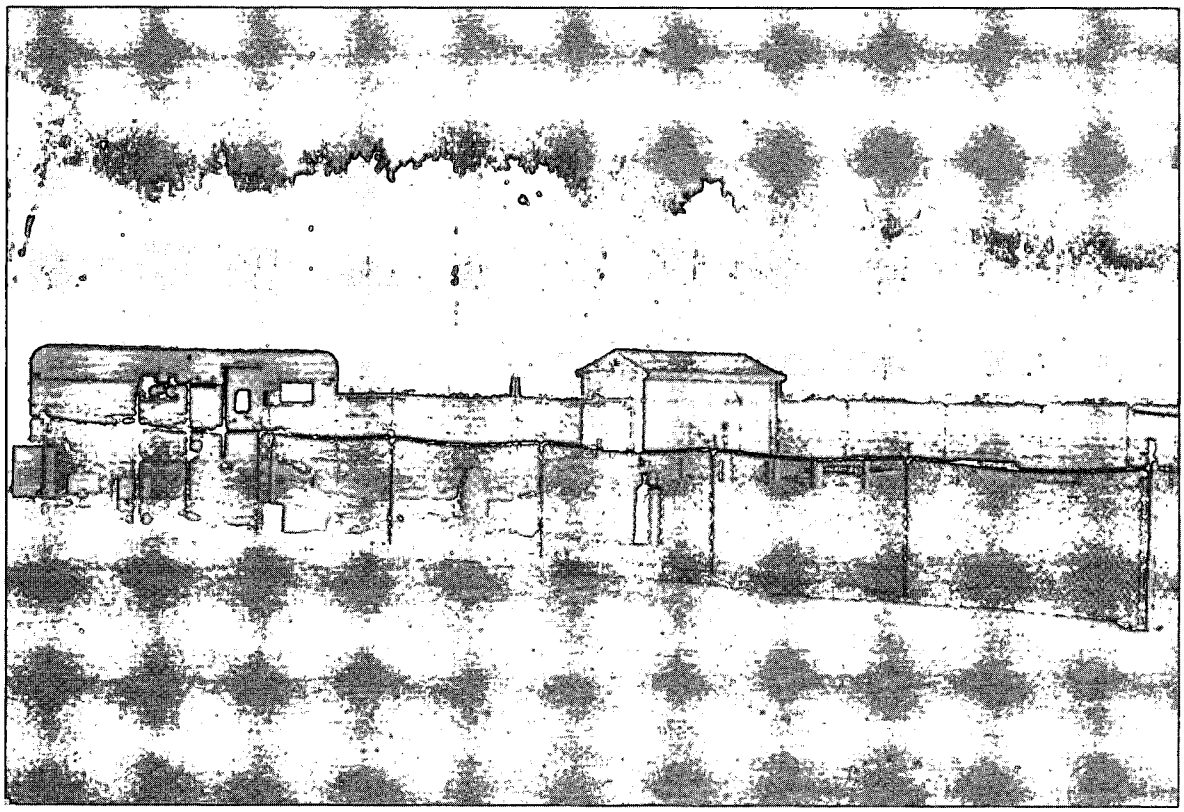
PREVIOUS WORK: Glaciological, hydrological and climatological observations have been carried out since 1965. Detailed topographic maps were prepared at the beginning of the IHD and for some glaciers sequential mapping has been completed. Special studies have from time to time been done on some of the glaciers, notably on Peyto and Sentinel Glaciers, where the most comprehensive programs have been carried out. For recent results see: Derikx (1972), Mokievsky-Zubok (1971, 1972, 1973a, b and c), Stanley (1971). Additional information in Østrem, G.: "The transient snowline and glacier mass balance in southern British Columbia and Alberta, Canada." Geog. Annaler, Vol. 55A No. 2 pp. 93-106. 1973.

WORK IN PROGRESS: Winter and summer balances are measured on all glaciers and ablation is measured at intervals throughout the summer. Meteorological data are recorded during the summer period and in some locations throughout the year. Melt water discharge is measured during the summer at all glaciers (except Ram River) by water level recorders. The most detailed program is carried out at Sentinel and Peyto Glaciers.

FUTURE WORK: The existing field program will continue through 1974 but a reduced level of activity if anticipated at the termination of the International Hydrological Decade. The studies at Sentinel and Peyto Glaciers will be extended into neighbouring icefield to determine the representativeness of the data from those two glaciers and the applicability of the models that have been derived from the data collected.



GSC (EMR) aircraft used for gamma-ray snow survey over Southern Ontario (G-72-21)



Part of Mer Bleue Experimental Site near Ottawa, (G-69-8)

PROJECT: G-69-3

GLACIER MELTWATER CONTRIBUTION TO THE FLOW OF THE NORTH SASKATCHEWAN RIVER

PRINCIPAL INVESTIGATOR: H. S. Loijens

COOPERATING AGENCY: Water Survey of Canada

OBJECTIVES: To develop a parametric hydrologic model for the quantitative assessment of the glacier meltwater contribution to the flow of the North Saskatchewan River at Saskatchewan Crossing.

LOCATION: North Saskatchewan River headwaters (52^{o} 45'N, 117^{o} 40'W) Banff National Park, Alberta.

PREVIOUS WORK: Field: Streamflow data available from Mistaya River (No. 05DA-7) and North Saskatchewan River (No. 05DA-6) since 1950 (mainly from May - November), and from other temporary stations in the basin, and meteorological observations from Peyto Glacier since 1965 (Project G-67-4).

Snow distribution was obtained from several snow courses and temporary meteorological recording instruments were operated at several locations. Streamflow, precipitation and glacier ice sampled for tritium analysis.

A detailed hydrometric program was carried out in the Mistaya Basin in the summer of 1971, when the most intensive field program was undertaken.

Collection of field data was terminated in September 1972. Data summaries available.

For results see: Derikx and Loijens (1971), Loijens (1972 and 1974b).

WORK IN PROGRESS:

1) Development and testing of a snow melt and runoff model for Silverhorn Creek basin, a small watershed in the Mistaya basin, by Messrs. F. Kuipers and G. W. Van de Wall Bake, graduate students at the Department of Hydraulics, University of Wageningen, The Netherlands.
2) Flow routing in the Mistaya River (G. W. Van de Wall Bake).

FUTURE WORK: Submodels describing respectively snowmelt, glacier runoff (Project G-72-8) and stream flow routing will be integrated to form a comprehensive hydrologic model for the Mistaya basin.

PROJECT: G-69-8

MASS AND ENERGY TRANSFER IN A SHALLOW SNOWPACK

PRINCIPAL INVESTIGATOR: L. Derikx

COOPERATING AGENCY: None

OBJECTIVES:

1) To determine the mechanisms of mass and energy transfer in a shallow snowpack during the period of snow accumulation.

2) To determine the mechanisms of moisture flux in terms of mass transfer properties of the snowpack during the period of snow ablation.

3) To synthesize the results of these studies into mathematical physically-based models and investigate the applicability in hydrologic systems analysis.

LOCATION: Mer Bleue, near Ottawa, Ontario.

PREVIOUS WORK: An experimental site at Mer Bleue (Central Experimental Forest) near Ottawa was selected in the spring of 1969 for cooperative investigations of snow melt and associated groundwater recharge by the Glaciology and Groundwater subdivisions (R. Harlan, Project GW-69-2).

WORK IN PROGRESS:

1) Processing and analysis of data.

2) Development of physically-based digital simulation models (temporarily suspended).

FUTURE WORK:

1) Continuation, refinement and extension of scientific data collection.

2) Refinement and extension of models.

PROJECT: G-72-8

HYDROLOGY OF GLACIERIZED BASINS

PRINCIPAL INVESTIGATOR: L. Derikx

COOPERATING AGENCY: None

OBJECTIVES:

1) To study the energy and mass transfer processes at the atmospheric-glacier interface in different scales, both in time and in space.

2) To synthesize the results of the energy and mass transfer studies in a flexible and adequate mathematical model to simulate the runoff from glacierized basins in the Canadian Cordillera.

3) To develop a statistical model for aerial extension of hydroglaciological information to ungauged glaciers.

LOCATION: Ottawa, Ontario, on the basis of field data from several glaciers.

PREVIOUS WORK: Glaciological, hydrological and meteorological data collected since 1965.

For results see: Derikx and Loijens (1971); Derikx (1971); Föhn, (1973); Goodison (1972a and b).

WORK IN PROGRESS: Temporarily suspended.

PROJECT: G-72-17

HYDROLOGY OF D'IBERVILLE BASIN, N.W.T.

PRINCIPAL INVESTIGATOR: L. Derikx

COOPERATING AGENCY: Marine Sciences Directorate, Frozen Sea Research Group.

OBJECTIVES: To determine the average monthly inflows of fresh water into d'Iberville Fiord.

LOCATION: d'Iberville Fiord (80^{o} 35'N., 79^{o} 00'W), Ellesmere Island, N.W.T.

PREVIOUS WORK: Office studies concentrated mainly on inventory, radiation and energy balance. For results see Wilkins (1973).

WORK IN PROGRESS: Temporarily suspended.

PROJECT: G-72-21

APPLICATION OF GAMMA-RAY SPECTROMETRY IN HYDROLOGY

PRINCIPAL INVESTIGATOR: H. S. Loijens

COOPERATING AGENCIES: Geological Survey of Canada, EMR, Ottawa; Atmospheric Environment Service, DOE, Toronto; Water Quantity Branch, Ontario, Ministry of Environment, Toronto.

OBJECTIVES: Determination of the water equivalent of snow cover based on gamma-ray spectrometer measurements of terrestrial radiation, and adaptation of data for use in operational run-off forecasting models.

LOCATION: Field tests all over Canada. Office: Ottawa.

PREVIOUS WORK: For results see: Grasty, Loijens and Ferguson (1973); Loijens, (1974a); Loijens and Grasty (1973).

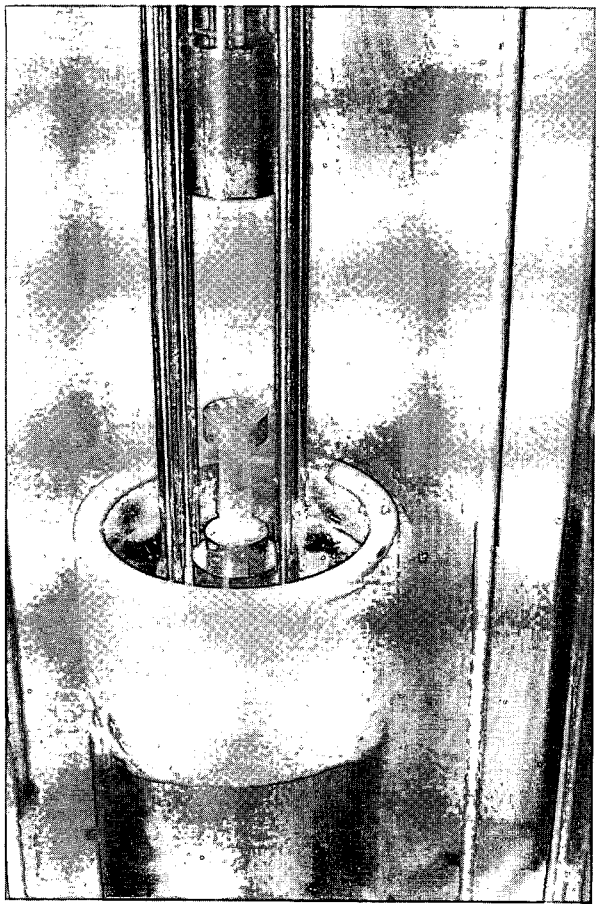
WORK IN PROGRESS:

1) Investigation of the effect of soil moisture on gamma-radiation. Surveys over Wilmot Creek basin (Bowmanville, Ontario).

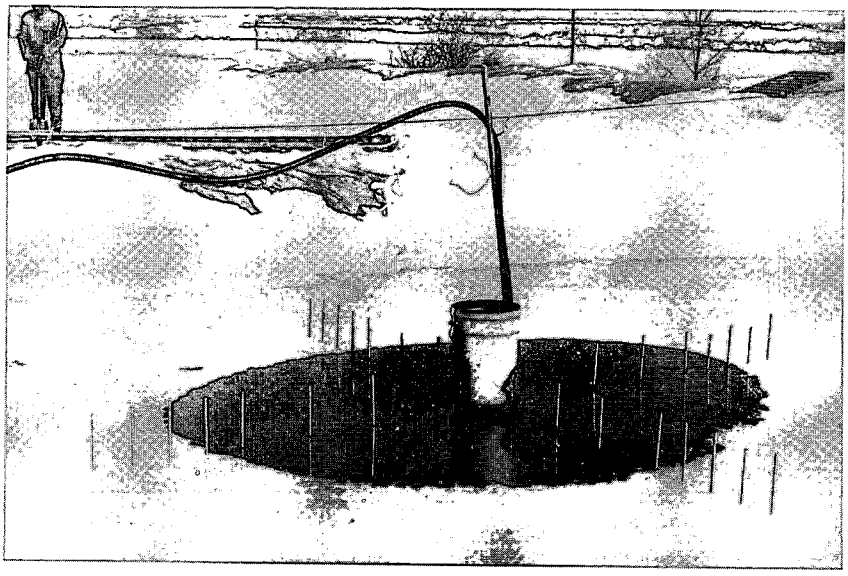
2) Calibration and testing helicopter system.

FUTURE WORK: Testing of technique on the Canadian prairies and in the Rocky Mountains.

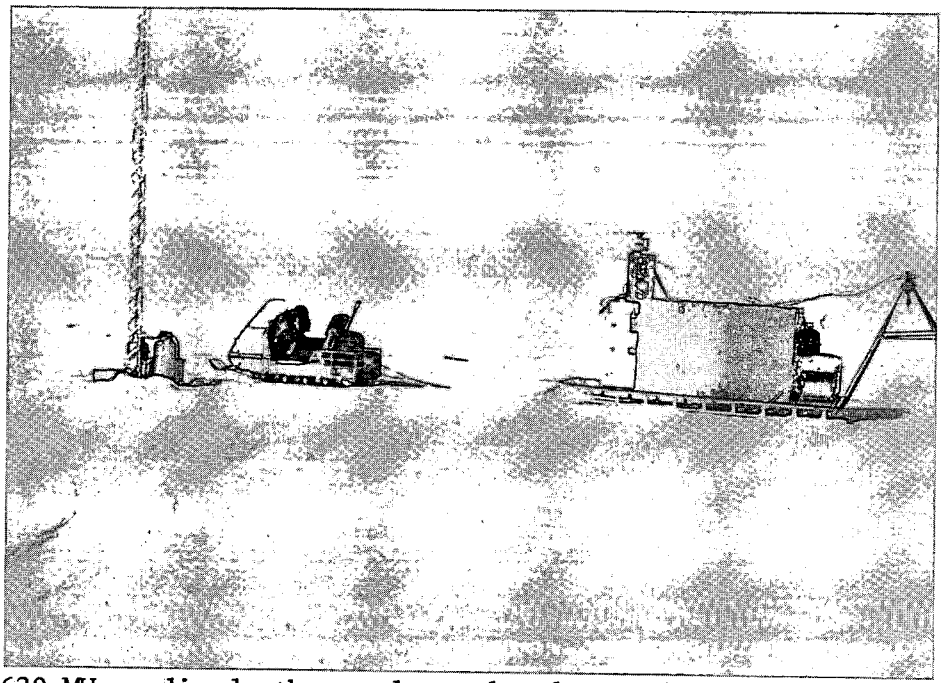
Optimising detector and system efficiency, and adaptation of data for use in hydrologic modelling.



Ice single crystal being lowered into a dewar containing liquid nitrogen prior to testing at 77K, (G-74-6)



Field Test on the Spreading of Crude Oil on Ice at Shirleys Bay, Winter, 1973 (G-71-2)



620 MHz radio depth sounder and radar positioning system on Barnes Ice Cap. (G-72-12)

PROJECT: G-67-17

DEFECTS IN ICE CRYSTALS

PRINCIPAL INVESTIGATOR: S. J. Jones

PUBLICATIONS: Jones, S. J. and Gilra, N. K. 1973 (a), Jones S. J. and Gilra, N. K. 1973 (b)

PROJECT COMPLETED

PROJECT: G-67-18

COMPUTER APPLICATIONS TO GLACIER FLOW: BERENDON GLACIER, B. C.

PRINCIPAL INVESTIGATOR: S. J. Jones

PUBLICATION: Fisher, D. A. and S. J. Jones(1971)

PROJECT COMPLETED

PROJECT: G-68-1

MECHANICAL PROPERTIES OF ICE CONTAINING IMPURITIES

PRINCIPAL INVESTIGATOR: S. J. Jones

PUBLICATIONS: Nakamura, T. and Jones, S. J. 1973 (a)
Nakamura, T. and Jones, S. J. 1973 (b)

PROJECT COMPLETED

PROJECT: G-71-1

DIFFUSION IN ICE

PRINCIPAL INVESTIGATOR: S. J. Jones

WORK IN PROGRESS: Preliminary results indicated agreement with results published by others, and due to the higher priority of other projects no further work was done. No report available.

PROJECT COMPLETED

PROJECT: G-71-2

SPREADING OF OILS ON ICE AND SNOW SURFACES

PRINCIPAL INVESTIGATOR: E. C. Chen

COOPERATING AGENCY: None

OBJECTIVES: To obtain information on the kinetics and mechanism of oils spreading on ice and snow surfaces.

LOCATION: Laboratory (45 Spencer Street) and Field Site (Shirley's Bay), Ottawa, Ontario.

PREVIOUS WORK: The spreading of crude oil on artificially prepared ice surfaces was investigated as a function of temperature, oil type and surface roughness. Correlations for the gravity-viscous and surface tension-viscous spreading stages were developed. Field work includes participation in the U.S. Coast Guard Arctic Winter Oil Spill Test (January, 1972) and spreading of Norman Wells crude on ice at Shirley's Bay (winter, 1972 and 1973).

For results see: Chen, Overall and Phillips, (1974).

WORK IN PROGRESS: The transition from one spreading stage to another for crude oil on ice is being studied. A correlation for predicting the spreading rate, which includes all spreading stages for crude oil on ice is being developed.

FUTURE WORK: Studies will be made on the spreading of crude oil on snow surfaces.

PROJECT: G-71-3

OIL/WATER EMULSION STUDIES

PRINCIPAL INVESTIGATOR: E. C. Chen

COOPERATING AGENCY: None

OBJECTIVES: To study the nature and stability of oil/water emulsions as a function of temperature in order to understand their significance for combating oil pollution in a cold environment.

LOCATION: Laboratory, 45 Spencer Street, Ottawa, Ontario

PREVIOUS WORK: Methods for the preparation of a reproducible oil-in-water emulsion, technique of sampling and analysis of the emulsion stability were established. The stability of several different types of crude oil-in-water emulsions and the influence of freezing on the stability of these emulsions were investigated.

For results see: Chen, (1974)

WORK IN PROGRESS: The effects of temperature on the properties and stability of petroleum oil-in-water emulsions are currently under investigation.

FUTURE WORK: Field tests on crude oil/water systems will be made.

PROJECT: G-72-5

AGING OF OILS ON ICE AND SNOW

PRINCIPAL INVESTIGATOR: E. C. Chen

COOPERATIVE AGENCY: Water Science Section, Water Quality Branch

OBJECTIVES: To study the changes in physical properties of petroleum oils caused by aging on ice or snow. The information is needed for assessing the effects of an Arctic oil spill.

LOCATION: Laboratory (45 Spencer Street) and Field Site (Shirley's Bay), Ottawa, Ontario

PREVIOUS WORK: A correlation between the changes in surface tension and the amount lost in evaporation during the initial aging of petroleum crudes was developed. Tests on this correlation on simulated evaporation of some hydrocarbon mixtures were also made. Field work was carried out during winter, 1972 and 1973.

For results see: Chen, and Guarnaschelli, (1973)

WORK IN PROGRESS: Field and laboratory studies on the aging of crude and petroleum oils are continuing.

FUTURE WORK: More field experiments will be carried out. Samples from actual oil spills will be collected, analyzed and the results compared with those obtained in the laboratory.

PROJECT: G-72-12

RADIO DEPTH SOUNDING OF BARNES ICE CAP

PRINCIPAL INVESTIGATOR: R.A. O'Neil, (N.R.C. Post Doctorate Fellow; Supervisor Dr. S. J. Jones)

COOPERATING AGENCIES: None

OBJECTIVES: To determine the depth of part of the Barnes Ice Cap, Baffin Island; to compare results at 35 MHz and 630 MHz radar frequencies; to measure attenuation in the ice.

LOCATION: Barnes Ice Cap, Baffin Island, N.W.T.

PREVIOUS WORK: For results see: Clarke and Goodman (1974), Goodman (1973 and 1974) Goodman and Clarke (1974) and Jones (1972).

PRESENT WORK: Field work will start in April 1974, and be completed by June 1974.

FUTURE WORK: Write report; no further field work planned at the moment.

PROJECT: G-73-2

DIELECTRIC PROPERTIES OF ICE

PRINCIPAL INVESTIGATOR: G. P. Johari

COOPERATING AGENCY: None

OBJECTIVES: To determine the crystallographic anisotropy of the dielectric constant of ice and hence the velocity of electromagnetic radiation in ice. Since natural ice, both glacier and floating ice, can have preferred c-axis orientations, it is important to know what anisotropy in velocity to expect when, for example, using radio echo sounding techniques.

LOCATION: 562 Booth Street, Ottawa, Ontario

PREVIOUS WORK: None by Ice Science Section. Reports in the literature are confusing, with at least one paper claiming 10-15% anisotropy and one claiming no anisotropy.

WORK IN PROGRESS: (March 1974) Preparing samples, preliminary results obtained.

FUTURE WORK: Experiment should be completed by December 1974, except for publication of report.

PROJECT: G-73-3

MECHANICAL PROPERTIES OF ICE UNDER HYDROSTATIC PRESSURE

PRINCIPAL INVESTIGATOR: V. R. Parameswaran, (N.R.C. Post Doctorate Fellow; supervisor - Dr. S. J. Jones)

COOPERATING AGENCY: None

OBJECTIVES: To determine the effect of a superimposed hydrostatic pressure on the mechanical properties of ice; to determine activation volumes for the flow of single crystal and polycrystal ice; to see what effect hydrostatic pressure has on the "flow law" for ice.

LOCATION: 562 Booth Street, Ottawa, Ontario

PREVIOUS WORK: None by Ice Science Section

WORK IN PROGRESS: (March 1974) Ordering equipment, and modifying presently existing equipment.

FUTURE WORK: Results should begin to be obtained by June 1974. It is anticipated that the project will be completed by August 1975.

PROJECT: G-74-6

MECHANICAL PROPERTIES OF ICE AT 77K

PRINCIPAL INVESTIGATOR: V. R. Parameswaran, (N.R.C. Post Doctorate Fellow; supervisor - Dr. S. J. Jones)

COOPERATING AGENCIES: None

OBJECTIVES: To measure the strength of ice at liquid nitrogen temperatures (77K or -196°C). To determine if there is a different mechanism of deformation at this temperature and, if so, what it is. Tests will be performed on pure single crystals, pure polycrystals, deliberately doped specimens, and a few tests will be done on natural sea ice. A wide range of strain-rates will be used.

LOCATION: Ice Science Section, 562 Booth Street, Ottawa

PREVIOUS WORK: None

WORK IN PROGRESS: (March 1974) The equipment has been built and the first tests have been completed.

FUTURE WORK: Further tests are needed at various strain-rates and using the different types of ice mentioned above.

PROJECT: G-74-7

ELECTRICAL BEHAVIOUR OF HEAVY (D_2O) ICE

PRINCIPAL INVESTIGATOR: G. P. Johari

COOPERATING AGENCY: None

OBJECTIVES: To determine the effect of isotopic substitution on the electrical properties of ice. Interest is mainly on obtaining a scientific understanding of the molecular processes responsible for the electrical and mechanical transport in ice.

LOCATION: Ice Science Section, 562 Booth Street, Ottawa, Ontario

PREVIOUS WORK: None by the Ice Science Section. Results of a somewhat cursory study on this were reported in 1952.

WORK IN PROGRESS: (March 1974) Experimental studies are nearly complete.

FUTURE WORK: Finish experiment and write report for publication.

PROJECT: G-74-8

GROWTH OF ZONE REFINED ICE CRYSTALS

PRINCIPAL INVESTIGATOR: S. J. Jones

COOPERATING AGENCIES: None

OBJECTIVES: To prepare pure and highly perfect single crystals of ice for future experiments both for our own and for other scientist's use.

LOCATION: Ice Science Section, 562 Booth Street, Ottawa

PREVIOUS WORK: None by Ice Science Section. Apparatus has been developed.

PRESENT WORK: Four large crystals (100 cm long by 10 cm cylindrical diameter) have been grown. X-ray topography indicates they have a low dislocation density and dielectric measurements indicate high purity.

FUTURE WORK: Further pure samples will be grown, one D_2O sample, and, later, doped ice will be tried.

Any scientist interested in obtaining samples for his own use should write in the first instance to Dr. S. J. Jones, outlining his requirements.

PROJECT: G-74-9

MECHANICAL PROPERTIES OF ICE CLOSE TO ITS MELTING POINT

PRINCIPAL INVESTIGATOR: S. J. Jones

COOPERATING AGENCIES: None

OBJECTIVES: To determine the flow behaviour of single crystal ice very close to its melting point and to compare the results with published polycrystal data.

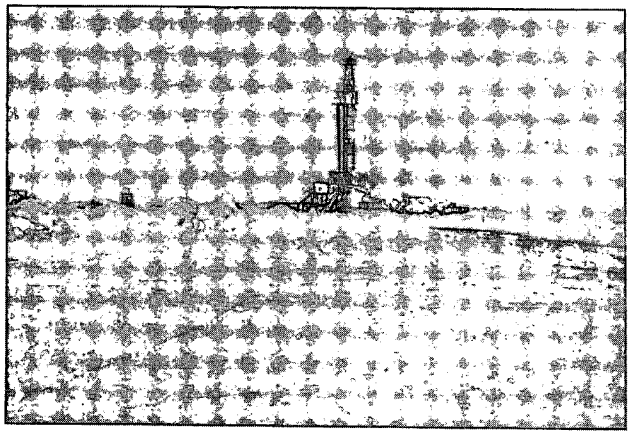
LOCATION: Ice Science Section, 562 Booth Street, Ottawa

PREVIOUS WORK: None by Ice Science Section.

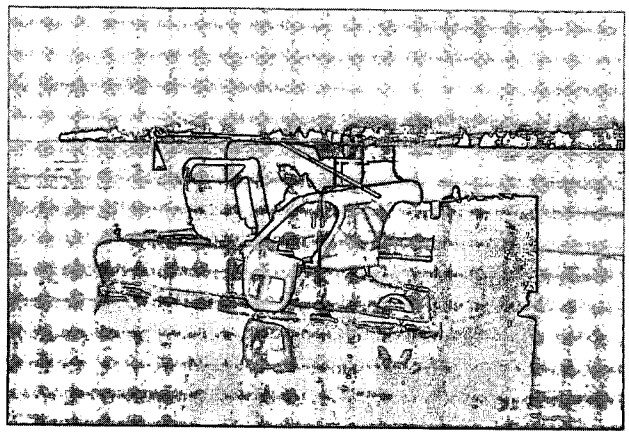
PRESENT WORK: Preliminary results have been obtained and equipment is being modified to allow higher strain-rates to be used.

FUTURE WORK: Further results are needed at temperatures close to the melting point. A report will then be prepared.

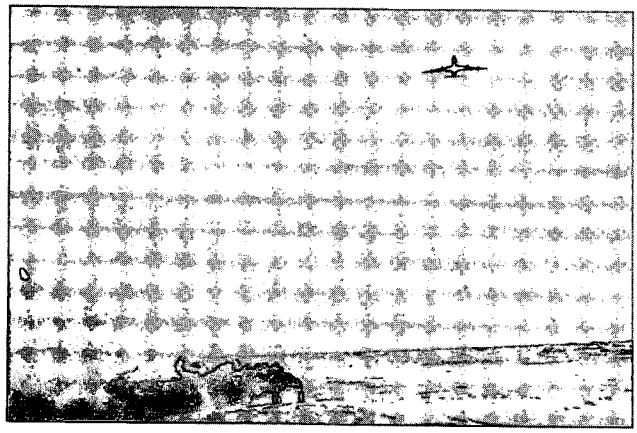
Floating Ice



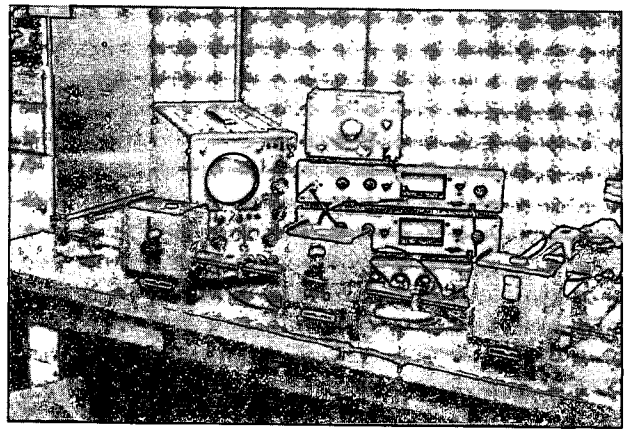
PANARCTIC - HECLA Artificial Sea Ice Platform (G-74-5)



ACV on St. Lawrence with experimental ice thickness radar (G-73-11 & G-74-3)



NASA - CV990 at AIDJEX 1972 (G-74-1)



10GHz Microwave Bridge used for measuring the Dielectric Properties of ice (G-74-4)

PROJECT: G-70-3

OIL POLLUTION IN ICE INFESTED WATERS

PRINCIPAL INVESTIGATOR: R. O. RAMSEIER

COOPERATING AGENCY: Marine Sciences Directorate, Victoria

OBJECTIVES: To study the interaction between oils and ice to develop effective containment and clean-up techniques which will be applicable to an ice-infested environment.

LOCATION: Laboratory, Ottawa, and various field locations.

PREVIOUS WORK: For results see: Ramseier, (1972, 1973 and 1974) and; Ramseier, Gantcheff and Colby, (1973).

WORK IN PROGRESS: Scenario papers for various seas in the Arctic Ocean.

PROJECT: G-72-13

GROWTH MECHANISMS OF RIVER AND LAKE ICE
(INTERNATIONAL FIELD YEAR FOR THE GREAT LAKES)

PRINCIPAL INVESTIGATOR: R. O. Ramseier

PROJECT TERMINATED, SEE PROJECT G-74-1

PROJECT: G-72-14

ICE INFORMATION AND MECHANICAL PROPERTIES OF
RIVER AND LAKE ICE
(EXTENSION OF THE NAVIGATION SEASON,
ST. LAWRENCE SEAWAY)

PRINCIPAL INVESTIGATOR: R. O. Ramseier

PROJECT TERMINATED, SEE PROJECT G-74-1

PROJECT: G-72-15

SEA ICE GROUND TRUTH
(ARCTIC ICE DYNAMICS JOINT EXPERIMENT)

PRINCIPAL INVESTIGATOR: R. O. Ramseier

PROJECT TERMINATED, SEE PROJECT G-74-1

PROJECT: G-72-22

OIL POLLUTION IN ICE COVERED RIVERS

PRINCIPAL INVESTIGATOR: B. Keevil and R. O. Ramseier

LOCATION: Ottawa, Laboratory

PROGRAM: To study the laboratory behaviour of oil under ice by obtaining data on oil spreading under ice in a closed circular tank and in a flume.

FUTURE: To be completed by March 1975.

PROJECT: G-73-9

ICE CONDITIONS ALONG ARCTIC SHORES

PRINCIPAL INVESTIGATOR: R. O. Ramseier

COOPERATING AGENCIES: AES, Ice Centrale; Ottawa; DND, Ottawa

OBJECTIVES: To determine the extent and movement of ice in channels and along shores of selected areas in the Canadian Archipelago in order to determine potential effects of ice on pipeline crossings.

CURRENT WORK: Analysis of data obtained from Quick-look ERTS1 imagery.

FUTURE WORK: Shore-ice interaction using SLAR.

PROJECT: G-73-10

AIR CUSHION VEHICLE ICE BREAKING

PRINCIPAL INVESTIGATOR: D. F. Dickins

COOPERATING AGENCIES: Ministry of Transport - Transportation Development Agency, Marine Safety Branch, Air Cushion Vehicle Division, Canadian Coast Guard, National Research Council.

OBJECTIVES: By conducting full scale field trials, model tests and theoretical studies, investigate the entire range of mechanisms involved in air cushion vehicle ice breaking and determine the economics and technical feasibility of applying the air cushion concept to an operational ice breaking role.

LOCATION: Ottawa, Parry Sound, Toronto and Tuktoyaktuk, N.W.T.

PREVIOUS WORK: Field tests have been completed in Toronto and Parry Sound, Ontario and at Tuktoyaktuk, N.W.T. For results see: Dickins (1974b and c) and Dickins and Ramseier (1973).

PROJECT TEMPORARILY SUSPENDED

PROJECT: G-73-11

ICE REGIME IN THE UPPER ST. LAWRENCE RIVER

PRINCIPAL INVESTIGATORS: Rene O. Ramseier and Robert J. Weaver

COOPERATING AGENCIES: St. Lawrence Seaway Authority, Ministry of Transport, Cornwall; Canadian Center for Inland Waters, Burlington; Department of Transportation and Communications, Ontario; Marine Sciences Institute, Helsinki, Finland.

OBJECTIVES: To study the growth and mechanical properties of river and lake ice to predict the physical and mechanical characteristics of floating ice by the use of standard meteorological and hydrodynamic parameters.

PREVIOUS WORK: Field data has been collected since 1972 and additional data have been obtained from airborne and satellite borne remote sensors. For recent results see: Ramseier and Dickins (1973); Ramseier, Dickins and Weaver (1972); Ramseier, Dickins and Weaver (1973).

CURRENT WORK: Analysis of SKYLAB, and NP3A remote sensing data.

FUTURE WORK: Ice thickness profiling using X-band impulse and FM radars. In situ current and temperature measurements under the ice cover.

PROJECT: G-74-1

PASSIVE AND ACTIVE MICROWAVE SIGNATURE OF FLOATING ICE

PRINCIPAL INVESTIGATORS: Rene O. Ramseier and Malcolm Vant

COOPERATING AGENCIES: U.S. Geological Survey, Tacoma, Wash.; NASA Space Flight Center, Goddard, Greenbelt, Md.; Department of National Defence, Ottawa; Canadian Center for Remote Sensing, Ottawa; Aerojet - Electro systems, Azusa, Cal.; NASA Johnston Space Flight Center, Houston; Carleton University, Ottawa; USSR Academy of Sciences, Moscow.

OBJECTIVES: Based on the physical properties of ice, to provide interpretation of micro-wave signatures obtained from ground based sensors and from sensors on aircrafts and satellites in order to determine the extent, type and inferred thickness of ice.

LOCATIONS: Ottawa, NASA Goddard and any large ice covered areas.

PREVIOUS WORK: Field surveys undertaken as part of AIDJEX Pilot project; the Bering Sea Experiment and from St. Lawrence Seaway ice studies. For recent results see:

Campbell, Gloersen, Ramseier, (1974); Gloersen, Ramseier, Campbell, Chang, Wilheit (1974); Gloersen, Ramseier, Campbell, Kuhn, Webster (1974); Meeks, Poe, and Ramseier (1974); Meeks, Ramseier and Campbell (1974); Ramseier, Gloersen, Campbell, Chang (1974).

CURRENT WORK: Analysis of ARGUS, SLAR and Zone paper NP3A passive microwave imagery obtained as part of the SKYLAB program. Analysis of ARGUS, SLAR imagery obtained of certain channels in the Canadian Archipelago.

FUTURE WORK: Shear zone experiment, Beaufort Sea; BESMEX; main AIDJEX 1975-76; Apollo Soyuz Test Program, Space Shuttle.

PROJECT G-74-2

ICE THICKNESS DISTRIBUTION IN THE SOUTHERN BEAUFORT SEA

PRINCIPAL INVESTIGATOR: Rene O. Ramseier

COOPERATING AGENCIES: Department of National Defence, Communications Research Center, Carleton University, Ottawa; Atmospheric Environment Service, DOE, Toronto; USGS, Ice Dynamics Project, Tacoma, Wash.; NASA, Houston; NASA, Goddard. Defence Research Establishment, Ottawa.

OBJECTIVES: To map the distribution of ice types and open water with the use of satellite and aircraft remote sensing data; to overfly pre-determined line profiles to obtain ice thickness data using an UHF radar and a laser profilometer to obtain ridge distribution and height.

LOCATION: Southern Beaufort Sea - continental shelf between US - Canadian border and Cape Bathurst.

PREVIOUS WORK: Sensor development and testing in the areas has been completed. For recent results see: Chudobiak, et. al., (1974); Meeks, Ramseier, and Campbell (1974); Poe, Stogryn, Edgerton, Ramseier (1974).

WORK IN PROGRESS: A study of ice dynamics in the Canadian Archipelago and adjacent Arctic Basin as determined by satellite observations and laboratory studies of the dielectric properties of fresh and sea ice at 10 GHz and 35 GHz.

FUTURE WORK: Field experiments in the Beaufort Sea.

PROJECT: G-74-3

RADAR TECHNIQUES TO MEASURE FLOATING ICE THICKNESS

PRINCIPAL INVESTIGATORS: Rene O. Ramseier, D. F. Page

COOPERATING AGENCIES: Communications Research Center, Department of Communications, Shirley Bay; Carleton University, Ottawa; Coast Guard, Department of Transport; NASA Space Flight Center, Goddard, Greenbelt, Maryland.

OBJECTIVES: To develop techniques to determine the thickness of ice directly by remote sensing techniques.

LOCATION: Ottawa, Great Lakes and St. Lawrence River, Arctic Ocean. Gulf of St. Lawrence.

PREVIOUS WORK: Sensor development and initial field tests have started. For recent results see: Venier, Cross and Ramseier (1974).

WORK IN PROGRESS: Design of an UHF and L band impulse radars. Modifications to X-band impulse radar and X-band FM radar.

PROJECT: G-74-4

DIELECTRIC PROPERTIES OF FLOATING ICE IN THE MICROWAVE REGION

PRINCIPAL INVESTIGATORS: Rene O. Ramseier and Malcolm Vant

COOPERATING AGENCIES: Carleton University, Ottawa; Communications Research Center, Department of Communications

OBJECTIVES: To determine the dielectric properties of naturally and artifically grown fresh water and sea ice as a function of frequency and porosity and in case of sea ice in addition as a function of salinity and brine pocket shape.

LOCATION: Ottawa and Beaufort Sea

PREVIOUS WORK: Laboratory and field experiments have started. For recent results see: Poe, Stogryn, Edgerton, Ramseier (1974) and Vant (1973).

WORK IN PROGRESS: Laboratory measurements of dielectric properties.

FUTURE WORK: To determine the dielectric properties in situ.

PROJECT: G-74-5

PHYSICAL PROPERTIES OF AN ARTIFICIAL ICE PLATFORM

PRINCIPAL INVESTIGATOR: R. O. Ramseier

COOPERATING AGENCIES: Department of Indian Affairs and Northern Development, National Research Council, Panarctic Oils Ltd., Foundation of Canada Engineering Corp. Ltd.

OBJECTIVES: To study the high salinity ice formed during the build-up of the platform with a view to determining its structural integrity, crystallographic composition, the seize, number and distribution of brine pockets and the brine volume changes with time.

LOCATION: Laboratory, Ottawa; Melville Island (8 miles offshore) N.W.T.

PREVIOUS WORK: Ice samples were collected several times during the build-up period and also after the construction phase. For results see Dickins (1974a).

WORK IN PROGRESS: Platform construction completed. Detailed analysis of ice cores from site proceeding in Laboratory.

FUTURE WORK: Additional on-site visit during post drilling monitoring programme will provide further samples for analysis. Long term measurements on the platform ice as long as logistics are feasible.

PROJECT: G-74-10

STABILITY EVALUATION AND CONTROL OF AVALANCHE SLOPES IN THE ROCKY MOUNTAINS

PRINCIPAL INVESTIGATOR: R. I. Perla

COOPERATING AGENCY: National Research Council of Canada and National Parks.

OBJECTIVES:

1) To find improved methods of evaluating avalanche slope stability from stratigraphic and meteorological variables.
2) To optimize methods for artificial release of unstable slopes.

LOCATION: Banff National Park and Calgary, Alberta.

PREVIOUS WORK: Not on this project, but report on avalanche conditions along the "Sunshine road" was prepared for Banff National Park by Peter Schaerer, National Research Council.

WORK IN PROGRESS: Selection of sites and instrumentation and planning of field program to start fall of 1974.

FUTURE WORK:

1) Field:
   (a) Insitu measurement of temperature, density and shear strength of snow stratigraphy in avalanche release areas.
   (b) Development of improved insitu techniques for measuring shear strength of stratigraphic discontinuities.
   (c) Development of improved methods of monitoring meteorological variables near hazardous release areas.
2) Laboratory:
   (a) Analysis of texture of snow samples removed from starting zones.
   (b) Investigation of snow fracture mechanisms in avalanche slope models.
3) Office:

   Correlation of meteorological and snow stratigraphy variables with avalanche events.

COMPLETION DATE: Study will continue for at least two winters.

Glacier Mapping

GLACIER MAPPING

PRINCIPAL INVESTIGATORS: I.A. Reid, J.O.G. Charbonneau

COOPERATING AGENCY: None

OBJECTIVES: To determine volumetric and linear changes of seven glaciers by carrying out Terrestrial Photogrammetric Surveys biennially.

The following glaciers are mapped: Sentinel, Sphinx, Bugaboo, Kokanee and Nadahini in British Columbia and the Athabasca and Saskatchewan in Alberta.

LOCATION: Hull, Quebec

PREVIOUS WORK ON THIS PROJECT:

1. Field: A terrestrial photogrammetric survey of the five glaciers in British Columbia was made in 1972 and 1974. A terrestrial photogrammetric survey of the two glaciers in Alberta was made in 1971 and 1973. The reports covering this work are in progress.

2. References: Reid, I.A., GLACIER SURVEYS BY THE WATER SURVEY OF CANADA. A paper presented at the Banff Symposia in September, 1972.

WORK IN PROGRESS:

1. Preparing reports on the surveys carried out since 1970.

FUTURE WORK: The mapping project of the seven glaciers is expected to continue.

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