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See table of contents

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this urgent request is a lack of sufficient funds and/or manpower. As a first step in tackling the problem, it was suggested that a meeting between practicing design engineers and research-oriented engineers should be arranged with the explicit purpose of selecting certain problems of immediate importance upon which more research should be focussed.

It is probably fair to say that, even where agreement could not be reached, the Conference resulted in a better appreciation of the different points of view held by the different professional groups involved in this business - the seismologists, the civil engineers and others. The researcher became more aware of the difficulties facing the design engineer, whereas he, in turn, was forced to become increasingly appreciative of the statistical nature of earthquake occurrences, our uncertainties in correlating all seismicity in Canada with tectonic features and associated seismic phenomena. It is also clear that not all the uncertainties are seismological - there is reason for considerable engineering dispute on the safety factors introduced by ductility and other factors in many designs and codes.

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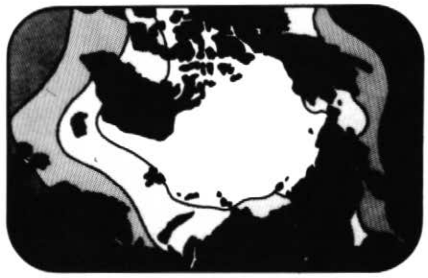

The Thermal Regime of Glaciers and Ice Sheets

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Introduction

This international symposium held at Simon Fraser University, April 8 to 11, 1975, was initiated by the National Research Council of Canada Subcommittee on Glaciers and was organized in cooperation with the Department of Geography at Simon Fraser University. The interdisciplinary nature of glaciology was evident from the wide range of research reports. The papers discussed topics from paleoclimatology to the design of high resolution thermometers. Advances in data acquisition, in knowledge of ice physics, and in computing power enabled participants to report research on major problems, including quantitative numerical models of ice sheet buildup and surging and isotopic studies of world climate changes over the past 10000 years.

There appears to be growing interest among glaciologists in presenting glacier research to the public, as indicated by several educational films prepared by some of the participants. R. Kuchera's film *Processes in Front of a Glacier* used time-lapse photography to illustrate motion and erosion at the terminus of the Athabasca Glacier. G. K. C. Clarke's film *Glacier!* described a field project to measure temperature profiles in a surging glacier in the Yukon, and a film by M. M. Miller displayed the opportunities for student summer research with the Juneau Icefields Research Program in Alaska.

The only field trip of the conference was an evening of downhill skiing at nearby Grouse Mountain.

Technical Sessions

Past surface temperatures and climate changes are being derived from the analysis of present temperature-depth profiles, and from O^{18}/O^{16} oxygen isotope ratio-depth profiles in the ice sheets of Greenland and Antarctica. An invited paper by G. de Q. Robin discussed the anbiguities in both methods, and showed that the results are compatible, when effects due to ice transport are small, or can be calculated.

T. Hughes discussed the possibility of convection and diapiric uplift of warm basal ice into the cold overlying ice sheet in areas where the basal ice is uncoupled from the bedrock, such as over subglacial lakes. In the discussion that followed, the validity of using a Reynolds number stability criterion for thin dykes and sills was questioned. These proposed diapiric sills have not been convincingly identified in radar reflection records.

A paper by H. J. Zwally reported on passive microwave measurements of near surface ice temperatures with radiometers on the Nimbus-5 satellite. With continued observations and improved knowledge of the emissivity properties of snow, he hopes to obtain accurate mean annual surface temperatures over large areas of the ice caps.

The paper which provoked the most spirited discussion at the symposium was given by K. Philberth, who proposed that radioactive wastes from fission power generation be stored in an ice sheet in Greenland or Antarctica. The containers, heated by their radioactive contents, would melt their way down to a predetermined level in the ice at a rate controlled by the amount of radioactive material inside. This would prevent the containers reaching the bedrock with the possible release of the radioactive contents. Because the ice in the proposed areas is cold, any leakage should always be imprisoned in frozen material, even if a container should rupture. After one century, the proposed containers would radiate insufficient heat to melt the surrounding ice and their descent would stop. Dumping the containers at an ice divide, where the ice velocity is nearly zero would minimize the danger of the containers being transported laterally out of the ice sheet. Calculations were presented to show that the energy released from the waste containers would be insufficient to unfreeze the bedrock or to influence the stability of the ice sheet.

This controversial proposal really should be considered along with the original proposal to build the fission reactors. A number of participants raised some basic objections to the plan. In case any accidents occur, or waste disposal policy is changed during the centuries that the containers remain dangerous, retrieval of the radioactive material from the ice would be awkward. The containers could fall into an englacial lake of the sort recently detected in Antarctica, spreading radioactive material throughout a large drainage system and into the ocean. It was also felt by some that not enough is yet known about the long term stability of climate and ice sheets to justify a commitment to the proposal now. The discussion was useful preparation for contributions to the radioactive waste disposal debate which is virtually certain to become a public issue.

Numerical models of ice sheets and glaciers were given a large amount of attention at the symposium. W. F. Budd, one of the leading experts in mathematical modelling, showed the good agreement obtained between the observed and calculated temperature profiles along a flow line in the Antarctic Law Dome Icecap. He also presented a computer film to illustrate the temporal development of surface profiles using a numerical surging model. The input parameters were the bedrock profile and the ablation-accumulation profile together with a simplified treatment of ice flux and basal lubrication. Depending on the input parameters, the model showed a variety of glaciers and ice sheets grow from zero thickness to either a steady state or to a periodically surging state. For very high accumulation input, the steady state may be called a continuous surge with ice velocities of tens of metres a day. Although these results are impressive, the physical details of basal lubrication are still uncertain.

Another impressive numerical study was presented by M. W. Mahaffy. A three-dimensional model of ice sheets was used to study the buildup of the Wisconsin ice sheet over Baffin Island and Labrador. The results are valid only in a qualitative sense because the buildup was initiated by arbitrarily lowering the snow equilibrium line to sea level and the flow equations were simplified to make calculations feasible for the necessary number of grid points. Although the results also depend on the assumed form of atmospheric circulation in the Wisconsin and the resulting accumulation and ablation rates, the work is an important step towards understanding the detailed development of continental glaciation.

Thermal regulation models for glacier surging were reviewed in an invited paper by G. K. C. Clarke. When the base of a cold glacier reaches the pressure melting point, a surge may be initiated. The base is cooled by advection of the ice and is refrozen immediately following the surge. A quiescent period follows until the surface accumulation and compressive flow again return the bed temperature to the melting point. The thermal regulation models adequately account for the surges of some small glaciers in the Yukon, but cannot be a general explanation of surges, since some temperate glaciers (whose beds never freeze), are now known to surge. The search for more general surge mechanisms is now an active area of investigation.

There were also a number of papers on physical processes in glacier ice. The invited paper by L. Lliboutry discussed the importance of salt impurities and liquid water in temperate glaciers (those that are at the pressure melting point throughout) and their influence on melting and refreezing in the sliding process at the glacier bed. C. Raymond analyzed the thermodynamical effects of liquid and vapour bubbles in ice, and G. Wakahama *et al.* presented a detailed study of the formation and fabric of superimposed ice (i.e., refrozen lenses of percolating meltwater). A proposal to directly monitor basal water pressure and englacial water flow in a series of holes to be drilled in the South Cascade Glacier was described by S. Hodge.

Finally, a novel paper by D. C. Ford *et al.* described the exploration of Mt. Castleguard cave, a water-worn passage extending seven kilometres through the limestone at the Columbia Icefields, Alberta. Basal ice from the icefields blocks the upper end of the cave. Isotope paleotemperature analyses of calcite growths and study of the exposed ice and stream deposits in the cave promise to give a new perspective to the history of glaciation in the Rockies.

The papers at this symposium revealed a capability to confront major problems in glacier dynamics, climatology, and ice physics. The papers which have not been mentioned due to limited space may be found in the symposium proceedings to be published as a special issue of the Journal of Glaciology.

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