

## J.B. Tyrrell and D.H. Dumble on Lake Ice

Gerard (1990) bewails the lack of formal interest in river and lake ice in Canada for much of this century. He refers back to another era, which can be viewed as ending some years before the publication of Barnes's (1928) text on ice engineering, when there was a great deal of interest in ice among Canadian professionals. The heyday of this era was the second half of the 18th century and the early years of the 20th.

I use the term "formal interest" because there has always been a keen interest in all the common forms of ice among observing Canadians. As a result, aboriginal and pioneer records often contain observations of and about ice, as do the diaries of Canadian naturalists today. Water in the solid phase is still very much a part of everyday life in Canada, despite the shift of population from rural to urban areas.

Gerard's point is that there has been an unhealthy lack of interest in one of the most prominent features of our environment for much of this century *among professionals who might be expected to systematize and make use of information and observations that were available*. And he is right. I suspect that this was one of the costs of the rapid urbanization of Canada.

However, until well into the present century, most Canadians were very conscious indeed of the fact that they lived with ice. The ice block industry, the freedom of winter travel on ice and snow roads, the cessation of travel during the breakup and freeze-up seasons, the negative effects of river ice on electricity generation and spring flood levels were all basic facts of life and interesting topics of conversation.

In those days, popular interest was paralleled by professional interest. Engineers, of various stripes, and others went to great lengths to interpret and explain ice phenomena and processes and to make use of available knowledge. The results of this work and thought were published in the journals of the day.

It is quite remarkable, however, how little of this easily available work has fed into the development of glaciology, ice science. It is rarely, if ever, cited in accounts of the evolution of glaciology, in sharp contrast to the easy acceptance of the work of amateurs and professionals who observed and measured glaciers in Europe at roughly the same time. I suspect that people like me, Canadians working with and teaching about ice, have been at fault here. We have underestimated the value of home-grown science against that in "mainstream" foreign journals. This phenomenon is not uncommon in other areas of Canadian culture.

I would like to introduce you to two samples of Canadian work on lake ice published between 80 and 140 years ago. One is the work of the famous northern mining geologist, J.B. Tyrrell; the other is that of a less-known civil engineer, J.H. Dumble. For Tyrrell I will treat a paper published in 1910 and for Dumble two related papers published 50 years earlier.

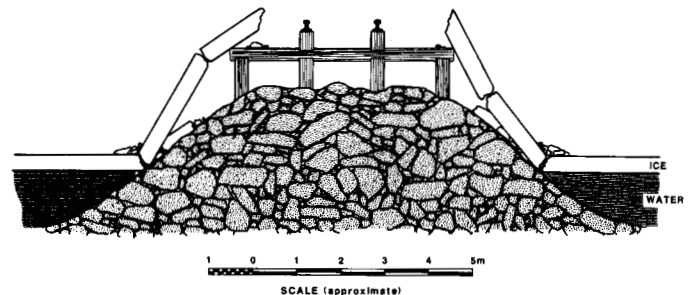
Dumble (1858, 1860) studied the effect of ice on the Cobourg and Peterboro Railway bridge over Rice Lake, Ontario. This was "perhaps the longest Railway bridge on this continent and one of the longest in the world" (Clarke, 1855). It was a 2.5 mile (4 km) long, partly pile, partly crib, structure in water

that ranged, with the season, from 14 to 22 feet (4.5-7.1 m). This was a very expensive structure for its day. Its construction was accompanied by dire predictions of destruction by ice. An editorial in the journal containing the Clarke (1855) article observes; "a greater engineering or commercial blunder can scarcely be found in the Canadas" (The Canadian Journal, 1855:268). Clarke's article contains a number of observations on the ice cover of 1854-55 and its effects and concludes with suggestions for transforming the bridge, at great expense, into a causeway before the ice finished it off. The journal's editor clearly thought that Clarke's paper was a bit of a snow job.

Dumble was engineer to the railway company. From his papers, he appears to have been more interested in the ice than the bridge. In fact, in his 1858 paper he generally treats the bridge as a touchstone for studying ice physics. He discusses and documents the expansion and contraction of ice in response to fluctuations in temperature, the effects of variations in ice thickness and type and the role of snow cover in modifying temperature-induced expansion and contraction based on observations and measurements around the bridge and effects around the lake shoreline. The reader should know that there is still discussion about the relative importance for shoreline development of ice shove from expansion and wind-induced ice shove (see below). However, there is no doubt that Dumble was observing ice expansion effects on his bridge.

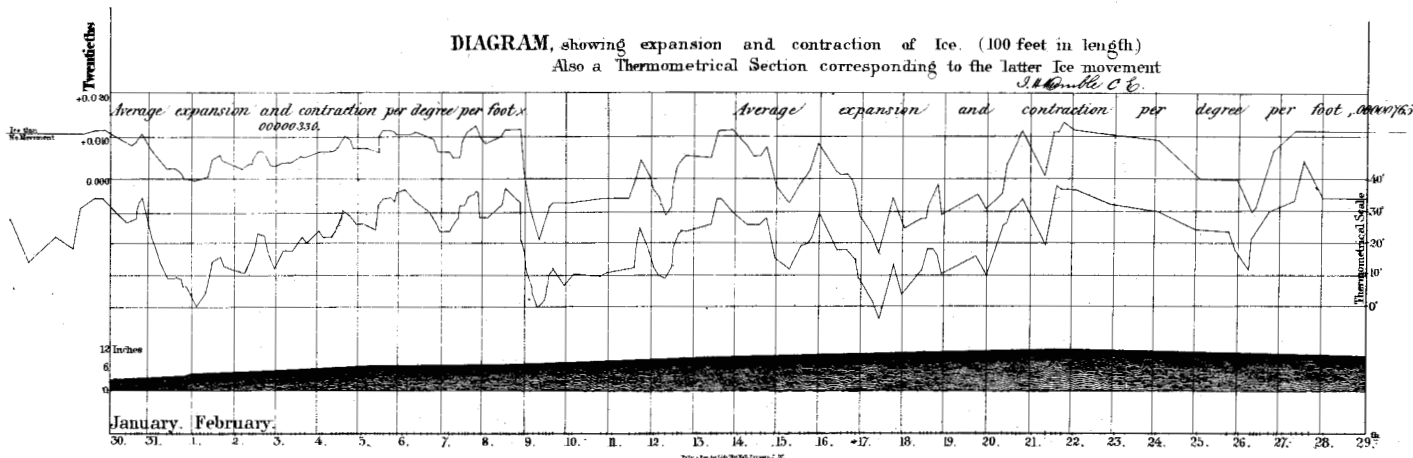
In his first paper, Dumble states that "ice is susceptible of expansion to a much greater extent than contraction" (Dumble, 1858:418). Later, after observing and pondering about fissure patterns on the lake, he began to suspect that this was not so. He felt obliged to verify or disprove his assertion, and to do so he designed and carried out an elaborate experiment. This experiment is the focus of his 1860 paper. In it, he does not mention his disintegrating bridge at all.

When the ice was well established on a mill pond near his home in Cobourg, he cut a 105 × 10 foot (33.9 × 3.2 m) hole in it, hauling out the ice in blocks. He built an open shed over the hole to protect new ice from precipitation and radiation effects. When the new ice cover reached 1.5 inches (3.8 cm),



"An extraordinary instance of ice piling was witnessed on our new embankment. The ice shoved from both sides until the fractured pieces met in the centre of the track" (Dumble, 1858:419). (Redrawn from Dumble's original diagram by Steve Gardiner, Trent University.)

DIAGRAM, showing expansion and contraction of Ice. (100 feet in length)  
Also a Thermometrical Section corresponding to the latter Ice movement



Dumble's plots of the results of his elaborate ice-expansion experiment. The data are presented in tables in Dumble (1860). This was a fold-out diagram at the back of the journal.

he cut an 18 inch (44.7 cm) moat around it, producing a free-floating floe. He then fitted the floe with a measuring device and, keeping the moat ice free, monitored its expansion and contraction. He made ice and temperature measurements around the clock for days. Results are provided in the journal through an elaborate fold-out chart.

The carefully itemized conclusions to this paper include a correction of his original assertion about the expansion and contraction of ice: "That with the same change of temperature, the expansion and contraction of ice are equal" (Dumble, 1860:423).

How many of us, while worrying about an expensive, failing, railway bridge, would show this sort of devotion to science? Surely work such as Dumble's should at least be mentioned occasionally in Canadian, and other, glaciology classes?

J.B. Tyrrell's paper (Tyrrell, 1910) was based on his presidential address to the Canadian Institute, read on 20 November 1909. It is interesting that Canada's leading mining geologist, a national northern legend in his own time, should choose lake ice as the topic for this important address. It seems to me that this reflects not only his own interest in the subject but that of his audience. As he says, "Most of us in Canada have opportunities for observing the formation and character of the ice which covers our lakes during the winter" (Tyrrell, 1910:13). He then proceeds to present an overview of the initiation, evolution and decay of lake ice and associated effects, based on decades of observations as a working geologist. He draws heavily on his arctic experience, including his work associated with the Yukon gold rush.

Tyrrell's article is quite different from those of Dumble. He had spent his working life travelling on ice in winter, in leads around lakes in the spring and on inshore waters during the summer. As a geologist, he was interested in the shorelines all year round. He was interested in the ice as a travel medium and as one of the controls of shoreline formation. His work had taken him to some of the most remote parts of Canada and onto some of our most famous lakes. His paper is an attempt to synthesize his own knowledge of lake ice and his knowledge, as a geologist, of the literature of the day for an informed lay audience.

He describes and explains freeze-up in terms of the development of both shorefast ice and ice in open water. He was fully familiar with the different results of freeze-up under calm, clear conditions (smooth "black" ice) and freeze-up associated with precipitation and/or turbulent conditions (rough, opaque ice). These are initiation scenarios that have important implications for the later evolution of the ice and for its effect on the biology and chemistry of the lake (e.g., Adams and Allen, 1988; Welch, 1991). For Tyrrell, they meant good or bad sledding conditions for himself and his dogs.

After considering the breakup phase, he discusses the sagging of the ice cover held fast to the shores as lake levels drop during the winter. He was very interested in and knowledgeable about conditions around the shores, for that was where he camped on his trips. Unlike Dumble, he was of the view that shorefast ice is a great protector of the shoreline during winter. He also believed that the entire expansion of ice resulting from a rise in temperature is taken up by the closing of cracks formed when the ice contracted during a fall in temperature. He says that various authorities ascribe all sorts of shoreline effects to the expansion of ice, but "I have spent many winters beside the frozen waters of our north country and have watched closely for evidence of the pushing of the ice towards the shore in winter and have never been able to detect any evidence of such action. The shores remain perfectly undisturbed all winter" (Tyrrell, 1910:18). If anything, he says, the evidence suggests a dragging of material from the shores! He does not deny that ice expands as temperature rises; he simply says that ice on lakes does so in such a way that it does not affect shorelines.

It is important to note here that he stresses "in winter"; he deals with ice-shove in the spring later, as we shall see.

Having described the establishment of an ice cover, Tyrrell goes on to describe the growth of clear black ice and that of opaque white or snow ice following the slushing of snow on top of the ice sheet. He was very familiar with the slushing process because of its effects on his sled and dogs. He was aware of the repeated slushing of snow on lakes, producing lenses of slush followed by successive layers of white ice. Again, these are processes and ice types that have great significance



J.B. Tyrrell in Churchill, 1893, following his epic journey from Lake Athabasca to Chesterfield Inlet to Churchill via the Dubawnt River, Dubawnt Lake and Baker Lake. (Photo from Gaskin, 1976, courtesy of the Thomas Fisher Rare Book Library, University of Toronto, and the Royal Canadian Geographical Society.)

for the lake as well as the traveller (*cf.* Gerard, 1990; Welch, 1991).

This brings him to the spring melt, the development of leads around a lake and the final decay of the ice cover. It is at this time that Tyrrell observed dramatic lake ice effects on his shorelines. He describes and provides photographs and measurements of shore features produced by *windblown ice*. Having observed pronounced ice-shove effects all around lakes, I used to interpret them as the result of all-round ice expansion. I imagined that wind-driven floes would produce markedly different effects on the upwind and downwind ends of lakes. In fact, the most dramatic effects are produced when the ice cover of a lake is essentially intact, with a moat all around it. Then, changes of direction of even light winds, acting upon a great expanse of ice, can produce remarkable effects at a variety of locations around a lake. People with cottages and docks on large lakes may be familiar with occasional ice shoves of this type (*cf.* Adams, 1977, and Adams and Mathewson, 1976, who draw largely on non-Canadian references).

The fact is that both processes, expansion and wind-induced ice shove, occur in different situations. There is no doubt that Dumble's bridge was being destroyed by ice expansion effects

*in winter*. No doubt too, his shorelines were being affected by the same process. But he was dealing with ice that was quite confined (in part by the bridge) and was hung up at a number of points rather than being free floating. Also, the alignment of his long, narrow lake is such that his section was often swept free of snow so that he was dealing with "glare" ice, minimally insulated from temperature changes. But on many of our lakes, where large expanses of ice are floating free and sagging from firmly held shorefast ice, and where snow and snow ice mute the effects of temperature changes, the effects of ice expansion are taken up in ways that do not affect the shorelines.

Tyrrell does not appear to have heard of Dumble, just as I had not heard of Tyrrell's ice work until recently. There is a good excuse for Tyrrell, as the papers of those days were not referenced as papers are today (but there were index volumes of their journals and, in fact, Tyrrell funded one; see below), but there is no excuse for someone like me, who has taught about ice for some decades, being unfamiliar with this early Canadian work. For this is not work that is buried away in explorers' diaries. It is in well-organized journals published in series that extend over generations.

Quite recently, the Royal Canadian Institute (196 Carlton St., Toronto, Ontario M5A 2K8; 416-928-2096), which was founded in 1852 and is still very active in, for example, the promotion of science among young people and the popularization of science, came across a large cache of its journals from the period covered by my examples. These include four major series and one minor. The volumes concerned are in mint condition, often uncut.

The index volume (Canadian Institute, 1914) for the period 1852-1912 contains many entries under "ice," including sea ice, ice bergs, river ice (including anchor ice), ice breakers and ice scoops (Dene). For those interested in the North, this index also includes such topic headings as: polar bear; polar hare; North-West Territories, Company and Passage; Labrador; Siberia; Yukon and Yenisei; McClure, Kane, Knight, Franklin and Belcher; whales; and igloos. This index was initiated and funded by J.B. Tyrrell himself.

It is my understanding that the Royal Canadian Institute is disposing of this new-found treasure very cheaply. As a result there is no longer any reason for access to such Canadian journals to be confined to very large or specialized libraries. You can have them in your home or your school. Then, perhaps, early Canadian contributions to ice science will at last flow into the mainstream of glaciology.

#### ACKNOWLEDGEMENTS

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