Geoscience Canada

Third International Conference on Permafrost

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Volume 6, numéro 3, september 1979

URI : https://id.erudit.org/iderudit/geocan6_3con02

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Éditeur(s)

The Geological Association of Canada

ISSN

0315-0941 (imprimé)
1911-4850 (numérique)

Découvrir la revue

Citer cet article

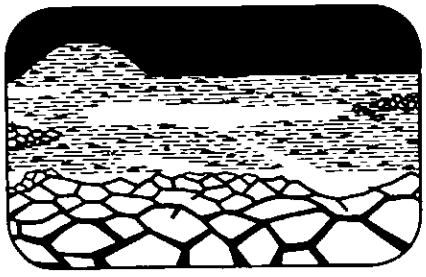
Brown, R. J. (1979). Third International Conference on Permafrost. *Geoscience Canada*, *6*(3), 142–145.

to the Wilson cycle of oceans, transform faults and hot spots, were referred to by one or more of the speakers. At the banquet which formed part of the event, Tuzo received the Albatross of the American Miscellaneous Society from the previous holder, Sir Edward Bullard. The Albatross is awarded for "unusual contributions to oceanography"; Tuzo's citation states that his was "making the faults run backwards".

The quality of the papers and the useful discussions contributed to making this symposium a most successful tribute to Wilson. Many persons remarked on the unusual cross-section of interests which this single assemblage of moderate size represented, from those concerned with the earliest times of the globe to those related to economic aspects of mineral exploration.

The papers presented will be published in a volume to be produced by the Geological Association of Canada under the Editorship of D. W. Strangway and with the support of the Geological Survey of Canada.

MS received June 4, 1979



Third International Conference on Permafrost

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The Third International Conference on Permafrost, sponsored by the National Research Council of Canada through its Associate Committee on Geotechnical Research, was held in Edmonton July 10-13, 1978 attracting nearly 500 scientists and engineers from 13 countries, mainly Canada, the United States and the Soviet Union. Delegates from the People's Republic of China attended for the first time. Several countries in Western Europe were represented: Denmark, France, Netherlands, Norway, Sweden, United Kingdom and West Germany. Japan and Argentina completed the list.

The technical program, during the four days of meetings, consisted of eight invited special review papers in plenary sessions covering the state-of-the-art in various high interest aspects of permafrost science and engineering and nearly 150 submitted papers in concurrent sessions. Simultaneous translation facilities were provided in the three official languages of the Conference - English, French and Russian. Poster sessions, films and exhibits by government agencies and private firms were also part of the program. The banquet address was given by Robert F. Legget, first Director of the Division of Building Research, National Research Council of Canada in which he traced the history of permafrost observations and investigations and made a plea for increased concern of environmental considerations in future northern development. Immediately after the Conference some delegates went on conducted field trips to various regions in northern Canada.

Special Review Papers

Each half day of the technical program began with the presentation of a review paper at a plenary session followed by submitted papers in three concurrent sessions. The first of the eight presentations, by J.R. Mackay (University of British Columbia) was concerned with ground ice, which is a vital factor in cryolithogenesis (the formation of permafrost earth materials containing ice). This in turn has important considerations in permafrost engineering. The hydrogeology of permafrost terrain by P.J. Mel'nikov (Soviet Union) pointed out the need for improved methods, especially remote sensing, in mapping groundwater geology. Groundwater occurrences greatly influence the distribution of permafrost and are extremely important in future resource development. The role of vegetation in the permafrost environment and results of revegetation in disturbed areas was presented by L.C. Bliss (University of Washington). He reported that northern varieties of agronomic species are well adapted for use in revegetating northern boreal forest lands but not the High Arctic. Jerry Brown (U.S. Army Cold Regions Research and Engineering Laboratory (CRREL)) and N.A. Grave (Soviet Union) discussed physical and thermal disturbances and protection of permafrost. Recommendations included continued observations on the past distribution of permafrost, terrain sensitivity mapping, stability of permafrost, computer modeling, long-term monitoring and development of environmental protection guidelines. The paper by W.J. Scott, J.A. Hunter (Geological Survey of Canada) and P.V. Sellmann (U.S. Army CRREL) on terrain analysis and remote sensing described the recent large advances in the use of geophysical methods to map the distribution of permafrost and identify bodies of ground ice.

Three engineering papers completed this part of the program. S.S. Vyalov (Soviet Union) presented a basic treatise on the interaction of foundations and permafrost. The two main approaches are to preserve the permafrost, or allow the permafrost to thaw during construc-

tion and use of the building. There has been considerable improvement in foundation design and building codes in recent years. A comprehensive paper on dams in northern regions, prepared by N.A. Tsytovich, Ya. A. Kronik and G.F. Biyanov (Soviet Union) described design and construction principles for earth dams using local materials, and analyzed earth dams and their foundations. The technology of frozen and unfrozen earth dams, placing cohesive earth materials in winter, stock-piling of earth materials and construction of discharge facilities were included. The paper by A. Liguori, J.A. Maple and C.E. Heuer (Exxon Production Research Company, U.S.A.) concerned the 1300 km Alyeska oil pipeline across Alaska from Prudhoe Bay in the continuous permafrost zone, to Valdez on the south coast of Alaska south of the permafrost region. More that half of the route has ice-rich permafrost; the pipeline was built above ground over these areas. A total of 78,000 vertical support members were erected and there are 84 major river crossings. Some pumping stations are on refrigerated foundations. Thermal protection of the permafrost was a major design consideration and innovations such as heat pipes were used.

Technical Sessions

In the technical sessions of submitted papers, there was heavy emphasis on geotechnical exploration and foundation engineering. Notable by their absence were papers related to municipal services (including water supply and pollution abatement, community planning and electrical generation and transmission). There were only three papers dealing with mining and petroleum engineering: two mining papers from the U.S.S.R. and a paper on gas hydrates in Northern Canada. About 60 per cent of the papers fell into the category of applied research and engineering and the remainder in more basic fields and laboratory investigations.

In the session on the physics and chemistry of water in frozen ground an important paper was presented on the determination of unfrozen water in frozen soil by pulsed nuclear magnetic resonance. The method has been developed and used to determine complete phase compostion curves for three soils. It is a non-destructive method for measurements of unfrozen water contents in frozen soils from 0.2°C to 2.5°C. Results show that the unfrozen water contents depend on ice content (i.e., total water content), contrary to earlier assumptions that unfrozen water contents are a function of temperature only. These findings show great promise in the discrimination of unfrozen water associated with mineral grain boundaries and the ice-water interfaces of the polycrystalline ices present in soil-water systems.

The session on frost heave was particularly well attended with prolonged discussions. Topics introduced included modeling of heat and mass flow, theoretical aspects of primary and secondary frost heave, laboratory studies of frost heave and heaving pressures and field studies related to northern gas pipelines. In general the contributions directed attention to heave that occurred over a long period of time, and the high heaving pressures associated with it. Field studies, however, have not yet given much evidence in this respect, and the subject remains of great importance especially in relation to chilled gas pipelines in the North.

Papers presented in the session on behaviour of thawing soils dealt with the effects that cycles of freezing and thawing have on the properties and behaviour of soils. Field and laboratory evidence confirm that successive freeze-thaw cycles result in sorting of soil grains and macroscopic alterations to the soil structure. Freezing also results in over-consolidation of the soil and can cause significant increases in the overall permeability of the soil when thawed. Field data indicate that pore pressures generated during thawing are governed by the rate of thaw relative to the rate of pore pressure dissipation, as predicted by theory.

In two sessions on permafrost hydrology, the presentation of lake tapping on the Colville River delta was most interesting. This was a general description of the dynamic geomorphology of delta lakes and channels involving channel shifting, degradation and erosion of frozen lake shores, deposition and permafrost aggradation within lake basins.

The ground ice session dealt with ice wedges, ice wedge polygons and ice-wedge ice. Basic differences in fabrics between active and deeply buried inactive wedges were pointed out. Cracks which transected massive ice were discussed and attention was called to the usefulness of Tyndall figures in studies of crystal size and orientation. Comparisons were made of the frozen soil structure beneath the trough and centre of a polygon. A detailed theoretical study of the mechanics of frost fracturing was presented. It will be interesting to verify this by field studies. The classification of polygonal-vein structures should prove widely useful.

In the session on cold regions soil science, photographs from Denmark of ice-wedge polygonal patterns within fields of grain were very convincing. This technique along with the profile exposures of fossil ice wedges provide an excellent tool for future studies. The intensity and dynamic pattern of earth hummocks within the Canadian High Arctic were well presented. Although their origins are not well known, the importance of cryoturbation in these treeless landscapes and of the dynamic nature of this process in burying organic layers was of interest.

Discontinuous permafrost received attention from Canada, the United States and the Soviet Union with presentations on the characteristics of frozen ground at the sourthern limit. Ground temperature observations, groundwater surveys, palsas and peat plateaus were analyzed and the use of air photos and airborne resistivity techniques were described. Along the Mackenzie River valley a computer analysis of 11,000 boreholes was carried out showing that ground ice increases northward.

The session on alpine permafrost dealt with studies in the Swiss Alps, the mountains of Central Asia, and the Canadian Rocky Mountains. In the Swiss Alps, in a study of active rock glaciers, bodies of frozen talus, cemented by interstitial ice, had measured rates of movement from 5 to 100 cm per year. The lower limit of active rock glaciers is approximately equal to the lower limit of discontinuous permafrost. Although some rock glaciers may contain ice of glacial origin it was recently discovered that most do not, but consist of perennially frozen debris. Permafrost to a depth of several hundred metres with a minimum temperature of -20°C has been encountered in the Tien Shan and the Pamir-Alai, within the boundaries of the U.S.S.R. Measurements made on Plateau Mountain, 80 km southwest of

Calgary, show that permafrost extends to a depth of 100 m or more. The upper layers of the permafrost can be shown to have become adjusted to the present climate whereas the lower layers are relic.

Two sessions dealt with the strength and creep behaviour of frozen permafrost soils and ice. The first paper, described a novel approach to the creep and strength response of frozen soils. It dealt with how the results from a series of laboratory creep or strength tests on frozen soils could be represented by a single "energy surface". Constant stress creep tests were carried out on undisturbed fine-grained permafrost samples at temperatures close to the melting point for durations of up to 100 days. These long-term tests were carried out in a low and intermediate stress range, commonly experienced in the design of engineering structures. The secondary creep rate relationships established by the authors represent the most comprehensive series of tests carried out to date for natural permafrost in temperature and stress ranges of interest to civil engineers. The results of a testing program to measure dynamic Young's modulus and damping ratio for artificially frozen laboratory soil samples were reported. The tests were specifically designed to simulate the low frequency loadings experienced during an earthquake event, and the dependence of the dynamic properties on temperature, strain amplitude and frequency was shown. These data for low frequency loadings will significantly enhance the data base currently available. A series of triaxial tests was carried out on compacted silt and clay soils. The test temperatures were in the range -0.5°C to -11°C, and the samples were tested at relatively high strain rates. The results demonstrated the high compressive strengths that are attained by compacted frozen soils subjected to relatively high rates of loading. The results of a testing program on frozen, compacted Fairbanks silt were presented. Tensile and compressive strengths were measured using a triaxial machine over a wide range of temperatures, and at high strain rates. The dependence of tensile strength, compressive strength and initial tangent modulus on temperature were shown, within the range of high strain rates employed in testing.

A triaxial testing program on artifical polycrystalline ice samples at the test temperature of -11.5°C, and strain rates in the intermediate to high range, indicated that the application of a large confining pressure of 30 mN/m^2 caused a significant increase in the yield stress, and a reduction in the flow law exponent from 5.4 to 3.9. All these papers dealt with laboratory test results, indicating that a major deficiency in field test results still exist. Controlled field tests on footings, pile foundations, tunnel openings and other load tests on natural permafrost are of paramount importance in assessing the field performance of structures on permafrost. Very few well-documented cases exist.

The geophysics sessions revealed that several electrical methods for resistivity mapping, radar methods for determining active layer depths, and others (magnetic induction, radiohm) were used to delineate high ice content ground. An emphasis of the session was on interpreting subseabottom permafrost in the Beaufort Sea off Alaska and northwestern Canada by seismic methods. The papers presented indicate success in this although there are unresolved problems. A paper on electromagnetic sounding of permafrost in the Northwest Territories showed that permafrost layering could be delineated by audio-frequency magnetotellurics. The last paper discussed radio probing of permafrost and how it can be used to determine direction of dips of subsurface formations, shallow faults or other subsurface structures and for mapping the base of permafrost.

The sessions on foundations in permafrost dealt with recent investigations of creep behaviour. A design philosophy by which creep settlement of foundations could be limited to safe and predictable levels was proposed. The use of a spherical cavity expansion model, to explain the creep pattern in frozen sand caused by a deep circular load, was demonstrated. Research into effects of different coatings and loading rates on the adfreeze bond between timber piles and moist sand, and a design of refrigerated piles were discussed. Other topics considered included the use of computer simulation programs to design pad foundations, and explosive energy coupling of frozen soils. Graphs giving the temperature at various depths beneath the centre of rectangular heated buildings on permafrost were discussed. A description of the installation of pile foundations for a microwave tower system between Gillam and Churchill, Manitoba was given. The design of ventilated pad foundations for heated buildings was considered, including the presentation of two case histories that lend support to the procedure proposed. An interesting case history of the construction of a successful steel pipe foundation for a warehouse constructed on Barter Island, Alaska was described. The session ended with a Soviet presentation of pile penetration tests both in permafrost and in the laboratory conducted over a period of almost 20 years.

In the session dealing with highway and railway construction experiences in permafrost regions of Northern Canada, Alaska, Sweden and the Soviet Union, two of the papers generally confirmed the usefulness of synthetic insulation in retarding permafrost degradation. Thaw subsidence and seasonal thaw penetration data were measured in some 30 sites along the Alyeska pipeline haul road. There was a very useful documentation of the considerable construction experience accumulated during development of the Dempster Highway north of the Arctic Circle.

Measurements of importance to the engineer engaged in construction in permafrost areas constitued the core of a session on applied studies of the permafrost thermal regime. A tabulation of n-factors (the ratio of the surface to air freeze/thaw indices) for various surfaces including cement, asphalt, and surfaces insulated at depth, yielded a theoretical equation for the n-factor as a function of air index, seasonal surface heat transfer exclusive of convection, surface coefficient of convection, and soil thermal properties. The study of the thermal interaction of a pipeline with the ground is essential for forecasting, among others, changes in permafrost conditions adjacent to the pipeline. In the U.S.S.R., engineers have undertaken such studies using field investigations, laboratory experiments, analogue computers, and mathematical models. These studies are part of wide-ranging geocryological investigations to determine both the existing permafrost conditions and those that will result from distrubance through construction of

engineering works. Natural gas hydrates, first reported from the U.S.S.R. and most recently from the Mackenzie Delta, possess ice-like physical and electrical properties that make possible their detection by appropriate logging methods. These are now being developed in Canada.

In the session on applied permafrost hydrology and erosion two papers described the effect of permafrost on costal erosion. The first described the coastal defence measures recently installed at Tuktoyaktuk in an attempt to minimize coastal erosion. These defences appear to offer some promise of success but are susceptible to vandalism and have not yet stood the test of time. The second was a fascinating description of the upset of the permafrost regime resulting from river diversion works within the southern fringe of the discontinuous zone. Up to 35 m of shoreline erosion occurred on Southern Indian Lake in northern Manitoba.

The session on arctic construction was hampered by the absence of some of the Soviet papers. A paper from CRREL outlined the problems of tunnel entrances in permafrost primarily because of the change in the thermal regime. A paper was presented on permafrost and applied aspects in Spitzbergen where some novel and successful methods of coping with this problem have been developed.

Four papers from the People's Republic of China evoked widespread interest. Permafrost exists in 22 per cent of the country - the Northeast, Tibet and the Northwest. The Chinese are carrying out fundamental and engineering field studies as well as laboratory work. One paper surveyed the experimental research on properties of freezing and frozen soils in China. Three field studies described tests on an experimental roadbed over thick ground ice in the Chinghai-Tibet region, the performance of an embankment at the lower limit of alpine permafrost in the Northeast, and two pile test sites in permafrost in Chinghai-Tibet in thick continuous permafrost.

Field Trips

Three field trips to various parts of northern Canada took place immediately after the Conference: Yukon-Alaska, the Lower Mackenzie Valley and Northern Manitoba-District of Keewatin. Three others were cancelled because of low enrolment.

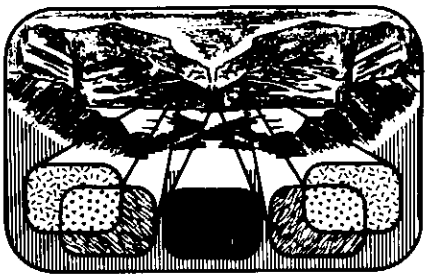
Conclusion

There were two main items at the closing plenary session. The United States invitation to hold the Fourth International Conference on Permafrost at the University of Alaska in about five years time was accepted. The matter of an international permafrost association was raised. The National Research Council agreed to investigate the possibilities by establishing an *ad hoc* secretariat and canvassing the international permafrost community to determine interest. The structure of the association, relations with other similar groups, relation of national committees to an international association and other items will have to be determined.

The Proceedings of the Conference are published in two volumes of submitted papers, review papers, banquet speech, poster sessions, exhibitors, films, open and closing plenary sessions. Volume I was published before the Conference and Volume II will be published in June 1979. Guides (written in English, French and Russian) of the six field trips will be published in the summer of 1979 as part of the Proceedings. English translations of the three Russian review papers and 49 submitted Russian papers (plus one French paper) will be published and sold separately in the summer of 1979.

Information concerning the published record of the Conference can be obtained by writing to:
Conference Services Office, National Research Council of Canada, Building M-58, Ottawa, Ontario K1A 0R6

MS received May 30, 1979



Comments Invited for Revision of American Stratigraphic Code

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Introduction

The American Commission on Stratigraphic Nomenclature (ACSN) is embarking on a thorough revision of the American Stratigraphic Code. The purpose of this note is to elicit the assistance and suggestions of interested geologists throughout North America whom the Commission seeks to represent.

Need for Revision

The current Code (ACSN, 1970) is but a slightly revised version of the Code written largely in 1960 and earlier (ACSN,1961), incorporating some minor amendments adopted by the Commission between 1962 and 1969. Although the present Code has served the profession admirably for almost two decades and has been drawn upon heavily for codes prepared in other parts of the world, it reflects the state of science at the time of its preparation. New tools and concepts developed during the past two decades have revolutionized the earth sciences. Seismostratigraphy and magnetostratigraphy, unrecognized then, are helping now to define the geometry and history of earth materials. Improved capability to drill at great water depths is helping to develop the framework of oceanic stratigraphy. The concept of subduction has led to recognition of both the complexity and significance of mé-