50TH EASTERN SNOW CONFERENCE
61ST WESTERN SNOW CONFERENCE
Quebec City 1993

Snow and Ice in the Publications of the Canadian Institute, 1852–1914

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ABSTRACT

This paper, written on the occasion of the 50th Anniversary of the Eastern Snow Conference, is intended to re-introduce a valuable repository of published work on snow and ice, the journals of the Canadian Institute. The Canadian Institute (since 1914 the Royal Canadian Institute) was a major outlet for a wide spectrum of pure and applied science, economics, literature and the arts in the latter half of the 19th century and the early years of this. Its journals were important vehicles for the work of Canadian and other scholars, notably physical scientists and engineers, for many decades. The Institute's publications' include The Canadian Journal, a Repertory of Industry, Science and Art, The Canadian Journal of Science, Literature and History, The Proceedings of the Canadian Institute, Transactions of the Canadian Institute, Proceedings of the Canadian Institute, (New Series). The current address of the Royal Canadian Institute, a good source for sets of these journals, is 720 Spadina Avenue, Suite 312, Toronto, Ontario, M5S 2T9.

INTRODUCTION

There is a wealth of recorded information on the science and technology of ice, including snow, in North America which is largely unknown to scientists and engineers of today. This includes the accumulated wisdom of aboriginal peoples, notably but by no means exclusively the Inuit, and the records of early immigrants and their pioneer descendants. Most of this material is only accessible to modern ice scientists through the efforts of oral historians and specialists who peruse diaries and other records to extract nuggets of valuable information. However, there is also a huge published literature from the early 20th and past centuries. This literature is the record of the work of predecessors of today's members of the Eastern Snow Conference - researchers devoted to various aspects of snow and ice science and technology. Some of this literature is easily found in the pages of venerable journals, such as Science and Nature, that are still published today. Other information, however, is in series of journals which are no longer published and so is less easily tapped by modern workers.

The general purpose of this paper, written for the 50th Anniversary of the Eastern Snow Conference, is to encourage members to become more aware of early observations of, and research on, ice in North America. The specific purpose is to arouse members' interest by introducing them to one set of lapsed journals, still easily obtainable, which contain the results of research which was undertaken decades or hundreds of years ago.

The Canadian Institute: its journals and their index

The Canadian Institute (since 1914, the Royal Canadian Institute) was founded in 1852. It was the major outlet for "....many branches of pure and applied science, Economics, Art, Literature, etc...." (Arnoldi, 1914, un-numbered page) in the latter 19th and early 20th centuries. Its journals were

"...one of the principal means by which the scientific labours of that day found expression...." (Arnoldi, 1914, un-numbered page). Four principal series of journals were published: The Canadian Journal, A Repertory of Industry, Science and Art and a Record of the Proceedings of the Canadian Institute (1852-55); The Canadian Journal of Science, Literature and History (new series) (1856-1878); Proceedings of the Canadian Institute (1879-1890); Transactions of the Canadian Institute (1890-1912). A 'minor' series Proceedings of the Canadian Institute (new series) was published from 1897 to 1904. These series may be of particular interest to working researchers, as distinct from historians of science, because the articles in them are fully indexed in Patterson (1914).

Patterson(1914) is organized alphabetically by topic and author. For example under " Ice" (p. 240f), there are entries such as "Action on shores....", "Contraction and expansion of ....", "formation of icebergs", and "Manner of disappearing.....". However, the Ice entry is followed by other major headings for 'Ice, Anchor', 'Icebergs'; 'Ice-breakers' and 'Ice-scoops, Dene'. Similarly the entry for 'Snow' (p.449f) has a number of sub-headings (e.g.,"note on stelliform crystals...") and is followed by other major entries for topics such as 'Snowfall', 'Snow Bird' and 'Snow-Shoes'. References to ice and snow, also appear under a wide variety of other headings, notably Arctic and Polar.

There are articles on ice, including snow, in every series. Even the short-lived minor series includes (vol.II, p.57,61) reports on observations in Canada from Albert Penck, the famous glaciologist. Members of the Eastern Snow Conference, in particular, may be interested in the large amount of material on the Great Lakes and St. Lawrence and in the regular reports on weather, including snow and ice conditions, in the Toronto and Montreal areas.

Examples of ice research in the journals of Canadian Institute

It is difficult to imagine the importance of, and interest in, all forms of ice in eastern North America during the publication period of these journals. One author (Editor?, 1852a), writing about the collection of sleighs sent from Canada to the Great Exhibition of 1851, in England, stresses the importance of good sleighing conditions in North America and concludes (p.88), "The completion of our magnificent system of Railways will render this question less important than it now is". Another (Clarke, 1855) provides detailed information on an extremely expensive railroad bridge designed (unsuccessfully, as it turned out) to resist damage by lake ice; there are similar articles for bridges over rivers. During that period, the ice block industry (with its associated science and technology) mined the lakes of eastern North America for 20 millions of tons of ice each year (Willard, 1977, 553), with exports to places as far away as Calcutta (Chambers, 1906, 59). This was a time when people were very interested in snow from what we would think of as a 'scientific' point of view. One example is Glaister (1855), "On the recent Cold Weather and on the Crystals of Snow observed during its continuance". It was also a time when ice was studied from less scientific points of view like that of Scoresby in the early 19th century, " some of the general varieties in the figures of the crystals may be referred to the temperature of the air; but the particular and endless modifications of similar classes of crystals can only be referred to the will and pleasure of the Great First Cause, whose works, even the most minute and evanescent......are altogether admirable" (quoted by Montgomery, 1985, 82). There was an ongoing, vigorous, debate about the freshness of water from sea ice (e.g., H.C., 1856) and the disappearance of lake ice in the spring (e.g., Birge, 1910). There was also concern about acid rain and snow and the effects of combustion products on the atmosphere (e.g., Coxworthy, 1853; Editor ?, 1852b). In those days, water pollution was already a problem......for the ice block industry!

The above description of the General Index, gives some indication of the range of ice-related topics in Canadian Institute journals. For this paper, two topics will be used to illustrate the relevance of such published work for modern researchers. The first has to do with expansion and contraction of lake ice, whereas the second deals with anchor ice in rivers..

Effects of expansion and contraction of lake ice

Three papers (Dumble, 1858, 1860, and Tyrrell, 1910) provide an illustration of both the strengths and weaknesses of science in the journals. Their common thread pertains to an interest in the effects of lake ice on shorelines and structures, but, in fact, there does not appear to be a thread linking author to author. Tyrrell (1910), for example, does not appear to draw on Dumble's work of half a century earlier. Referencing was sporadic in those days.

Dumble (1858) uses detailed observations of

Rice Lake, Ontario, to reach the following conclusion (p.422):

"Ice is a most delicate thermometer, and from the brief statement of facts connected with its phenomena the following general inferences may be derived:

1st. That ice is capable of expansion and contraction.

2nd. That ice (up to 32°) expands with a temperature *higher* than that which had *just previously existed.*

3rd. That ice contracts with a temperature lower than that which had just previously existed.

4th. That ice does not expand or contract with a uniform temperature.

5th. THAT ICE IS SUSCEPTIBLE OF EXPANSION TO A MUCH GREATER EXTENT THAT OF CONTRACTION (my capitals).

6th. That when ice is equally dense, thick, and glare, and equally acted on by a heated atmosphere, it expands from the centre towards the circumference.

7th. That ice expands towards the line *of least resistance."*

Dumble (1858) documents damage by expanding ice, and makes it clear that rate and **magnitude** of temperature change are important in the expansion of ice and its resulting damage. He also points out that thickness and type of ice, and presence/absence of snow cover, are important variables controlling this process. His observations involved snow-free, "glare" ice in a relatively confined situation. Although Dumble had observed ice expanding around lake margins and had ample evidence of damage caused by expanding ice sheets, he failed to detect equivalent evidence of contraction (see #5 above). This may have been because his attention was focused at the lake margins or other damage points -- he was looking for actual evidence of the ice **pulling back** from shorelines. As an engineer, Dumble knew that materials expand with rising temperature and contract as temperature drops, but he states (p.418), "Ice, unlike most other solids, does not seem to possess the property of contraction to the same extent as it does the power of expansion". This conclusion clearly worried Dumble. Perhaps he received feedback on the article focusing on his 5th inference because he later (Dumble, 1860) returned to the topic, complete with the results of an elaborate experiment.

In his second paper (Dumble, 1858), Dumble reports that he cut a ca. 30m x 3m hole in the ice of a mill pond, hauling out the ice blocks. He built a roof over this hole and allowed new, clear, ice to develop. He then cut a moat around the edge of the new ice so that the remaining sheet was floating free. A wooden gauge on the newly-formed ice sheet was used to measure its expansion and contraction. Then, keeping the moat ice-free, he measured temperature and expansion and contraction, day and night for a month, presenting the results in tables and a fold-out chart (reproduced in Adams, 1992). His inferences in this paper (p.423) include "That with the same change of temperature, the expansion and contraction of ice are equal", thus correcting his earlier mistake!

Dumble's devotion to 'pure' science is all the more admirable for the fact that he was engineer in charge of the bridge, mentioned above (Clarke, 1855), that was being steadily destroyed by ice. In his transects of Rice Lake, he had come to realise that the evidence for contraction lay in fissures across the entire lake rather than solely at the margins and/or around his bridge.

Fifty years later, the distinguished engineer and geologist, J.B. Tyrrell looked back on a lifetime working on and around lakes (Tyrrell, 1910). He had no difficulty in accepting the expansion and contraction of ice with variations in temperature and the various controls of those volume changes (including snow cover, ice thickness, etc.) but he challenged the authorities of his day (including G.K. Gilbert of the U.S. Geological Survey, but excluding Dumble) on the matter of effects of expansion. He wrote (p. 18), "... I have spent many winters beside the frozen waters of our north country.....but (my capitals) HAVE NEVER BEEN ABLE TO DETECT ANY EVIDENCE OF SUCH ACTIONS (i.e. ice-shove from expansion). The shore remains perfectly undisturbed all winter.....and if there is any change in the shore it would appear to be ... a drag towards the water...". His evidence of ice expansion was out on the lake in leads and ridges. He believed that the ice was frozen too hard to the ground, around the lakes, to permit any shoreward movement (p.18).

Tyrrell believed that the elaborate features produced around lakes by ice, including large ramparts of boulders, were the result of the 'almost irresistible' (p.19) force of loose ice, drawn backwards and forwards by wind in the spring (cf Adams, 1977).

Between them, Dumble and Tyrrell, from work in very different lake and climate environments, compiled the bases for a comprehensive model of the geomorphological roles of lake ice. Such a model includes expansion and contraction (and their controls) and the effects of wind during break-up (and their controls). Their observations, measurements, **thought processes** and conclusions merit the attention of modern researchers.

Anchor ice in rivers

It is interesting that Gerard (1990), in a review of the current status of 'floating ice hydrology', refers back to the 19th and the early part of the 20th century as a time when interest in river ice was high. Gerard notes (1990, p.107) that the lack of interest shown in ice hydrology in Canada today is astonishing. He cites Henshaw (1887), Keefer (1898) and Barnes (1928) as examples of useful Canadian work of the earlier era of high interest and productivity. It is interesting to read the account of frazil ice formation and accumulation, and their consequences, in Gerard (1990) with the 19th century debate about anchor ice in mind. At that time, it was a mysterious phenomenon which caused a great deal of trouble for engineers and it was mooted as an explanation for the plucking action of glaciers (Youle Hind, 1878). A number of contributions to this debate appear in the journals of the Canadian Institute.

Montreal, below the Lachine Rapids, was famous for ice jams and their associated effects. The evolution of the harbour of Montreal and the construction of its bridges, especially the Victoria Bridge, were controlled to a considerable extent by ice conditions.

Logan (1853) provides a vivid description of ice conditions above and below Montreal. Commenting on the accumulation of ice at the ice bridge, he states, (p.75), "....nearly the whole surface of the stream being covered with it (frazil), and the quantity is so great that to account for the supply many, unsatisfied with the supposition of a marginal origin have recourse to the hypothesis that a very large portion is formed on and derived from the bottom of the river....".

Keefer (1862, p.175) treats ice conditions at Montreal in greater detail. He describes the generation of 'sludge' or 'brash ice' in upstream rapids with 'spongy' masses of it being "stowed away under the ice field" (p.175). He notes the effects of this ice in blocking river flow and describes trying (and failing) to push a bridge crib down to the river bed through a ca. 3m "bank of 'frozee' (frazil, fr.) and anchor ice" (p.176). He states that some believe that such ice forms on the river bed and floats to the surface while others think it forms on the surface and is carried to the bottom. He believed that it formed on the bed. He suggests that the mode of formation "is analogous to that by which dew and hoar frost are formed........ probably due to radiation from the warm bed of the stream to the colder surface current and the still colder atmosphere" (p.177). Ice so formed is released when conditions become warmer. To put this into context, it should be noted that elsewhere (Keefer, 1862, p.178) he points out that "radiation is but another term for magnetism". On the same page, he raises an issue which persisted in ice science until well into the 20th century - "Whether the specific gravity of anchor ice, while it remains at the bottom, is greater or less than that of water........may be questioned".

Thompson (1863) treats anchor ice more 'academically'. In this paper, he too draws heavily on experience in the St. Lawrence at Montreal. This paper is closer in scope to the first part of Gerard (1990) which deals with the initiation of a river ice cover, with growth of marginal ice and generation of frazil. On the matter of anchor ice, he notes (p.321), "On account of the tendency of bottom water approaching the freezing point and of ice to float, it has long been regarded as a rather singular circumstance that ice should ever be found growing at the bottom of a river". He then cites and generally refutes various explanations of anchor ice which were current then and earlier in the century. These include: the "radiation from the bottom to the cold sky" hypothesis; " a peculiar aptitude to the formation of crystals on the stones and asperities of the bottom.."; slower water velocities near the stream bed favouring crystallization (he says this, <u>if anything</u>, militates against crystallization); and freezing at the bed due to globules of cold air entrained above open rapids (he says these would freeze anywhere in the turbulent water column).

Thompson (1863) suggests that there is no formation of crystals (i.e. change of state) at the stream bed. Rather, crystals and fragments may be formed anywhere in the water column that is cold enough. They are whirled around until they adhere to something, where they then grow by 'regelation'. This is a term for the process whereby two moist pieces of ice adhere to each other. It was a topic of considerable interest in the literature of those days (see Chambers, 1906). It provided Thompson with an accumulation process which did <u>not</u> require a change of state.

Here again, are observations, thought processes and hypotheses which are a valuable basis for ice researchers today.

CONCLUDING REMARKS

The Eastern Snow Conference is a remarkable example of scientific and technological cooperation between the United States and Canada, extending over half a century. The alternating of meetings and officers between the two countries has proved to be an effective means of sharing the benefits of ice research in eastern North America. As the Great Lakes and St. Lawrence form a boundary between the two countries, examples of research based on them are appropriate reminders of the vast store of fine research that was undertaken long before the Eastern Snow Conference was founded. I focused on one set of journals, in Canada. I recommend Willard (1977) as a useful entrée to early lake ice work in the United States and elsewhere.

The Royal Canadian Institute, successor of the Canadian Institute, does not today publish scientific journals. It does however play an important role in promoting science among young people and the general public. A few years ago, the Institute came across a considerable store of its journals in mint condition. I must confess that it was this discovery, rather than the archives of a major library, that drew my attention to the journals. They are now available, from the address indicated in the abstract, at modest cost. Full sets can be consulted at the Thomas Fisher Rare Book Library of the University of Toronto.

ACKNOWLEDGEMENTS

I am grateful for the assistance of the Royal Canadian Institute, the Thomas Fisher Rare Book Library of the University of Toronto, A. Brunger, S. Gardiner and M. Miller of Trent University, C.S.L. Ommanney of the National Hydrology Research Institute and J-C Dionne, Université Laval (who has incorporated this set of publications into his work, e.g., Dionne, 1969, 1989, 1992).

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