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Résumé de l'article

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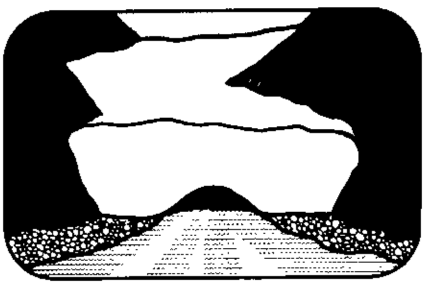
Conference Reports



Field Course in Glacial Hydrology

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Summary
Glaciology and glacial hydrology (the study of the melt waters from glaciers) have not received attention in Canada in proportion to the extent of the country's glaciers. By contrast, Scandinavia has a long tradition of scientific studies, greatly accelerated in recent years by the utilization of melt waters for hydroelectric production. The possibility of increased hydroelectric power production from glacial waters in Canada, and the environmental problems this might involve, motivated Carleton University's course in glacial hydrology. The course is given by Dr. Gunnar Østrem who has been in charge of Norwegian glaciological studies in relation to that country's power production. The nature of the course given at Peyto Glacier is discussed, and questions of responsibility for providing expertise in a rapidly developing field are considered.

Field Course
Because of its size and situation, largely within the Arctic and subArctic regions, Canada has many beautiful and dramatic glaciers. Glaciers never cease to arouse wonder, whether described to children or adults, and provide materials for the most interesting slide and film presentations. Yet a vast majority of Canadians are unaware of Canada's riches in this respect, are vague as to what a glacier is, and do not comprehend the significance they may have in the production of hydro-electric power.

Until recently those who study glaciers professionally in Canada have been a small but devoted band. Nevertheless, their studies have achieved international recognition. In the last two decades, however, scientists in the Federal Government together with representatives from a few Universities have constituted a group of some 40 persons involved in a concerted effort to study the behaviour and significance of glaciers in Canada. But in spite of the prominent research of a few teachers, notably at McGill, Toronto, Guelph, and the University of British Columbia, glaciology still receives only scant treatment at most Canadian universities. Glaciers may be referred to in the general context of glacial geomorphology or geophysics, but research and graduate courses are given at few Canadian universities.

The reasons for this situation are primarily twofold: first, most glaciers are in remote areas of the arctic or inaccessible areas of the Cordillera and second, glaciers and glacial melt waters have not as yet played a major role in the Canadian economy.

In Scandinavia the situation is very different. Swedish and Norwegian scientists, over a period of more than 50 years, have produced numerous works on the behaviour of glaciers. The Governments of both countries have promoted those glaciers which are easily accessible as tourist attractions and, since World War II, hydro-electricity derived from glacial melt waters has been a major factor in Norway's economic success. Indeed, Norway's greatest natural resource has been her rivers which often originate in high mountain regions, in large measure fed by glaciers. Norwegian engineers are renowned for their expertise in the construction of dams and tunnels through mountains for provision of electric power. In addition to being a large exporter of electricity, domestically Norway not only has the world's largest per capita consumption of electricity, but also the cheapest rate to the consumer.

At the same time, industrial development has created considerable controversy regarding the effects of the construction of dams and the diversion of rivers for the purpose of generating power. Scandinavians, by long tradition, are lovers of nature and spend much of their leisure time walking, skiing and climbing in the mountains and forests of their countries. The development of hydro-electric power has resulted in the loss of magnificent waterfalls and the majority of the major rivers and lakes are now changed in relation to their natural characteristics in terms of flow, depth, form and general appearance. The twin desires for economic gain and minimum damage to the environment have necessitated very detailed studies of the behaviour of rivers, and more particularly of the glaciers which provide the source of their waters.

For many years Carleton University gave limited place in its physical geography and other earth science programmes for the study of the behaviour of glaciers and glacier-derived waters, although the Geography and Geology Departments have given an evening course in Glaciology for some years. However, in 1969 the Geography Department formulated a programme for advanced study in physical geography, which it believes is in line with current needs and trends in earth sciences. This programme, referred to as the Geotechnical Science Programme has as its theme the studies of the scientific properties of the materials and processes of the earth's surface, with particular regard to those properties which bear upon man's activities and relations with these features. This programme was made possible by the fact that the Department acquired very substantial laboratory and workshop space; it has been able to develop this aspect of physical geography into an area of major concentration. Major areas of activity are microclimatic studies which involve both theoretical modelling of ground and near-surface temperatures and measurement of thermal properties and processes in soils, vegetation, snow, etc. The stability of slopes, as influenced by their history and the physical properties of the earth materials, especially their dependence on soil moisture conditions, is another area of major concern. Research is also carried on into rock glaciers and certain fluvial phenomena.

Gunnar Østrem, who was invited to become a visiting professor at Carleton during the 1972 academic year, is well known to glacial geomorphologists for his classic study of ice-cored moraines and the extent of their occurrence in Scandinavia, which has led to similar studies in Canada. Concurrent with the completion of this work, Østrem was appointed to the Norwegian Water Resources and Electricity Board with the task of developing studies of the mass balance and hydrology of the Norwegian glaciers. In 1962 he was appointed head of the Glaciology Section of the Board and his pioneering work in the last eleven years has involved developing techniques for assessing water power resources, recording and mapping of mass balance of ice surfaces in large regions of Norway, and notable studies of sediment-transporting glacier streams and snow hydrology. Dr. Østrem is a distinguished teacher and for many years has also been a member the Department of Geography, University of Stockholm, where he is currently Associate Professor. During the 1960s Østrem became a visiting scientist for a year at the Federal Department of

Figure 1
Snow density determination, Peyto Glacier.

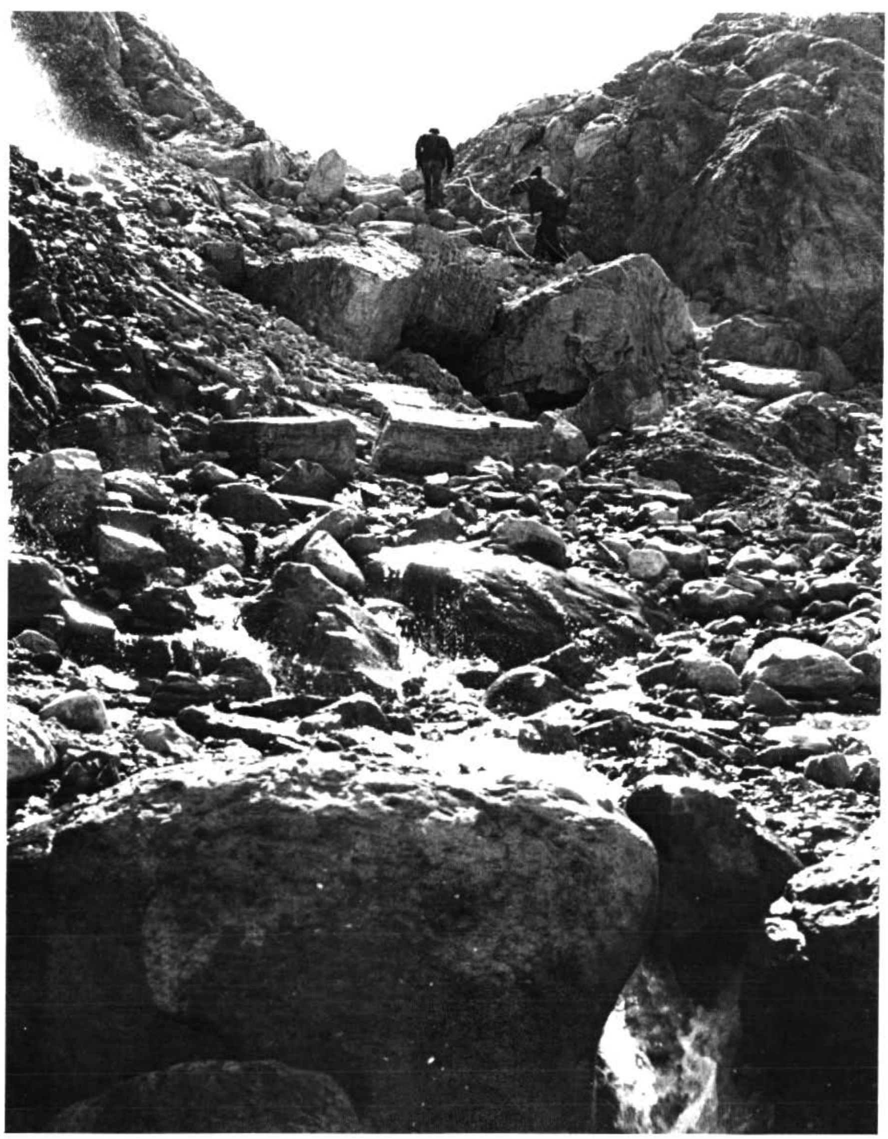

Figure 2
Glacier snout and melt water, Peyto Glacier.

Energy, Mines and Resources in Ottawa and also spent some time as a consultant to UNESCO in Turkey and Chile. In these latter countries his work involved lecturing and demonstrating to local hydrologists and engineers on the principles of hydrology for irrigation and other purposes.

While at Carleton in 1972 he gave a graduate course in Glacial Hydrology during the winter term. But as his scientific work in large measure is built upon his field experiences and techniques it seemed appropriate for him to give a field course during the summer of that year. In cooperation with the Federal Government a two weeks' intensive course was arranged and a site at Peyto Glacier, Alberta, was selected. The course turned out to be more of the nature of a scientific symposium, the registrants ranging from university professors, through government scientists, to undergraduate students, including a number of students from the United States. Those who attended, lived and worked glacial hydrology for fourteen days. The success of the course led to consideration of a repeat course in the summer of 1974.

The energy crisis of October, 1973 gave added impetus. Government officials, both Federal and Provincial, expressed support, particularly in view of the renewed attention that could be given to hydro-electric development in Canada. Interest was not confined to those faced with the problem of resource development. Those concerned primarily with conservation and the analysis of the environmental effects of hydro-electric development supported the course as a means of gaining more understanding of the problems involved.

Dr. Østrem was once again willing to visit Canada to give the course. It was held during the first two weeks of August, again at Peyto Glacier, with the permission of Parks Canada. The camp log reports sunshine almost every day (and sunburn), and daily programmes of lectures and fieldwork. The latter involved sampling of snow and ice for density, water equivalent and other measurements, using a variety of coring equipment; measurement of stream discharge and load; and crevasse rescue practices!

Associated "laboratory" and "office" studies (in a tent by the ice) included construction of rating curves and examination of daily discharge variations; filtration of sediments and calculation of sediment loads; preparation of isohydates (lines of equal water discharge); studies of mass balance; ice crystallography; and an exercise based on a real, proposed power development in Norway. Twenty-five hours of lectures were given, some by course participants, and covered topics as diverse as snow-line identification on ERTS images; hydro-electric power production and nature conservation; and surging glaciers.

The composition of the group participating was similar to that of 1972: a mixture of undergraduates, graduates and special students, i.e., professional hydrologists and university teachers. Space limitations kept the number at the camp down to 10.

Applications for registration for the 1972 course from Canadians had been disappointing, in view of the expressed need for this kind of knowledge in Canada. For the 1974 course, a detailed information sheet was circulated some ten months prior to the course to University departments who it was thought might have potential participants. Despite the fact that only preliminary applications were requested there was little response. In the spring of 1974 the information sheet was again circulated, this time to selected individuals with known glaciological interests. It was distributed quite widely in the United States. The result was maximum enrolment.

It is interesting to speculate why such a course, in a specialized but nationally important topic, has attracted relatively few Canadian applications. The cost did not constitute a barrier: the normal graduate course fee applied, together with a nominal charge per day for food. Together, these costs constituted a sum substantially less than that required for current field courses in, for example, permafrost, which attract many more Canadian applicants.

Because relatively little attention is given to glaciology in Canadian universities there are of course, relatively few graduate students seeking such a course to complement their studies. Much of the expertise increasingly required in glacial hydrology has therefore to be provided by scientists already advanced in their careers, and about a third of the participants have been in this category, seeking to 'update' their professional knowledge. But the field season is short and employers are often loath to release people for even two weeks, and this in turn restricts potential applicants.

A measure of the success of the course is the fact that Carleton's Department of Geography has decided to offer it at fairly frequent intervals in the future. In the summer of 1975 the course will be given with a substantial variation. It will be held at Finse in Norway concurrently with a course offered by the Department of Geography of Oslo University. That University has for many years held annual courses at Finse where glaciers and periglacial phenomena are easily accessible. Several course leaders are planned from both Carleton and Oslo Universities and Dr. Østrem is expected to be present for part of the time.

There are several reasons for holding such a course in Norway. It may attract Canadian students for differing reasons. The tradition of earth science and particularly glaciological and periglacial geomorphological studies in Norway means that there is much to be learned from the Norwegians. On the other hand, the Norwegians are interested in certain problems, such as permafrost, which are currently the subject of much attention in Canada and which have been given relatively less significance in Norway in the past. In this period of scientific expansion no country can afford to overlook the body of knowledge and experience that may exist elsewhere, especially in matters where economic well-being, and the quality of our environment are likely to be shortly at stake. Just as bringing distinguished scientists to Canada greatly benefits Canadians, so will Norwegians and Canadians benefit by meeting in Norway.

Persons interested in either the course in Norway, or the field course in glacial hydrology expected to be offered in 1976 or 1977 again in Canada (probably at a glacier in the coast mountains in B.C.) may obtain further information by writing to the Department of Geography, Carleton University.

Acknowledgements
This article is partly based on contributions, oral and written, from persons taking part in the course.

MS received, September 12, 1974.

Correction
In the last issue, the report on the Conference on Grenville Geology and Plate Tectonics was attributed to only one author, A. J. Baer. The list of authors should have included the other members of the Canadian Geodynamics Committee, R. F. Emslie, E. Irving and J. G. Tanner.

Geodynamics of Iceland and the North Atlantic Area

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Iceland, the ancestral home of the first explorers of North America, has become a scientific playground and a key study area for geoscientists concerned with the development and understanding of the Plate Tectonic Hypothesis (PTH). This anomalous volcanic island is located astride the Mid-Atlantic Ridge and represents the largest 'outcrop' of the Mid-Ocean Ridge system. With relative ease, PTH can be tested in Iceland, and under this stimulus a wealth of new observational evidence has been accumulated there in recent years.

Under the auspices of a NATO Advance Study Institute, some 80 scientists from 12 countries assembled recently in Reykjavik to examine this new evidence. PTH was put to test and found not wanting; the new observations have suggested, however, refinements to the hypothesis and new experiments to expand further the framework for global geology. The group that came together in Reykjavik consisted mostly of those already converted to the new hypothesis. When the proceedings of the Institute are published, all the critics of the PTH will not be silenced. A strong contingent of Soviet scientists who originally suggested the format for the meeting and who were going to present the opposing points of view did not show up and thus a big gap was left in the programme.

The oldest rocks in Iceland are 16 million years old. The rocks are younger towards the centre of the island and the most recent ones are located within two neovolcanic zones, splitting the land from southwest to northeast, roughly paralleling the trend of the Mid-Atlantic Ridge in this area. The rocks are of basaltic composition with only a small fraction with acidic affinities. The area is an active geological laboratory. It has been estimated that in the last ten thousand years some 480 km^3 of eruptives have been produced in 250 volcanic eruptions. The heat flow is intensified and the heat production has been estimated at 15,000 Mw/sec. (Part of this heat is utilized by the Reykjavik District Heating System to heat 80 per cent of the homes and provide hot water. In 1970 the total sales of hot water amounted to an equivalent of 1170 million kwhrs of electrical energy. Without the hot water system, at the present day prices, it would cost some $10 million a year in foreign currency to pay for imported fuel oil – an economic burden which the country could not afford.) The area is also an active seismic zone and provides an unparalleled opportunity to study the swarms of microearthquakes associated with the rifting of the earth's crustal layers.

Over forty years ago it was recognized that Iceland is 'anomalous' and it is still so classified, primarily because all other oceanic islands of comparable size represent continental fragments. The first experiments to obtain direct evidence for Wegener's continential drift theory were attempted by German scientists in 1938 and the Institute heard from one of the original investigators, Professor A. Schleusener, University of Hanover, about the continuation of that work. Using precise geodetic surveying and repeated gravity measurements, the aim is to measure the actual displacement and widening of Iceland