COLLECTING AND PRESERVING THE HISTORY OF SNOW AVALANCHE ACTIVITY, RESEARCH AND SAFETY IN CANADA

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ABSTRACT: Collecting and preserving the objects and records of avalanche activity, research and safety provides valuable historic resources to avalanche professionals, the public and researchers in a variety of disciplines. Not only do these collections give insight into the nature of avalanches, they help focus and substantiate safety and research programmes. As a public education project to present a nationwide overview of avalanche science and safety for the Virtual Museum of Canada, we addressed the question of where and how avalanche archival resources are acquired, stored and indexed in Canada. Through discussions and interviews, site visits to museums and archives and internet-based collection searches, we identified existing archival resources and added new objects and metadata to these collections. We found well-archived avalanche incident records since 1782 including 884 avalanche-related deaths and we were able to map most of these fatalities. We found few resources documenting the experience of Aboriginal peoples with avalanches or three-dimensional artifacts from any time period (e.g., contemporary snow measurement tools). For the most part, publicly accessible archival resources were poorly indexed and most often discovered within collections catalogued to other subject areas such as transportation and mining. Archival resources related to the present-day transportation and recreation industries were poorly represented in formal archives and museums and often lacked detailed metadata. Avalanche safety and snow research professionals working in cooperation with museums, archivists and historians could help to illuminate significant chapters of Canadian history and provide information of ongoing value to many sectors of the economy.

KEYWORDS: railway, highway, mining, recreation, museums, archives

1. INTRODUCTION

Historic records, images and recordings are recognized by avalanche safety and research professionals as valuable sources of information (McClung and Schaerer 2006). These resources, and related three-dimensional artifacts (e.g., snow study tools), also are of value to historians, museums, climatologists, ecologists, educators, the public and any industry or sector of the Canadian economy operating in terrain threatened by avalanche hazard (e.g., transportation, mining, tourism and recreation, power generation and transmission, pipelines, forestry). Therefore, there is considerable potential for mutually beneficial collaboration to collect, preserve and access these historic resources.

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In Canada, significant snow avalanche incidents and associated disruption of travel corridors, safety warnings and loss of life, receive extensive public attention through the media each avalanche season. In contrast, the widespread occurrence of avalanches across the country and Canada's long-standing accomplishments in snow and avalanche research and safety are less well-known and their stories infrequently synthesized (e.g., Cunningham 1887, Peck 1970, McFarlane 1985, Schaerer 1995, Simpson 2002, Everts 2003, Stethem et al. 2003, Liverman 2007, Di Stefano 2013, Woods 2013, 2014, Labrecque and Woods 2014).

The complexities of avalanche events and the terrain in which they occur create a high potential for confusion and misinformation. For example, Canada's largest loss-of-life avalanche incident (58 fatalities, Rogers Pass, March 4, 1910) is frequently misrepresented in terms of location and number of casualties (Woods 2010).

Historical research related to snow avalanches relies on sources of information of varying reliability. These range from first-hand communication

with avalanche professionals and published research papers, to poorly-labelled (or mislabelled) images, objects and narratives.

Searching publically maintained archival sources for images and textual materials relevant to snow avalanches can be challenging and objects and artifacts are virtually non-existent. Avalanches may not be a searchable category or they may be indexed as 'slides', 'snowslides', or 'snow slides' or 'nadere' (in Japanese). Care must be taken to distinguish them from other types of avalanches such as rock, mud or ice (e.g., Woods 2013). These issues mean that significant archival resources could be easily missed by archival searches and require parallel searches of related topics (e.g., Canadian Pacific Railway, snow, mining, disturbance ecology). Few museums in Canada maintain collections of avalanche-related materials or instruments. These objects are what provide insight and speak to the history of avalanche research in Canada.

In contrast, the depth and detail of historically important information produced and maintained by the present-day avalanche safety and research community in Canada is astonishing. Principle sources include: 1) the online incident database publically available through the Canadian Avalanche Centre; 2) the "Avalanches Accidents in Canada" series of technical reports (Stethem and Schaerer 1979, 1980, Schaerer 1987, Jamieson and Geldsetzer 1996, Jamieson *et al.* 2010); and, 3) avalanche atlases produced for specific areas and operations (e.g., Schleiss 1989).

As research for an educational project to make Canada's snow avalanche history accessible to the general public through a virtual exhibit within the Virtual Museum of Canada, we conducted a scan of currently available archival resources and began a programme of acquisition of new resources.

In this paper, we report on our progress and recommend ways to enhance collaboration between avalanche research and safety professionals and the archival and museum community.

2. METHODS

We restricted our search to materials related to snow avalanches and snow research relevant to snow avalanches (also known as slides, snowslides or snow slides).

We used a broad-spectrum approach to assess current archival resources including: on-line and site visits to selected archives and libraries; review of the archival holdings at the Canadian Avalanche Centre located at Revelstoke, British Columbia; personal communications with avalanche professionals; taped interviews with current or former avalanche professionals; on-site visits to the archival holdings at Rogers Pass; and, an appeal to the public for images and other information related to avalanches. New resources were added either to the collections at the Revelstoke Museum and Archives (e.g., film, oral interviews and photographs) or the Canada Science and Technology Museums Corporation collection (three-dimensional artifacts).

We used optical character recognition (ORC) tools to perform multiple searches through digitized sources such as online government reports and newspapers (e.g., Minister of Mines, BC 1889, Anonymous 1913). These sources were searched with multiple passes using the terms "snow", "slide" and "aval". In some cases, we searched by location name (e.g., Rogers Pass, Molly Gibson Mine) or the name of a known victim.

Although the present-day boundary of Canada was our focal area, we included events of international significance relevant to Canada (i.e., cross-border events). To illustrate the geographical context of avalanche fatalities, we used the incident database available on the Canadian Avalanche Centre (CAC) website (http://www.avalanche.ca/cac/library/incident-report-database/view/). Additions and corrections to this database stemming from our research were sent to the CAC on an ongoing basis. Where possible, we cross-referenced incidents in the CAC database with other sources such as official death records, inquisition findings and news accounts. Locational data was standardized to latitude longitude format expressed in decimal degrees.

Although much data also were available on non-fatal incidents, their analysis was beyond the scope of our current project.

To reflect our historical interest in the data, we categorized each incident in a way that emphasized the primary activity that brought people into potential risk from snow avalanches (e.g., Industry: Mining, Recreation: Snowmobiling, see Tbl.1).

3. RESULTS & DISCUSSION

3.1 Fatal incident locational data

We found 464 mappable fatal avalanche incidents in Canada from 1782 to 2014 (Fig. 1).

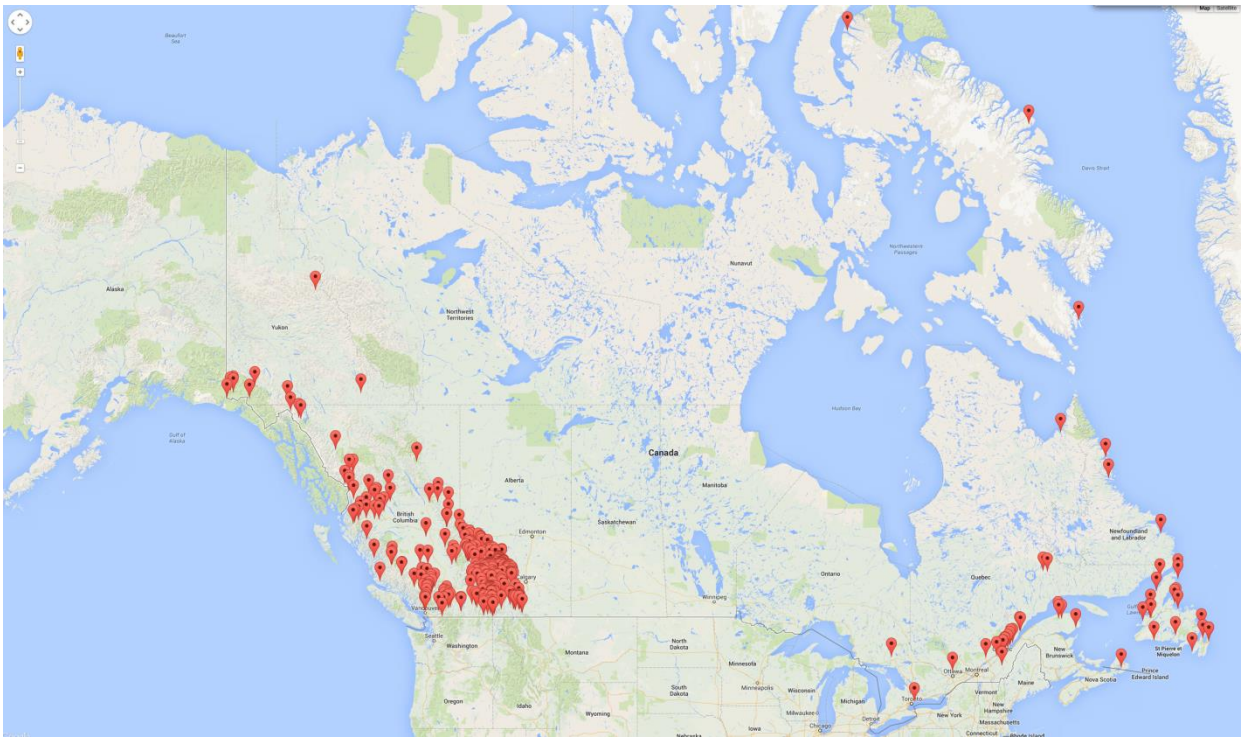

Fig. 1: Fatal snow avalanche incidents in Canada (1782-2012, N=464)

These incidents were widespread across the country with concentrations in the mountains of western Canada, the Atlantic coast and along the St. Lawrence River in Quebec.

While separation of snow avalanches from other types of mass movement events (e.g., landslides, mudslides, rockslides) was usually straightforward, a slide at Britannia Mine, British Columbia (57 fatalities, March 3, 1915) proved difficult to classify and has been excluded from the dataset pending further research (see Woods 2013).

Quality of fatal incident data ranged from comprehensive to fragmentary. Many pre-1980 incidents in the CAC database lacked reference to external documentation. This was especially true for early avalanche records in Quebec. Of 26 fatal incident records in Quebec during 1825-1977, only one was supported by external documentation. In contrast, of 20 pre-1980 fatal avalanche incidents in Newfoundland and Labrador (1782-1962), 19 were supported by external documentation and the snow avalanche history of this province has been comprehensively summarized by Liverman (2007).

Location data within the CAC database was expressed in a mixture of UTM (NAD 27 and NAD 83) and latitude/longitude formats. Error estimates for locational data were either not provided or only qualitatively described (e.g., 'location not exact').

While this may not be an issue when the data are viewed at the regional or national level (e.g., Fig. 1), modern online mapping tools will allow fine scale site inspection that may or may not be in the exact location of the incident. Therefore, these data should be used with caution at the local scale.

Provisional mapping of the dataset proved to be an efficient data-edit tool to quickly reveal gross errors in locational data (e.g., reversed easting/northing, lack of the minus sign for all longitudes in Canada). This mapping also quickly allowed researchers familiar with the avalanche incident to correct the location and assign an error estimate.

Most available fatal incident compilations lacked the names of the people involved in the incident. This made it difficult to cross-reference incident data with other sources (e.g., death certificates, coroner's reports, media reports).

Although the first documented fatal avalanche accident in Canada involved an Aboriginal community in Labrador (22 fatalities, Nain, NL, 1782), we found very little information illuminating Aboriginal experiences with avalanches despite their coexistence in snow avalanche country for millennia before European exploration and settlement of North America (Simpson 2002).

We found two fatal incidents of international scope. April 3, 1898, snow avalanches killed approximately 65 people in the Chilkoot Pass while travelling to the Klondike goldfields in Canada. Although this incident is of relevance to Canadian history, it happened on the American side of the Pass (National Park Service 2011).

March 4, 1910 an avalanche in Rogers Pass, British Columbia killed 58 people in Canada's deadliest avalanche on record. However, viewed at a larger geographic scale, this avalanche was part of a suite of at least 10 fatal incidents that happened in a 10-day period (February 24 to March 5, 1910) as storms swept across the north-western United States and adjacent areas in Canada resulting in 180 fatalities (Beals 1910, Woods 2010, unpublished data from this project). The Rogers Pass incident also had international implications since 32 of the men killed were Japanese contract workers (Woods 2010). Access to community newspapers and records written in Japanese was instrumental in working out the details of this incident.

3.2 Fatal incident historic categories

We assigned 884 fatalities in 470 incidents to categories including a number of incidents that require further research (Tbl.1). These data illustrate the predominance of recreational related fatalities (56%), followed by industry (14%), transportation (16%), towns (11%) and other (3%). The time distribution of these categories changed dramatically during our study period both between and within major categories. For example, the earliest records (1782-1800s) were predominately related to towns (e.g., steep banks along the St. Lawrence River in Quebec); from the 1880s to the 1920s, many incidents related to railways and mining resulted in fatalities; and, from the 1980s to the present, most avalanche victims were engaged in a variety of recreational activities.

3.3 Avalanche and snow research in Canada

The earliest professional documentation of avalanche activity we found in Canada was associated with the design and construction of defence structures for the Canadian Pacific Railway through Rogers Pass, British Columbia during the winter of 1884-85 (Sykes 1885, Cunningham 1887). A second wave of field study started in the 1950s associated with the routing of the Trans-Canada highway through Rogers Pass (Schaerer 1995, Schleiss 1989). Today, recreation is the dominant activity associated with avalanche fatalities and the primary focus of many public safety and research programmes (e.g., CAC). In addition, several Canadian universities have had avalanche-related studies including the UBC Avalanche Research Group (http://ibis.geog.ubc.ca/avalanche/) , the Centre for Natural Hazard Research at Simon Fraser University (http://www.sfu.ca/cnhr/types.html) and the Applied Snow and Avalanche Research group at the University of Calgary (ASARC, http://schulich.ucalgary.ca/asarc/).

Tbl. 1: Avalanche Fatalities in Canada 1782-2014

Category	*Fatalities*	*(Incidents)*
Industry	119	(49)
- Mining	116	(46)
- Trapping	2	(2)
- Logging	1	(1)
Recreation	494	(340)
- Skiing (back-country, self-propelled)	129	(88)
- Snowmobiling	114	(90)
- Mountaineering	90	(53)
- Skiing (back-country, mechanized)	85	(45)
- Ski resort	38	(33)
- Hunt and fish	5	(4)
- Other recreation	33	(27)
Transportation	140	(36)
- Railways	105	(22)
- Trails & roads	35	(14)
Towns	93	(21)
Other	38	(24)
- Safety programmes and search & rescue	5	(4)
- Unknown and miscellaneous	33	(20)
All categories	884	(470)

In the 1940s, Canadian George Klein invented a snow study kit while working on the design of aircraft landing skis for landings on snow. Klein's instruments and methods were quickly adopted into the avalanche research and control programmes in Rogers Pass. Components of the kit remain in use to this day (Bourgeois-Doyle 2004, Labrecque and Woods 2014). Klein also was an early innovator in the field of snow crystal classification and collaborated as part of an international team that

developed a standardized snow classification system (Schaefer et al. 1954).

Our investigations revealed no single-source comprehensive synthesis of the history of Canadian involvement in snow research and avalanche safety in Canada.

3.4 Archival snow avalanche resources in Canada

The Canadian Avalanche Association (CAA) maintains the only archival collection dedicated to this topic in Canada (Art Twomey Library). It is accessible by appointment and is not fully catalogued or maintained by full-time archival staff. However, it contains a wide variety of material including reports, photographs, taped interviews, avalanche atlases and three-dimensional objects. Since 1991, the CAA has administered a professional subscription-based information service called InfoEx© where professional avalanche workers exchange weather, snowpack and avalanche information. Access to this database is through an application process with the CAA (personal communication, Mary Clayton, CAC, 2013).

The Revelstoke Museum and Archives (RMA), in Revelstoke BC contains extensive visual, text and audio resources related to snow avalanches in Canada. These can be accessed through direct contact with the curator or through the museum's website (http://www.revelstokemuseum.ca/, see Land of Thundering Snow). This archive contains a special collection of material from veteran avalanche expert Peter Schaerer focused on avalanche studies and safety programmes in Rogers Pass, British Columbia (Schaerer 1995).

The Canada Science and Technology Museum Corporation in Ottawa (CSTMC), Ontario has a small collection of three-dimensional artifacts related snow study and avalanche safety (e.g., Klein snow study kit, avalanche transceivers, see http://www.sciencetech.technomuses.ca/english/about/hallfame/u_i19_e.cfm).

Although many relevant resources (especially images) are found in other archives across Canada, they were poorly indexed for "snow avalanche" research. These archives require multiple searches using related terms (e.g., snow, slide, avalanche), activity-based searches (e.g., Canadian Pacific Railway, Trans-Canada Highway, mining), or area-based searches (e.g., Rogers Pass, Kootenay Pass, Sandon).

Our keyword searches of digitized historic documents identified many previously unindexed historic mining incidents (Woods 2013). However, this text-mining was dependent on the ability of the digitization process to correctly recognize characters in the original document (e.g., smudged or partial letters may be incorrectly categorized). As programmes to digitize historic documents continue, machine-readable sources will undoubtedly improve our ability to search for avalanche information.

Our experience with the avalanche safety and snow research community was that as a group they valued historically important objects, documents, recordings and visuals but lacked formal programmes for long-term acquisition and preservation of this material. For example, virtually every field worker now has a digital camera and takes multiple photographs of important events. However, the images we viewed were rarely completely labelled (date, location, subject, photographer) or stored in a non-compressed format. Given the ease with which these images can be shared via the internet, it becomes very easy to mix collections and lose the provenance of individual items. Similarly, while old field equipment and instrumentation gives way to new, objects of historical significance may be discarded or relegated to storage spaces lacking long-term stability (e.g., no temperature or humidity control).

3.5 Questions for further historical research

There are many questions regarding Canadian snow science and avalanche history that are still unanswered. Some of the most interesting questions that we believe are worthwhile to be investigated include:

1. What can we learn from the Aboriginal experience with avalanches in Canada?
2. Where are the details of the pre-1980 avalanches in the historic record of the province of Quebec?
3. What role has Canada played in the evolution of safety and research technologies related to snow avalanches in the global context?
4. How have the instruments and methods of snow and avalanche research and safety used in Canada evolved over time? Who developed them? What are the milestones? Where are the objects?

3.6 Recommendations for collecting and preserving Canadian snow science and avalanche history

Based on our research, we have the following recommendations for the future collection and preservation of documents and artifacts related to the history of Canadian snow science and avalanche safety:

1. Express locational incident data in a common format (e.g., decimal degrees) to facilitate mapping and error checking. Whenever possible, these data should be mapped and individuals familiar with the incident invited to comment on accuracy. A quantitative error estimate should be associated with each mappable incident location.
2. Within guidelines and regulations for the protection of personal information, include the names of the individuals involved in fatal incidents in incident databases to facilitate future historical research and collaboration of incident details across data sources.
3. Map and historically categorize non-fatal avalanche incidents.
4. Interview and record experienced avalanche research and safety professionals in Canada. Interviews offer a time-efficient method of gathering information as well as leads to potential archival sources (e.g., storage rooms). Transcripts of these interviews should be stored in digital databases suitable for machine-based content searches.
5. Invite public and corporate participation in identifying new archival resources. Focus these efforts in communities and workplaces in or adjacent to snow avalanche terrain and amongst recreationists using these areas.
6. Synthesize a history of snow research and avalanche safety in Canada from the first avalanche reports and papers, the scientific instruments used in the study of snow avalanches, their development, intended and unintended uses, the users, their techniques and the context under which they were developed and used.
7. Develop archival plans for the long-term collection, preservation, storage and accessibility of historical snow research and avalanche safety resources in collaboration with the museum and archival community. Within Canada, material should be preserved in archives that follow the archival statement of principles within the Canadian 'Rules for Archival Description' (Bureau of Canadian Archivists 2008).

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