Avalanche accidents in Canada. III. A selection of case histories 1978-1984

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III. A SELECTION OF CASE HISTORIES 1978-1984

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ABSTRACT

The circumstances, rescue operations, snow and weather conditions, and avalanche data of 49 avalanche accidents in Canada are described. Skiers, mountain climbers, snowmobile operators, workers, and various structures were involved. Statistics of avalanche accidents in Canada from 1978 to 1985 are included.

ACCIDENTS CAUSÉS PAR LES AVALANCHES AU CANADA
III. CHOIX DE CAS DOCUMENTÉS D'ACCIDENTS DE 1978 À 1984

par P.A. Schaerer

RÉSUMÉ

L'auteur décrit les circonstances de 49 accidents causés par des avalanches au Canada, les opérations de sauvetage, les conditions météorologiques et d'enneigement de même que les données ayant trait aux avalanches elles-mêmes. Ces accidents ont impliqué des skieurs, des alpinistes, des motoneigistes, des ouvriers ainsi que diverses constructions. Ce document renferme aussi les statistiques concernant les accidents causés par des avalanches au Canada de 1978 à 1985.

FOREWORD

Winter travellers in mountains are frequently exposed to avalanche hazards for considerable periods of time but seldom observe avalanches in motion or the destruction they cause. Descriptions of accidents and the circumstances leading to them, however, can be useful in alerting people to potential dangers and stimulate concern for safety measures. To promote such awareness the Avalanche Centre of the Institute for Research in Construction, National Research Council of Canada (NRCC), collects and publishes statistics and case histories of avalanche accidents.

The present publication, Volume III of a series, describes 47 avalanches that resulted in death, injury, or property damage between 1978 and 1984, plus two major disasters of previous years, 1910 and 1950. Volumes I and II (Stethan and Schaerer 1979; 1980) describe avalanche accidents before 1978. The information now presented was compiled by staff members Peter Schaerer and Paul Anhorn and snow safety consultant Chris Stethem, who worked under NRCC contract No. OSX83-00171. The accident data were collected through interviews with eye witnesses and people involved in rescue operations, as well as from newspaper articles and reports compiled by the Alpine Club of Canada.

It is hoped that the experiences of the unfortunate victims and the lucky survivors will promote interest in safety measures. It is recommended that people who traverse avalanche terrain develop the skills to evaluate weather conditions and snow profiles.

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INTRODUCTION

Avalanche researchers at the National Research Council of Canada have collected information about avalanche accidents in Canada since 1969 that resulted in death or significant property damage. Table I is a summary arranged according to the type of accident. Fatalities have averaged seven per year, but there has been a shift lately to a greater number among those engaged in recreational activities as opposed to those at work. Comparison of Tables I and II makes this particularly clear. Table II reflects the recorded-accident distribution for the years between 1953 and 1969, but probably does not contain the correct total number since not all accidents were recorded in that period.

A decrease in the number of accidents on roads and in residences and the workplace reflects greater concern for safety. For example, mines used to be developed with little consideration for avalanche paths, but management is now more aware of the danger and provincial mine inspectors are trained to recognize hazardous terrain that requires the introduction of safety measures. It has become common practice to consider avalanche hazards when permits for land development and building are issued. The hazards on roads are monitored by trained maintenance personnel who close them during critical periods and use explosives to control avalanches in some areas. The tendency for a greater number of accidents to be associated with recreational activities has also been noted in the United States where climbers represent the greatest number of victims (Williams and Armstrong, 1984). These statistics lead to the conclusion that education about avalanche safety should now be aimed mainly at skiers, climbers and snowmobile operators.

Property damage includes destroyed or damaged buildings, bridges, tramways, chairlifts, hydro transmission lines, machinery, railway equipment, and road vehicles. The true value of damage is suspected to be greater than that shown in Table I since minor damage may go unreported and the additional monetary loss due to disrupted service on roads, railways, powerlines and mines is not calculated. The value of lost or interrupted service is often greater than the cost of replacing destroyed structures and equipment, but it is difficult to estimate. A reasonable figure would be about $1 million per year if all unreported avalanche events and losses from interrupted services were included.

The statistics on fatalities and property damage in Table I do not reflect the full extent of the avalanche hazard. Every year many people are caught in avalanches but escape unharmed or with minor injury. In order to obtain a more accurate picture, industry and government agencies were requested in 1979 to report all incidents involving persons, vehicles or property. The forms used for reporting are contained in the Guidelines for Weather, Snowpack and Avalanche Observations (Avalanche Research Centre, 1986). The names of persons involved need not be reported and information from individual reports is confidential, made public only in summarized form.

Table III, a summary of reports between 1979 and 1985, shows that an average of 42 people per year have encounters with avalanches. It is

suspected that the true number may be about double this since many people are not aware of the reporting system, forget to file a report, or wish to avoid publicity.

Noteworthy from Table III is the number of people (an average of four per year) completely buried but rescued alive. These rescues are effected by witnesses who find the buried person either by transceiver signals or by probing and shovelling immediately at the most likely spot. The number of incidents reported in Table III are distributed about equally among the three mountain systems of Western Canada: Rocky Mountains, Columbia Mountains, and Coast Mountains.

Most Frequent Mistakes

The principal objective of this and the earlier publications on avalanche accidents (Stethem and Schaerer, 1979, 1980) is to draw attention to mistakes and to learn from them. Accidents involving people have occurred when either terrain or snow stability was judged to be safe but was not, or people made errors after recognizing unsafe conditions. Analysis of the accident case histories shows that mistakes were made repeatedly through failure to recognize the following:

- deposition of wind-transported snow,
- possibility of avalanches releasing above a travel route,
- terrain traps in narrow valleys,
- steep slopes, trees, rocks, crevasses below a travel route,
- weak layers and bonding deep in the snowpack,
- influence of high air temperatures and solar radiation,
- possibility of a second avalanche in the same path,
- concentration of people in an avalanche path,
- need to wear transceivers and carry shovels.

Errors in Terrain Analysis

Many back-country travellers seem to lack the knowledge and skill to recognize the subtle variations in terrain that cause depositions of drifting snow. Accidents have occurred when snow slabs fractured on the lee side of small ridges running in the fall line of long slopes, in shallow cirques where one side is more subject to deposition of wind-transported snow than the other, and below rolls of terrain.

Avalanches that started on the slopes above skiers and snowmobilers were the cause of numerous accidents. Travellers often crossed a slope not steep enough to slide until their weight and motion produced a local failure that propagated to steeper slopes above. Usually the avalanche starting high above was large and moving fast when it reached the victims, making escape impossible.

Skiers travelling through narrow valleys have been trapped and buried deep in the deposit of avalanches from short adjacent slopes. Here the avalanches might have been harmless if the snow had not piled up in the

valley bottoms. Obstacles such as rocks, trees, and crevasses below a travel route were also the cause of injuries, often fatal, when people were swept down even by small avalanches. Collisions with rocks and burials in crevasses were the most frequent causes of death of mountain climbers caught in avalanches. The lesson to be learned is that steep, rough terrain or narrow valleys below travel routes strongly increase the risk, and that one should always consider the consequences of being carried down by an avalanche.

Errors in Snow Stability Evaluation

Errors in evaluating snow stability can be traced to failure to recognize deep slab instabilities and weather changes. Inability to recognize the existence of weaknesses deep in the snowpack was the most frequent cause of accidents among skiers and snowmobilers. Often the snow at the surface was well consolidated, giving an appearance of stability, but the danger lay hidden below. The following types of snow were responsible for hidden weaknesses and instabilities:

- surface hoar,
- facetted crystals formed at the surface,
- snow that fell in the shape of plates, columns, or needles,
- new snow poorly bonded to the top of a rain or melt crust,
- loose snow with a poor bond below a crust,
- depth hoar.

Layers of surface hoar and facetted crystals were more frequent failure planes and lubricating layers for avalanches than were depth hoar and crusts. Fractures in depth hoar at the ground surface were common in accidents in December. Later in the winter the snow usually failed initially near the surface and broke into the depth hoar when it was in motion. The combination of a weak layer beneath and a hard one on top has the potential for a snow slab failure that will often propagate over a wide area, resulting in large avalanches.

Snowfall, strong winds, high temperatures, or a combination of all these factors on the day of an accident or the one before were responsible for poor snowpack stability in 26 of the 47 accident cases reported between 1978 and 1984. In the other 21 cases the unstable condition was the result of weather earlier in the winter. Snowfall usually can be recognized readily as a cause of avalanche hazard, but people sometimes fail to realize the significance of high temperatures and strong winds. Accidents have occurred when rapidly rising air temperature produced unstable snow before climbing parties could retreat to safety, or when a high air temperature during the night prevented the snow from cooling and gaining strength in the early morning hours.

Wind often made the difference between stable and unstable conditions. For this reason backcountry travellers must watch continuously for signs of drifting and evaluate all slopes with respect to the possibility of wind-deposited snow.

Action of People

The accident cases have demonstrated the importance of safety measures described in avalanche handbooks and pamphlets. Measures that have contributed significantly to survival include:

- wearing transceivers and carrying shovels,
- being mentally alert and prepared for an encounter with avalanches,
- fighting to remain at the surface when carried down by the avalanche,
- sticking a hand to the surface when the avalanche stops (this produces a vent for air and aids searchers,
- quick action by witnesses who often locate the buried persons from objects on the surface more quickly than by a transceiver search.

Unfortunately, old errors are too often repeated. Some are mentioned here as a reminder:

- cars stopping in avalanche paths,
- maintenance crews removing snow in avalanche paths and being hit by a second avalanche,
- skiers and hikers travelling alone, buried in an avalanche and found too late,
- parties crossing avalanche paths with insufficient spacing between individuals,
- transceivers not being worn,
- parties having an insufficient number of shovels,
- skipole straps on wrists and safety straps attached to boots,
- survivors panicking and leaving scene rather than making an immediate search.

Hazard to Mountain Climbers

Minor changes in weather - small snowfall, increase in wind speed, a shift in wind direction, sun - can trigger avalanches within a very short time on the steep and rugged terrain favoured by climbers. They can be caught off guard by such changes. Snow-filled gullies, preferred climbing and descent routes, are particularly hazardous because wind and sun have a stronger effect on the snow stability there than on ridges. Furthermore, gullies are channels for natural avalanches.

Hazard to Snowmobile Operators

Avalanche slopes are attractive for snowmobiling. Running a machine up a steep slope as far as its power allows, then making a quick turn, seems to be a popular activity. Unfortunately steep slopes are also likely avalanche paths, and the weight, bouncing and vibrations of the machine can trigger avalanches. Eight snowmobilers lost their lives in avalanches between 1973 and 1985. Snowmobilers usually go in groups, and lives could have been saved if all members had worn transceivers or at least had been equipped with probes and shovels and started probing and shovelling close to the last

sighting of a victim. In four of the eight cases a part of the snowmobile was visible at the surface and the operator was found within 5 m of the machine.

There appears to be a need to educate snowmobile operators to recognize hazardous terrain, to use safety equipment, and to take action when an accident occurs.

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Table I Fatal Accidents and Property Damage, 1969 - 1985

Year	No. of Fatal Accidents	Number of persons killed							Property Damage	
		In Buildings	On Roads	Near Ski Areas	Back Country Skiers	Mountain Climbers	Other Recreation	Total	Number of Cases	Estimated Value
										$
1969-70	1			1				1	1	520 000
1970-71	2					4		4	2	280 000
1971-72	8		6	5	1	4	2	18	4	700 000
1972-73	1						1	1	3	800 000
1973-74	4	7		1	2			10	3	900 000
1974-75	0							0	0	0
1975-76	3		3		1		1	5	1	20 000
1976-77	9			2	6	4	1	13	0	0
1977-78	3					5	1	6	0	0
1978-79	7			1	11	1	1	14	6	1 300 000
1979-80	3				1	2		3	1	150 000
1980-81	6				8	2		10	1	20 000
1981-82	8		1	1	2	7		11	2	10 000
1982-83	6			1	1	3	1	6	1	20 000
1983-84	3						4	4	1	200 000
1984-85	4				5		1	6	3	700 000
Total	68	7	10	12	38	32	13	112	29	5 620 000
Per cent		6	9	11	34	28	12	100		

Fatalities "near ski areas" are skiers who have left marked ski area boundaries and skied outside the maintained and controlled ski runs. Back country skiers include people who were cross-country skiing or ski mountaineering, or who had been taken to the top of a mountain by helicopter or snowcat. Mountain climbers are all those who climbed or hiked on foot, winter or summer. The category "other recreation" is the designation for operators of snowmobiles and people with toboggans and snowshoes.

Table II Fatal Accidents, 1953 - 1969

Number of reported accidents: 22		
Persons Killed	Number	Percent
In buildings	39	59
On roads and at worksites	5	8
At ski areas	5	8
Back-country skiing	9	13
Mountain climbing	8	12
Other recreational activities	0	0
Total for 16 years	66	100

Table III Number of Persons and Vehicles Involved in Avalanches

	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85	Average 6 years
Total incidents reported	28	24	45	33	35	35	33
Total number of persons involved	25	55	49	46	40	33	42
Caught but remained on surface	15	25	22	18	17	13	18
Partially buried, not injured	4	10	14	18	11	13	11
Partially buried, injured	0	4	3	0	6	0	2
Completely buried, rescued alive	3	6	9	4	2	2	4
Partially buried, dead	1	1	2	2	0	0	1
Completely buried, dead	2	9	9	4	4	6	6
Total number of vehicles on roads	10	2	11	4	8	8	7
Trapped	6	0	2	1	4	3	3
Partially buried	4	2	9	3	4	5	4

LIST OF ACCIDENTS

4 March 1910	Rogers Pass, B.C.	Railway workmen killed
16 February 1959	St. John's, Newfoundland	Persons in buildings killed
29 February 1978	Chelmsford, Ontario	Snowshoer killed
11 February 1978	Mica Creek, B.C.	Helicopter crash
20 August 1978	Moraine Lake, Alberta	Mountain climber killed
16 December 1978	Dennis Creek, B.C.	Skier killed
13 February 1979	Fernie, B.C.	Chairlift damaged
13 February 1979	Rogers Pass, B.C.	Bridge damaged
13 February 1979	Mica Creek, B.C.	Powerlines damaged
14 February 1979	Spillimacheen Range, B.C.	Skiers killed
20 February 1979	Whistler, B.C.	Skier killed
23 February 1979	Revelstoke, B.C.	Skier killed
24 February 1979	Kootenay National Park	Skiers killed
28 February 1979	Jasper National Park	Mountain climber killed
17 March 1979	Gold Bridge, B.C.	Snowmobile operator killed
15 March 1980	Revelstoke, B.C.	Skier killed
8 August 1980	Slesse Mountain, B.C.	Mountain climber killed
20 August 1980	Mount Athabasca, Alberta	Mountain climber killed
18 February 1981	Revelstoke, B.C.	Skier killed
21 February 1981	Yoho National Park	Skier killed
22 February 1981	Banff National Park	Skier killed
22 February 1981	Banff National Park	Skiers killed
6 March 1981	Lake Louise, Alberta	Skier buried
2 April 1981	Yoho National Park	Mountain climbers killed
8 April 1981	Golden, B.C.	Skier injured
29 June 1981	Mount Logan, Yukon	Mountain climbers buried
9 December 1981	Mount Washington, B.C.	Skier injured
12 January 1982	Terrace, B.C.	Workman killed
15 January 1982	Banff National Park	Skiers buried
18 January 1982	Purcell Mountains, B.C.	Skiers killed
5 February 1982	Banff National Park	Mountain climber killed
22 February 1982	Jasper National Park	Skier killed
11 June 1982	Mount Logan, Yukon	Mountain climbers killed
19 August 1982	Bugaboo, B.C.	Mountain climber killed
20 August 1982	Mount Robson, B.C.	Mountain climbers killed
22 August 1982	Jasper National Park	Mountain climber killed
November 1982	Lake Louise, Alberta	Mountain climber killed
27 November 1982	Mount Sheer, B.C.	Hiker killed
8 January 1983	Apex Mountain, B.C.	Skier killed
13 February 1983	Kananaskis Country, Alta.	Skier killed
14 February 1983	Squamish, B.C.	Workman buried
3 July 1983	Banff National Park	Mountain climber killed
18 September 1983	Jasper National Park	Mountain climber killed
26 December 1983	Hudson Bay Mountain, B.C.	Skier injured
7 January 1984	Golden, B.C.	Snowmobile operator killed
26 January 1984	Cassiar, B.C.	Tramway damaged
29 January 1984	Flathead Pass, B.C.	Snowmobile operator killed
11 February 1984	Redfern Lake, B.C.	Snowmobile operators killed
13 April 1984	Whistler, B.C.	Skier injured

ROGERS PASS, B.C. 4 MARCH 1910

Sixty-two workmen killed, one injured

LOCATION

The accident took place at the summit of Rogers Pass, B.C., elevation 1330 m. The main line of the Canadian Pacific Railway had been completed over the Pass in 1885 and it opened for regular traffic in the spring of 1886. Snowsheds were built in 1886 and 1887 as protection against avalanches, No. 17 at the summit being one of the longest. There was a second track in the open at the side of the shed, but it was used only in the summer.

A track diversion was later built in a cut 15 to 18 m east of snowshed No. 17 with the object of reducing the grade (Figure 1). Because no known avalanche had crossed the snowshed from the west since the line opened, and because the slope on the east side was covered with heavy timber, a snowshed was considered unnecessary for the new track. That through the snowshed was abandoned.

An avalanche disaster in 1910, other problems with snow and avalanches, steep grades, and a need to replace in the near future all the 25-year-old timber snowsheds led to the decision in 1912 to relocate the railway line in the new 8-km long Connaught Tunnel 160 m below the summit. When the tunnel was opened in 1916, the railway line over the summit was abandoned. Rogers Pass Summit came back to life with the construction of the Trans-Canada Highway between 1957 and 1962. Now a historical trail parallel to the highway marks the old railway snowshed No. 17. Artillery fire and earth mounds protect the road traffic from avalanches at this location.

WEATHER

About 220 cm of snow had fallen during the nine days prior to the accident. On 3 March heavy rain and warm weather had weakened the snowpack. It snowed heavily all 4 March and the storm increased to blizzard conditions in the early hours of 5 March.

ACCIDENT

At approximately 18:00 h on 4 March 1910 an avalanche from Cheops Mountain overran shed No. 17, blocking the diversion railway line. The old track through shed No. 17 was not usable. A 63-man crew started to dig through the avalanche in blizzard conditions but felt safe below the heavily timbered mountain on the east, knowing that no avalanche had occurred there before. It is not known whether lookouts were posted. By 23:30 hours the men had made a steep 7-m deep cut through the obstructing snow. On the track, back of the toiling gang, was a rotary snowplough hooked to a large steam locomotive. The snowplough had been withdrawn from the snowbank when its blades encountered uprooted trees and rocks, so that most of the work was done by shovelling.

A foreman had gone back to a watchman's shack to report on the progress of the work. When he returned he suddenly realized that the beam of light from the rotary plough and the lights from the lanterns had disappeared. After a few more steps he saw that another avalanche had come down and buried the work site. As he stood in the dark he heard a faint cry for help from above the broken timber of the snowshed on the parallel track, where he found the only survivor of the avalanche, a fireman from the rotary plough's locomotive.

The fireman had been in the gangway of his engine when the avalanche struck, but the force of the snow in motion sucked him out through the window and threw him 30 m to the top of the snowshed. When the avalanche stopped only his hands were visible in the snow. He was able to dig himself out, but realized that with severe internal injuries, a badly fractured leg, and his light clothing drenched he would not survive without help. Luckily he was found by the foreman who gave him his coat. The foreman, unable to carry the injured man in the deep snow, walked one mile for help. He sent back two men to cover the fireman with blankets but the fireman protested: "Two slides have come down now, and I have been in one of them. If a third one comes I don't want to be rolled up in a blanket, so pull me out of here!" He was dragged to a sleeping car and left alone until daylight. Only then was he moved 3 km to Glacier where a doctor set his shoulder. As he was being evacuated to Revelstoke a telegraph message preceded him stating that he was the only survivor and was not expected to reach Revelstoke alive. All along the line at each sectionhouse, people came to see whether he was still alive. The lone survivor of Canada's worst avalanche disaster lived until 1973.

When the foreman's message reached the railroad division town of Revelstoke, 70 km to the west, the midnight ringing of the town's fire bell was a first call for full civic action. Two hundred inhabitants, including doctors and nurses, were dispatched on a relief train. No train could reach the Rogers Pass Summit from the east because another avalanche had blocked the line, but that from Revelstoke arrived at the scene of the accident by daylight. The snow was up to 10 m deep where the ill-fated crew was buried (Figure 2). Again, it was a matter of slow shovelling, for the deposit was hard-packed, like ice (Figure 3). Most of the victims were found in the trench, upright, in natural positions. Escape must have been impossible owing to the depth and nature of the cut. Four bodies were not found until May, victims carried away from the tender of the locomotive where they had been shovelling snow into the tank. The 150-ton locomotive had flipped on its side and the rotary, weighing almost 100 tons, was lifted right out of the cut and thrown on top of the shed.

AVALANCHE

The first avalanche on the afternoon of 4 March ran from the top of Cheops Mountain west of Rogers Pass from an elevation of about 2400 m, falling 1100 m over a distance of 2600 m. The second, fatal avalanche originated east of the monument marking the summit of Rogers Pass, in a cirque just north of Avalanche Crest. The starting zone elevation and travel distance were roughly the same as for the Cheops avalanche. The

deposit covered all of shed No. 17 with over 2 m of avalanche snow; 80 m of the shed was destroyed.

Source: Information compiled by Paul Anhorn from newspaper reports and documentation in the archives of Parks Canada at the Rogers Pass Centre, Revelstoke, B.C.

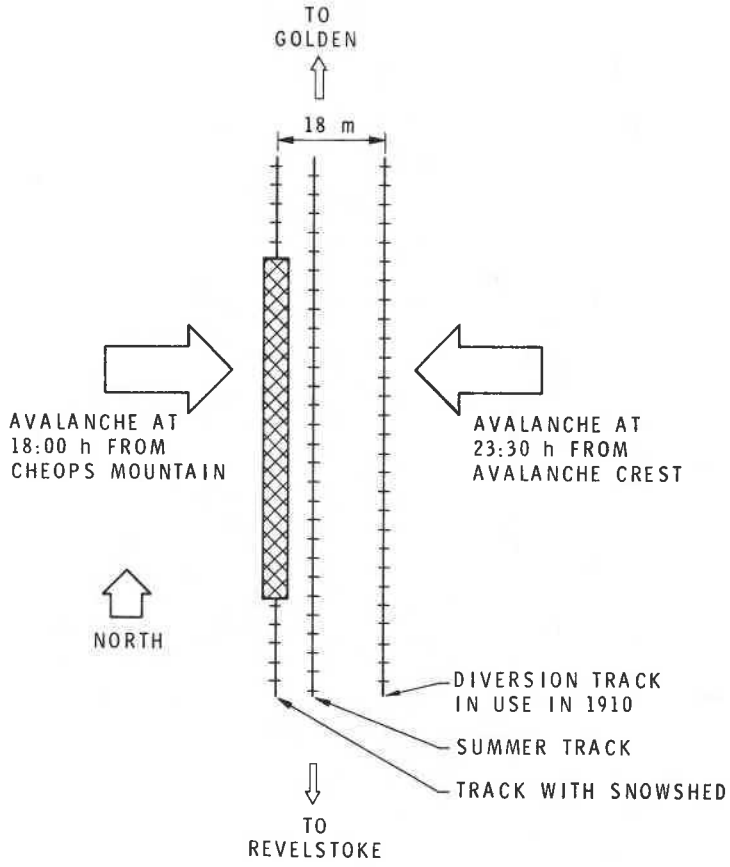

FIGURE 1
SKETCH MAP OF RAILWAY TRACKS, ROGERS PASS, 1910

FIGURE 2

SNOW CUT FILLED BY AVALANCHE OF 4 MARCH 1910
(PHOTO CREDIT: PROVINCIAL ARCHIVES OF BRITISH COLUMBIA,
CATALOGUE NO. 59131)

BR 6786-2

FIGURE 3

REMOVAL OF AVALANCHE SNOW BY SHOVELLING AND ROTARY PLOUGH AT ROGERS PASS (PHOTO CREDIT: ARCHIVES OF THE CANADIAN ROCKIES, BANFF, ALBERTA, CATALOGUE NO. NA 71-1658)

BR 6786-3

ST. JOHN'S, NEWFOUNDLAND 16 FEBRUARY 1959

Five residents killed, nine injured

WEATHER

One of the worst snowstorms Newfoundland ever experienced started at 17:00 h on 15 February 1959, raging all night and the following morning. At the weather station in St. John's 82 cm of new snow and temperatures around -10°C were recorded. Winds up to 225 km/h created drifts 6 m deep. Winds did not abate until about 11:00 h on 16 February.

ACCIDENT SUMMARY

Two avalanches descended in rapid succession on the tiny fishing village of Outer Battery, overlooking the narrows in St. John's East. Shortly after midnight the first avalanche trapped 11 people in a bungalow when it slid over the roof into the sea below. At 01:05 h another large avalanche knocked two dwellings from their foundations, slamming them into others and causing death and thousands of dollars worth of damage. One house was completely destroyed. The other, a two-storey structure, was lifted from its foundations although the avalanche ripped off only the top storey. On the day after the avalanche the kitchen on the main floor looked just as it always had except that it was roofless.

RESCUE

The noise of the avalanche alerted neighbours who were able to rescue four victims from the demolished house and three children catapulted from the roofless one. One little girl was thrown 60 m as the roof was torn off and landed on the doorstep of a rescuer's house. Two hours after the avalanche occurred rescuers found a girl, still conscious, under the wreckage with a hot stove across her leg, which was badly burned. At 03:30 h the storm peaked. Visibility was nil and for safety reasons the rescue attempt had to be suspended. Four hours later the rescuers made another attempt to defy the weather and look for survivors. Their efforts bore fruit when they heard a voice calling from beneath the rubble. At 13:00 h, 12 h after the avalanche had struck, the victim was freed. Moments later a body was discovered beneath the roof, under a mattress. Only 3 m further a couple was removed from the debris. They had all been crushed by the building and the huge amount of snow. The last missing person was found dead at 13:45 h.

COMMENTS

Avalanches powerful enough to destroy houses are possible wherever large amounts of snow fall on steep slopes. This may be expected even in Eastern Canada where strong winds can create dangerous drifts and cornices near the tops of hills.

The accident in St. John's demonstrates yet again that people buried but protected by structures have a greater chance of survival than people

buried in snow. Thanks to the spirited efforts of rescuers who worked in -20°C temperatures one life was saved many hours after the accident.

Source: Information compiled from newspaper reports by Paul Anhorn, Rogers Pass Field Station, Revelstoke, B.C.

CHELMSFORD, ONTARIO 29 JANUARY 1978

One snowshoer killed

A Sudbury man died when he was buried while snowshoeing with a friend in a gravel pit. He slid down a 30-m embankment and snow from above fell on top of him. The other person was not hurt.

Source: The Province, Vancouver, B.C., 31 January 1978, p. 5.

MICA CREEK, B.C. 11 FEBRUARY 1978

Helicopter crash with fatalities and injuries

ACCIDENT SUMMARY

The accident site was 40 km southwest of Mica Creek in the Monashee Mountain Range. At 09:30 h a helicopter carrying the pilot, a mountain guide, and twelve skiers approached the landing site at the top of a ski run. Two successful landings had been made there earlier in the day. Just before reaching the site the machine made a radical 180-deg left turn to approach down the south-facing slope with one skid on the snow. After 25 m the skid with the skibasket attached to it hit a rock, the helicopter broke apart, and the passengers were thrown out over a distance of at least 100 m. The snow, weak from solar radiation, released an avalanche when the helicopter hit, burying the skiers.

RESCUE

Most people were only partially buried, though many were injured. One passenger, an airline pilot from Germany, was completely buried but was able to free himself. Unhurt and well trained for emergency situations he started a search with his avalanche rescue transceiver. After all passengers had been located and dug out, he took a portable radio from the guide and hiked up the mountain to call for help because radio transmission was impossible at the lower altitude where the accident happened. He climbed for almost 2 h to reach the original landing site where radio contact could be established with a helicopter in Valemount, 120 km away. This helicopter, via its base, contacted Mica Creek, where a second helicopter was about to be dispatched.

AVALANCHE

A soft slab avalanche of size 2.5 started at elevation 2500 m. At the 0.1 to 0.2-m deep fracture line the slope incline was 45 deg, decreasing to 30 deg in the run-out zone. The avalanche dropped 300 m in elevation.

COMMENTS

Although the crash of the helicopter was the initial cause of death, injury and property damage, the accident is reported because the falling craft released an avalanche that mitigated the damage. Four people, including the pilot and the guide, died from injuries sustained in the crash, but the ensuing avalanche cushioned the impact and probably saved the other passengers' lives when the helicopter split apart. In addition, the snowdust from the avalanche prevented ignition of fuel spilled all the way down the mountainside.

Source: Sepp Renner, Canmore, Alberta.

MORAINE LAKE, ALBERTA 20 AUGUST 1978

One mountain climber killed

Two mountaineers started down the 3 - 3½ Couloir, a steep 600-m high ice chute, from the Graham Cooper bivouac hut at noon. One descended cautiously near the rocks on the side of the gully, but the other cramponed down the middle on shallow snow. When he was only a few hundred feet down, a small wet snow slide swept him several hundred feet out on the rocks below. He suffered multiple injuries and died while being evacuated by the Lake Louise Warden Rescue team.

The accident occurred under warm temperature and rain conditions following wet snow. At such times this type of gully route should be avoided.

Source: Accidents in North American Mountaineering, Vol. 4, No. 3, Issue 33, 1980 (published by Alpine Club of Canada).

DENNIS CREEK, B.C. 16 DECEMBER 1978

One skier killed

WEATHER AND SNOW CONDITIONS

The accident site was at the southern edge of a storm that deposited 93 cm of snow at Fidelity Mountain (100 km north, elevation 1900 m) between 14 and 16 December. Five cm of new snow was measured at New Denver 10 km south of the accident site on 14 December.

LOCATION

Dennis Creek, a tributary of Slocan Lake, is north of New Denver, B.C., on the west side of the Selkirk Mountains, which are known for high precipitation and relatively high winter temperatures.

ACCIDENT SUMMARY

A party of eight skiers, including two local guides, had climbed by ski from a logging road to the top of a 2200-m high mountain at the headwaters of Dennis Creek. Two inexperienced skiers were the first to descend in the untracked snow, and after the second entered the concave slope an avalanche released above them and carried them out of sight of the others.

RESCUE

When the avalanche stopped, a search with rescue transceivers located both casualties quickly (Figure 4). The upper skier was buried completely, lying on her back, but she was able to create an air space in front of her face and finally to push out a hand. She suffered six broken ribs, spleen damage, and mild exposure. The other skier collided with a tree. Her head was under 1.5 m of packed avalanche snow but a ski boot was exposed, hooked into the tree. Cardio-pulmonary resuscitation was administered immediately, but to no avail. Death was due to a broken neck and suffocation.

Meanwhile, two party members had skied to the valley for help. They were delayed when they could not start their vehicle on the road, but fortunately a logging crew gave them a ride to town. The local police were not aware of the Provincial Emergency Programme and refused to order a helicopter, but the skiers contacted a helicopter operator in Nelson, 60 km to the south. The pilot was familiar with Dennis Creek and was able to fly up in the dark and evacuate everyone by 19:00 h, 5 1/2 h after the avalanche had occurred.

AVALANCHE

The avalanche was caused by poor bonding between old layers of snow and triggered by the weight of the skiers. The initial slope failure was 20 to 30 cm above a thick ice layer, and the secondary failure occurred on the ice layer itself (Figure 5). The depth of the slab avalanche varied from 0.1 m to 1.0 m. It had a width of 40 m. The avalanche started at an elevation of

2150 m and the path had a length of 700 m, an average incline of 33 deg, and aspect west.

COMMENT

The condition of the injured person had deteriorated considerably, but a good knowledge of first aid, enough manpower and a determined effort by the pilot to fly the party out in the dark probably saved her from further distress.

Source: John Tweedy, Rossland, B.C.

FIGURE 4

AVALANCHE PATH AT DENNIS CREEK SHOWING SKI TRACK AT LEFT AND AVALANCHE FRACTURE LINES AT RIGHT
⊗ LOCATION OF INJURED SKIER
⊕ LOCATION OF FATALITY

BR 6786-4

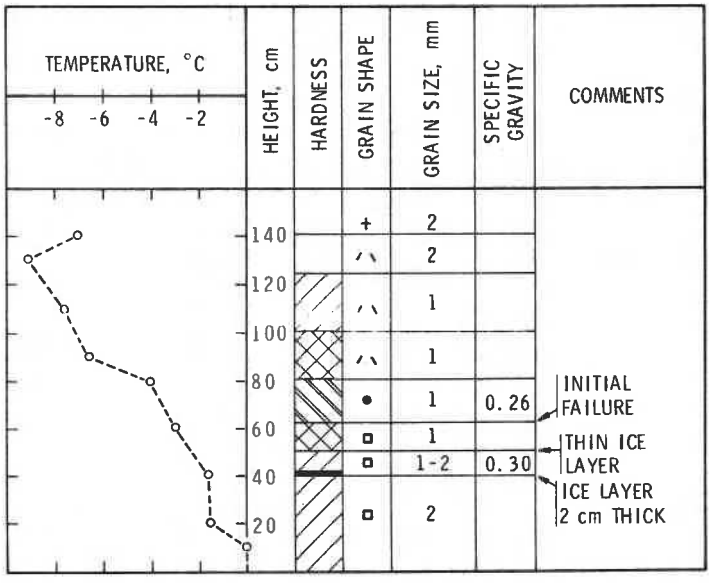

FIGURE 5

SNOW PROFILE AT FRACTURE LINE, DENNIS CREEK, OBSERVED 19 DECEMBER 1978

FERNIE, B.C. 13 FEBRUARY 1979

Chairlift damaged

SUMMARY

On 13 February 1979 between 02:00 and 04:00 h an avalanche destroyed towers 12 and 13 of the half-year-old Griz chairlift at Snow Valley Ski Area in Fernie, B.C. The avalanche ran in the Dancer path of Lizard Bowl, a part of the ski area. The avalanche was larger than usual and advanced to the lower part of the bowl and the chairlift built at the edge of previous large avalanches. The cost of repairing the damage, including replacing towers, was $80 000.

WEATHER

Daily snow and weather observations are made in the Fernie Ski Area at elevation 1650 m, about 900 m horizontal distance from the starting zone of the damaging avalanche now reported. The snow profile on 31 January 1979 contained a layer of depth hoar of low strength in the lowest 25 cm of the snow pack, with 100 cm of medium hard to hard snow on top of it.

Date	Time	Temperature Max °C	Temperature Min °C	New Snow cm	Storm Snow cm	Snow Depth cm	Wind
6 Feb	15:50	-5.5	-7	4	4	138	N light
7 Feb	10:10	-3	-11	20	24	158	NW mod
	15:45	-4.5	-7	T	21 cl	155	calm
8 Feb	08:10	-5	-12	T	T	153	calm
	15:50	-7.5	-10.5	6	6	159	calm
9 Feb	08:00	-2.5	-8	6	11	163	calm
	16:30	-1	-3	11	20	172	calm
10 Feb	07:50	0	-3	15	32	183	calm
	16:00	-1.5	-4	20	51	196	calm
11 Feb	09:30	-2	-4	24	69 cl	212	NE light
	15:00	-2.5	-4	T	T	211	calm
12 Feb	08:20	-1	-3	15	15	221	calm
	16:00	-1.5	-2	13	27	231	calm
13 Feb	13:40	0	-2	33	59	255	N light

On 13 February rainfall occurred below elevation 1500 m

AVALANCHE ACTIVITY IN LIZARD BOWL

7 Feb Three natural avalanches, size 2 and 3, during night.

Three avalanches, size 3, released by avalauncher at 08:30 h, including one avalanche at Dancer.

10 Feb One natural avalanche, size 3, during night.

11 Feb Six natural avalanches, size 3, during night and early morning, including Dancer.

Three avalanches, size 3, released by avalauncher.

13 Feb Seven natural avalanches, size 3 and 4, during night.

AVALANCHE

The head wall of Lizard Bowl has an incline of 48 deg and during snowstorms avalanches frequently run in several paths. They usually stop on the talus slope, 26-deg incline. The Dancer avalanche on 13 February 1979 started at elevation 1980 m, and after sliding over the head wall it set in motion deep unstable snow on the talus slope at 1780 m. It contained new snow deposited between 6 and 13 February, old snow from early winter snowfalls, and probably snow from previous small avalanches.

The avalanche was 200 m wide and ran a distance of 1600 m on an average incline of 18 deg. From observations of the deposited snow it was concluded that it contained powder snow, dry flowing snow, and a wet flowing component originating in wet snow on the lower reach. Snow packed against tree trunks and broken trees indicated that the dry flowing part of the avalanche was 8 to 14 m deep.

The dry flowing snow damaged the chairlift when it reached towers 12 and 13 at an estimated speed of 75 km/h. The deposited dry snow was between 1 and 3 m deep and had a specific gravity of 0.34. The avalanche was classified as size 4, with an estimated mass of 30 000 tonnes.

COUNTERMEASURES

The following measures were introduced after the accident to ensure the safety of the lift passengers and minimize future structural damage.

- The avalanche paths in the Lizard Bowl will be controlled regularly by firing an avalauncher.
- The avalanche hazard analyst for the ski area must give permission to operate the lift and may close it when the hazard demands.
- Lift towers 12 and 13 were reinforced against avalanche impact pressures by encasing the steel structures in concrete.
- Earth works designed to deflect the dense flow of avalanche snow were built at towers 11, 12 and 13.
- A rock-filled timber crib intended to act as a deflector for avalanches was placed in front of towers 10 and 11.
- The avalanche channel at the elevation of tower 13 was deepened by approximately 3 m using a bulldozer.

COMMENTS

Forest growth and calculation of the run-out distances of maximum avalanches indicated that avalanches had reached the lift location previously. The estimated tips of avalanches for given return intervals are shown on Figure 6. The avalanche on 13 February 1979 corresponds to one

that can be expected to occur, on average, once every 50 years, although it happened to strike during the lift's first year of operation. On the same day a large avalanche broke into a forest with 100-year and older trees in the adjacent Currie Bowl.

Sometimes there is no choice but to build chairlifts through avalanche paths, but when this is necessary the risk must be assessed by estimating the frequency of avalanches, the associated structural damage, and the financial loss from the interruption of services. The towers should either be designed to withstand the expected avalanches or be protected with deflector dams or walls; the safety of the passengers must be ensured by closing the lift during hazardous periods. Duration of closures can be minimized significantly when the avalanches are controlled by explosives. All these measures are now in effect at the Fernie Ski Area.

Source: Staff of Fernie Snow Valley Ski Ltd., Fernie, B.C.

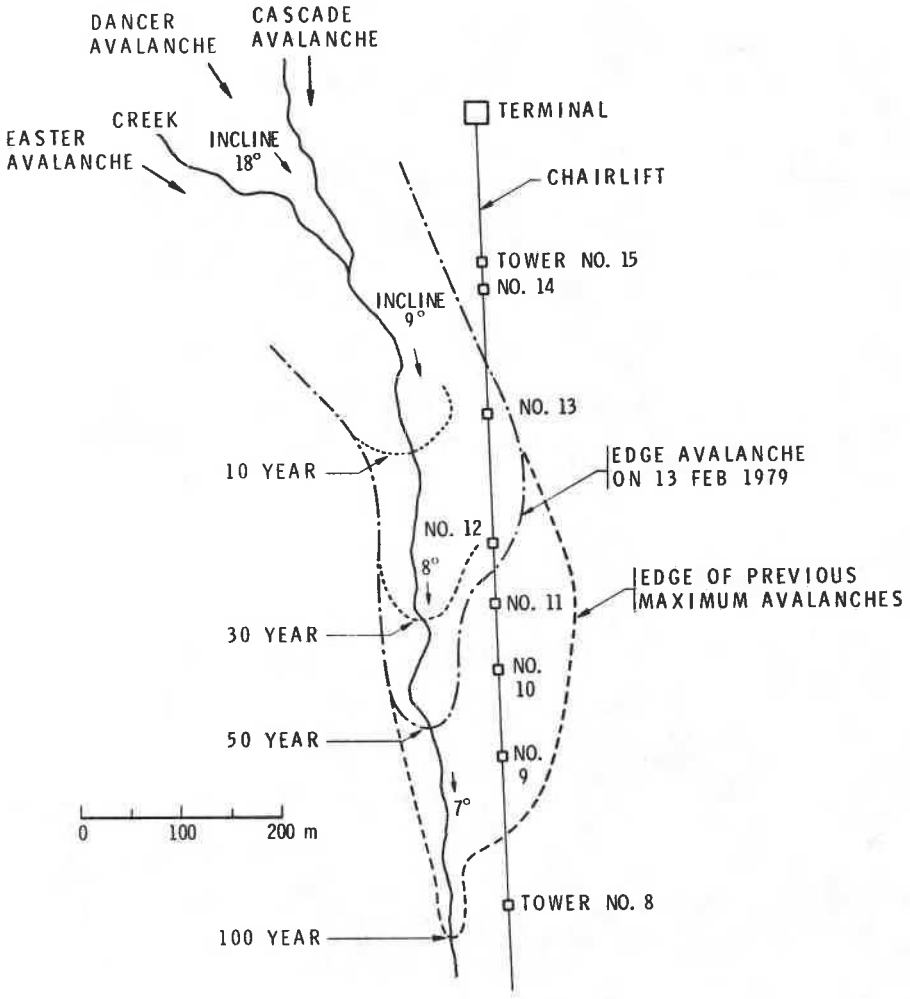

FIGURE 6

RUNOUT ZONE OF AVALANCHES AT FERNIE WITH ESTIMATED REACH OF AVALANCHES FOR GIVEN RETURN INTERVALS

ROGERS PASS, B.C. 13 FEBRUARY 1979

Railway bridge damaged

WEATHER AND SNOW CONDITIONS

Observations at Fidelity Mountain, elevation 1875 m, 10 km west of accident site.

Date 1979	Temperature Max °C	Min °C	New Snow cm	Water Equivalent New Snow mm	Storm Snow cm	Snow Depth cm
5 Feb	-6.5	-12.5	29	21	37	249
6 Feb	-6.5	-11	7	4	39	252
7 Feb	-7	-10.5	31	21	61 cl	271
8 Feb	-8.5	-11.5	1	1	1	259
9 Feb	-5	-11	41	29	40	292
10 Feb	-4	-6.5	21	17	39 cl	290
11 Feb	-4	-6.5	12	7.5	12	291
12 Feb	-5	-8	17	15.5	24	297
13 Feb	-2.5	-7.5	27	23	45	312

SUMMARY

On 13 February 1979 extensive avalanche control, firing of a 105-mm howitzer, was carried out for the highway and railway at Rogers Pass. Unusually large and violent avalanches were released either by the artillery fire or they occurred naturally. At 15:30 h, following artillery fire at the Cougar Creek East target, an avalanche was released and ran the full length of its path. The railway bridge located at the edge of the usual run-out zone was lifted off its foundation, pushed 25 m to the side, and came to rest undamaged on the snow.

The bridge consisted of two single-span through-plate steel girders 33 m long and 2.95 m high, with vertical clearance of 2.4 m above the river. The total mass of the bridge was roughly 150 tonnes.

During the next three days railway maintenance crews lifted the bridge back into place using heavy cranes brought to the site by rail and over a quickly-built access road from the highway. The railway line was closed for 101 h as a result of the work and delays caused by other avalanches that blocked the railway and the highway on the east side of Rogers Pass. The cost of moving the bridge back into place was estimated at $200 000, but the interruption of traffic on the important rail link had significant additional financial consequences.

AVALANCHE DATA

The Cougar Creek East avalanche track is an open slope 250 m wide, with an average incline of 29 deg and north aspect. The track, steep at the bottom, breaks abruptly into the level run-out zone at an elevation of 1100 m. Avalanches occur five to ten times a year and usually stop within 100 m of the run-out zone. The railway line is 190 m from the beginning of the run-out zone. The 1979 avalanche ran a distance of 310 m.

The avalanche on 13 February 1979 started at elevation 1820 m on a slope of 39 deg and north aspect. The deposit was dry snow without contamination, on the average 1.6 m deep. The measured mass of the deposited avalanche snow was 16 300 tonnes. Damage to trees, observations of depth, nature and density of the deposit, and the run-out distance lead to the conclusion that the moving avalanche had a dry flowing component 4 m deep with a density $G = 50\ kg/m^3$, and at the bridge a speed $V = 105\ km/h$. It impinged on the bridge at an angle close to 90 deg. These data suggest an impact pressure $p = G \cdot V^2 = 43\ kPa$ or 4140 kN over the total surface of a girder. The strongly turbulent avalanche probably produced uplift forces that reduced the friction on the bearings and allowed the bridge to be pushed to the side.

COMMENT

This case demonstrates that artillery fire must not be relied on for the protection of structures. It is not always possible to release avalanches at the optimum time, when they are small and will run out in front of the object. Occasionally the firing produces large, destructive avalanches. A study of protective measures, carried out later, has concluded that earthworks could be built to deflect flowing avalanches and reduce the impact and buoyancy forces to a safe level. The earthworks, however, would have to be unacceptably large. Other options would be to change the course of the river and place the bridge outside the avalanche path or reinforce the bridge.

Source: Information compiled by Peter Schaerer.

MICA CREEK, B.C. 13 FEBRUARY 1979

Powerline damaged

The snow and weather conditions on 13 February 1979 produced destructive avalanches in many areas. A large avalanche crossing the Revelstoke - Mica Creek highway at avalanche path No. 70.5 broke a tower of the 500-kV transmission line. The falling tower, in turn, pulled down six others of the same line, was pushed to the second parallel circuit and damaged a tower there. The estimated damage to structures and lines was $500 000.

The tower that initiated the chain reaction was built in the centre of an avalanche path where avalanches probably reach the line about once in 20 to 30 years. The starting zone at elevation 1600 m is 1000 m above the valley and the avalanches run over a well-defined 30-m-wide track. The destroyed tower was replaced immediately with a new one at the side of the avalanche path. In addition, the new tower and others in the area were protected by earth deflectors 5 to 8 m high.

SPILLIMACHEEN RANGE, NEAR GOLDEN B.C. 14 FEBRUARY 1979

Seven skiers killed

WEATHER

In February of 1979 the stability of the snowpack in southern British Columbia was poor. Below-average snowfall in December and January coupled with low temperatures resulted in layers of both depth and surface hoar. Between 5 and 13 February a series of storms deposited new snow on top of the weak layers.

The weather responsible for the avalanche that damaged the bridge at Rogers Pass on 13 February (page 27) is indicative of the conditions in the Spillimacheen Range 50 km to the southeast. On 13 February wind from the southwest with an average speed of 61 km/h was observed at the McDonald Shoulder at Rogers Pass. By 14 February the weather had cleared, the temperature had dropped to -17°C and the wind had shifted to light from the northeast.

ACCIDENT SUMMARY

Two guides with eight clients were on a helicopter ski week in the Purcell Mountains south of Golden, B.C. On 14 February 1979, after having been grounded for three days by the storm, the guides selected five runs on gentle terrain with south and west aspects. The last run of the day was on "Railroad" in the Spillimacheen Range. This run, having an easterly aspect, was chosen because it was above the fuel cache where the helicopter pilot could refill before the flight back to Golden. At 16:00 h the head guide led the group from the landing at elevation 2600 m down a gentle slope with a small ridge where the strong westerly wind of the previous day had scoured the snow and left patches of exposed ground. The same slope had been skied earlier in the winter.

About 300 m down the slope the guide stopped on a gentler part of the terrain, re-assembled the group, then continued his descent. When he had covered another 100 to 200 m he heard a sound like an explosion and felt the snow moving under his skis. Looking over his shoulder he could see the majority of his clients still standing close together and a large avalanche developing above them. The guide tried to ski out of the path of the avalanche, but within a few seconds he was engulfed. The turbulent motion of the avalanche pulled him down and threw him back to the surface several times. He lost consciousness momentarily, but when the avalanche stopped he luckily found himself on the surface.

RESCUE

The guide had lost his skis and pack in the avalanche but had kept his portable two-way radio and rescue transceiver inside his jacket. He could see neither people nor equipment on the large avalanche deposit when he called his helicopter pilot who in turn alerted another helicopter ski company 17 km to the south. By the time the helicopter could reach the disaster site the lone guide had located one buried skier with his rescue

transceiver and started to dig by hand. The helicopter supplied shovels and probes, and 15 min after the avalanche had occurred the skier was freed from about 1 m of snow. He was unconscious and blue but recovered quickly after resuscitation. Meanwhile, higher up on the slope another skier was able to free himself, shaken but unharmed. The three were the only survivors.

At 16:25 h the first of the seven fatalities was freed from 1.6 m of avalanche snow after being located by transceiver. Within the next 20 min additional rescue teams consisting of mountain guides and doctors from another heliski group had arrived and were busy locating, digging out and trying to resuscitate victims. All victims were located by transceiver by 17:10 h, but it was 20:00 h before the last one was dug out. Ten men with large shovels struggled to free him from 4.5 m of hard snow. Six of the bodies were immediately flown to Golden; the seventh was flown out the next morning because the helicopter could not return safely in the dark. All victims had died of suffocation.

AVALANCHE DATA

The avalanche started at an elevation of 2560 m on a slope of 30 deg, aspect east. The crown, spreading across the full width of a cirque, had a total width of 1400 m and a depth between 0.6 and 3.7 m (Figure 7). The failure occurred in a thin layer of surface hoar between hard and very hard windpacked snow at the crown (Figure 8) and probably in soft old snow lower down the slope (Figure 9). The avalanche could have been triggered by either the guide when he skiid ahead or the combined weight of the skiers waiting in a group.

The avalanche ran a distance of about 900 m over an average incline of 18 deg. The dry snow deposit had a width of 800 m and a maximum depth of 8 m.

COMMENTS

The snow and weather conditions leading to the avalanche provided classic ingredients for a large event: a weak base produced by earlier cold weather, deep new snow, strong wind, and high temperatures. Snow stability was extremely poor on 13 February and the deep instability was lingering on 14 February despite the end of the snowstorm, falling temperature, and a shift in the wind. In numerous other incidents medium-to-hard snow slabs over weak layers typically represented in Figure 9 have been observed to spread failures over wide areas and to fracture above skiing parties.

The guide had realized the instability of the snow but not its seriousness. He chose a route in terrain where he did not expect the group to trigger an avalanche or at least where avalanches would be harmless. Unfortunately the failure of the snowpack spread over an unexpectedly wide area and the avalanche that fractured above the group was unusually large for skier-released avalanches. The wide fracture, the cirque-shaped terrain, and the deep snow in motion made escape nearly impossible.

It is noteworthy that those buried close to the surface, including the guide, had lost their skis. The skis of the other victims had released but

were held by safety straps; this might have contributed to the deep burial. Safety straps are not now recommended for skiing in potential avalanche terrain.

Source: Information collected by Paul Anhorn, Rogers Pass Field Station, Revelstoke, B.C., and by Peter Schaerer.

FIGURE 7

CROWN OF AVALANCHE AT SPILLIMACHEEN RANGE, LOOKING SOUTH
(PHOTO NRC)

BR 6786-7

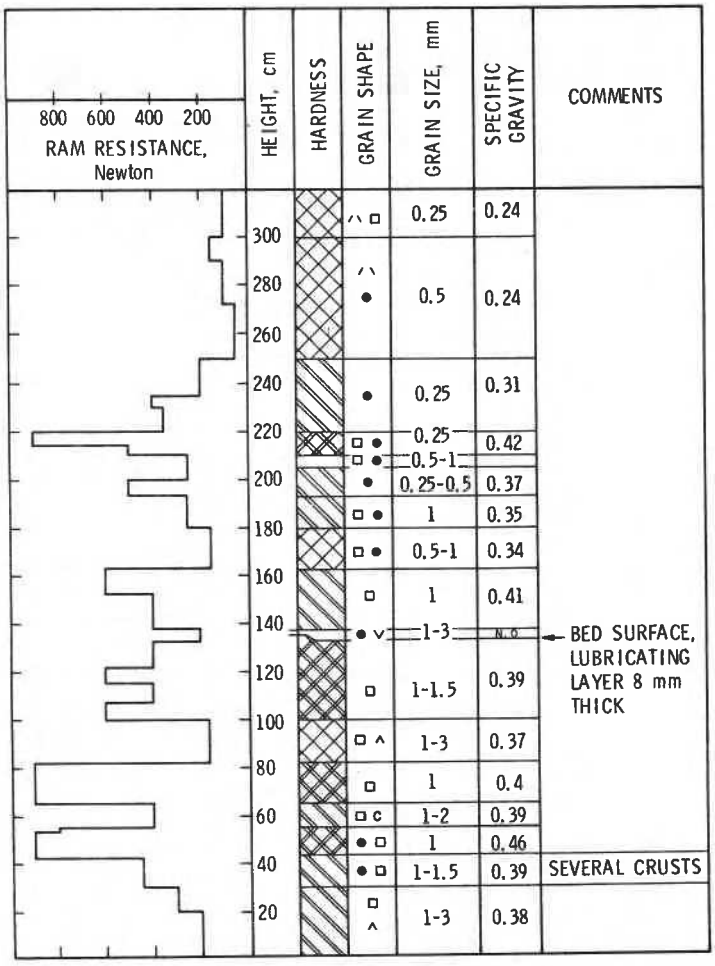

FIGURE 8

SNOW PROFILE AT FRACTURE LINE, SPILLIMACHEEN RANGE (ELEVATION 2560 m), OBSERVED 15 FEBRUARY 1979

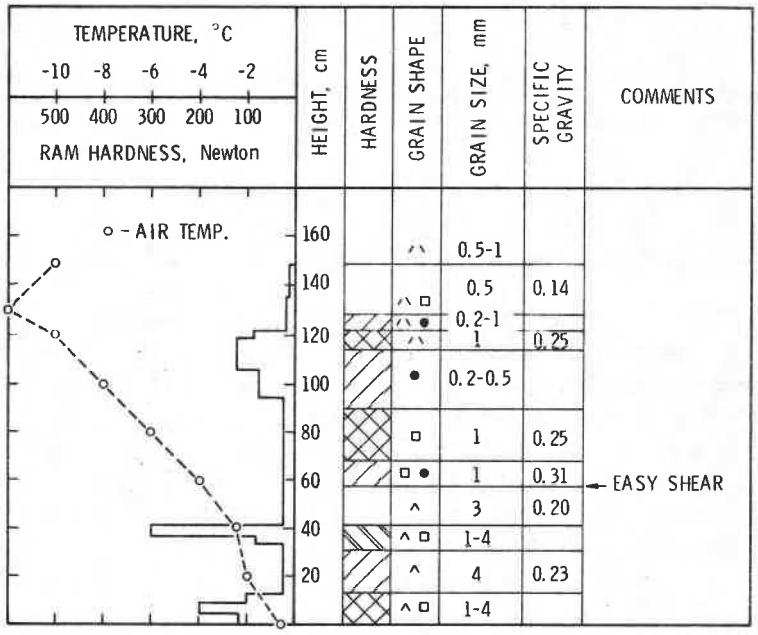

FIGURE 9

SNOW PROFILE IN RUNOUT ZONE OF AVALANCHE, SPILLIMACHEEN RANGE (ELEVATION 2350 m), OBSERVED 17 FEBRUARY 1979

WHISTLER MOUNTAIN, B.C. 20 FEBRUARY 1979

One skier killed

WEATHER

Observations at Blue Chair Study Plot, Elevation 1585 m
(wind at elevation 1910 m)

Date	Time	Temperature Max °C	Temperature Min °C	New Snow cm	Storm Snow cm	Snow Depth cm	Wind km/h
15 Feb	09:00	-8	-15	1	1	155	SE10-20
	14:00	-5.5	-8.5	2	3	152	SE 5-20
16 Feb	09:00	-6	-8.5	8	10	153	SE 5-15
	14:00	-1	-6	2	8	153	SE10-20
17 Feb	09:00	-5	-9	10	18	160	SE20-40
	14:00	-4	-6	27	40	185	SE20-40
18 Feb	09:00	-2.5	-8	19	54 cl	187	S 10-15
	14:00	-4.5	-8	0	0	184	SE 0-5
19 Feb	09:00	-4	-9	12	12 cl	187	SE 0-10
	14:00	-5.5	-6.5	1	1	186	SW 0-15
20 Feb	09:00	-5.5	-12	3	3	182	Calm
	14:00	-6	-7	0	0	180	N 0-5

The winter of 1978-79 was unusual for the South Coast Mountains. Below normal snowfall combined with low temperatures during the months of November, December and January led to the formation of an unstable base of depth hoar throughout the Whistler alpine region. From 13 to 15 February explosives released large avalanches at most controlled sites, and several large avalanches occurred naturally in the surrounding area. Fractures propagated over wide areas, often releasing avalanches simultaneously on several slopes.

ACCIDENT SUMMARY

At approximately 11:30 h on 20 February two skiers parted after descending the ridge between the Back Bowl and Burnstew Basin beyond the Whistler ski area boundary. One man skied back to the Blue Chair and the other continued towards the Burnstew Basin exit traverse. At approximately 12:00 h several skiers on the ridge observed a large dust cloud from an avalanche in Burnstew Basin. They did not report the avalanche, although one party skied into the Basin and traversed the deposit.

At 20:30 h family members reported a missing person at the ski area. It was established that the missing skier had failed to make a work-related

telephone call scheduled for that day and that he had been skiing on the ridge and separated from his companion. The ski area staff initiated a night search.

RESCUE

Between 21:15 and 22:15 h a search of lounges in the valley was carried out. At 22:30 h rescue teams were assembled at the gondola base. Three teams were despatched at 23:15 h from the mid-Whistler area. One party travelled by snowcat down to Fitzsimmons Creek, and the other two went up to begin a search near the point where the missing skier was last seen. At 00:30 h one of the search parties found an extensive avalanche fracture line in the area, and at 02:15 h ski tracks leading into the fracture line. The avalanche was very large, had removed snow to the ground, and broken trees in the run-out zone.

Because it was known that the missing skier was carrying a rescue beacon, a search below the point of entry was made but no clues were found. The search was suspended at 04:00 h until daylight owing to hazards to the rescuers. At 07:30 h the rescue teams were reorganized, with the inclusion of three avalanche dogs. It was decided that the site should be searched by helicopter and protective avalanche control carried out as necessary.

From the air the fracture line could be seen extending approximately 1200 m over the full width of the ridge above Burnstew Basin. Several pockets of snow hazardous to the rescuers were identified (Figure 10). Helicopter bombing initiated at 10:00 h released several size 2 avalanches and one size 3 avalanche. At 11:00 h the searchers and three dogs began a grid search of the avalanche deposit.

At 12:50 h a dogmaster picked up a faint transceiver signal at the northern edge of the deposit in gladed timber, then a rescuer located the victim, his head 1 m below the surface and one boot protruding. The victim was evacuated by helicopter at 15:00 h after his death was confirmed. Later it was determined that he had died of suffocation. The operations were concluded by 17:30 h.

AVALANCHE

The failure plane in the snowpack was at a crust of faceted snow grains (Figure 11), but once in motion the avalanche removed snow to ground level. The avalanche started at an elevation of 1855 m and fractured over a 1200-m width on an east-facing slope. The crown face depth varied from 0.5 to 1.2 m on a slope with an average incline of 39 deg. The avalanche ran 350 m and deposited small blocks of snow to a depth of 2 to 4 m. It caused minor damage to the forest.

COMMENT

The victim was caught only 20 m from the northern limit of the avalanche after traversing almost 200 m across the slope from his point of entry. The avalanche may have been triggered by the victim himself or by a larger group of skiers on the ridge above.

Warnings of extreme avalanche hazard to backcountry skiers were posted, but the victim chose not to heed them and skied alone in a known avalanche path. The rescue beacon he carried served little purpose except to assist in finding his body. The victim had attended an avalanche training course the year before the accident.

Source: Chris Stethem, Whistler, B.C.

FIGURE 10

STARTING ZONE AT BURNSTEW BASIN AT POINT OF ENTRY OF VICTIM
(PHOTO COURTESY CHRIS STETHEM)

BR 6786-10

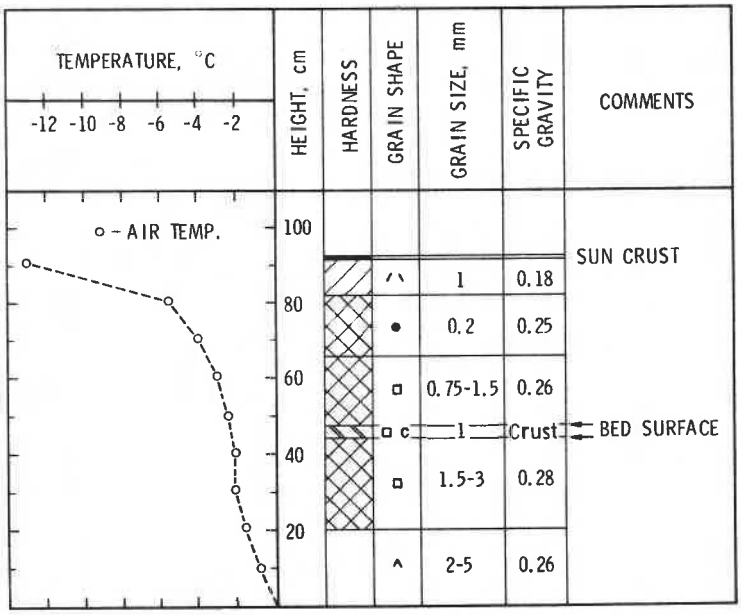

FIGURE 11

SNOW PROFILE AT FRACTURE LINE, BURNSTEW BASIN, OBSERVED 21 FEBRUARY 1979 AT 16:00 h AT POINT OF ENTRY

MOUNT MACKENZIE, REVELSTOKE, B.C. 23 FEBRUARY 1979

One skier killed

LOCATION

The Mount MacKenzie ski area is 5 km south of Revelstoke in the Selkirk Mountains. The developed zone ranges from 500 to 700 m above sea level. Since a road and a ski run were cut into the forest in 1978 skiers have been transported by oversnow vehicle to the summit of the mountain, elevation 2350 m. Occasionally some are taken by helicopter. The short top section of the ski run is in open terrain above the treeline.

WEATHER

Low temperatures in December and January produced depth hoar in most mountains of Western Canada. This condition, which was a contributing factor in other accidents between 13 and 28 February 1979, was observed at Mount MacKenzie.

Following are the 24-h observations of the weather at Fidelity Mountain, 1875 m above sea level and 40 km east of the accident site.

Date	Temperature		New Snow	Snow Depth	Wind
1979	Max °C	Min °C	cm	cm	km/h
15 Feb	-5	-14	0	304	NE 18
16 Feb	-7	-12.5	T	298	NE 32
17 Feb	-8	-12	7	298	NE 32
18 Feb	-4	-8.5	24	314	NE 40
19 Feb	-4	-10.5	1	305	S 36
20 Feb	-6.5	-10.5	5	305	S 36
21 Feb	-8.5	-14	T	300	NE 25
22 Feb	-11.5	-15.5	T	296	NE 28
23 Feb	-11.5	-16	T	290	NE 32

ACCIDENT SUMMARY

Four skiers were flown to the peak of Mount MacKenzie by rented helicopter. Their leader chose a route slightly north of the standard run, and after skiing a short distance in steep terrain, stopped. A second, following skier fell and lost one ski while still above the leader. At that moment an avalanche released from the top and engulfed the fallen skier. The leader of the group was able to ski sideways to safety; the two other party members were still near the top and outside the slide area. The avalanche occurred at 09:20 h.

RESCUE

After the accident the leader skied down to the ski area at elevation 500 m to call for help while the two other survivors made a surface search. Rescuers flown to the site by helicopter organized a probe line at 11:15 h. At 14:00 h a trained avalanche dog was brought in and began to search from the top down. At the height of the search there were over sixty people involved.

As the victim's last-seen point was on the southern edge of the avalanche, the main search concentrated on this side, but the dog finally found the body at the northern edge of the deposit under 1 m of snow at 16:45 h. The dead skier had been carried over 500 m by the avalanche and thrown against rocks and trees. He had died of head injuries.

AVALANCHE DATA

The avalanche, starting at an elevation of 2250 m, was a dry snow, hard slab flowing along the ground. The fracture was 1 to 2 m deep and 200 m wide. The avalanche ran 700 m on an average slope of 32 deg facing NW. The deposit contained large angular blocks and had piled up to a maximum depth of 6 m with an average depth of 2.5 m.

COMMENT

The group was not equipped for backcountry emergencies. None of the skiers carried an avalanche transceiver, commonly used by heliskiers, so that it was not possible to locate the buried victim quickly. There was no avalanche dog near Revelstoke at the time, and it took over 4 h to fly one in. By that time the victim's chances of survival were very poor, even if his injuries had not been fatal. After the accident Parks Canada recognized the need for a better search and rescue program in the area and now has a trained avalanche dog in nearby Glacier National Park.

Source: Information collected by Paul Anhorn, Rogers Pass Field Station, Revelstoke, B.C.

STANLEY BASIN, KOOTENAY NATIONAL PARK, B.C. 24 FEBRUARY 1979

Two skiers killed

WEATHER AND SNOW CONDITIONS

No snow had fallen in the two weeks prior to the accident, but Stanley Basin is very much affected by turbulent wind. Low temperatures from December to the day of the accident had formed a weak depth hoar layer underneath a moderately thick windslab.

ACCIDENT SUMMARY

Four cross-country skiers were returning from a day's outing in Stanley Basin. At 13:30 h a large avalanche struck them from above as they were descending in an avalanche path. All four skiers were caught and carried down about 300 m.

RESCUE

When the avalanche came to a halt one person was buried upright to her chest; a second skier was partially buried face down, but was able to create an airspace around his face and call for help. The cries were heard by an ascending group of skiers who rushed to free the two. Both survivors carried turned-off avalanche transceivers in their packs. After 20 min of frantic searching a pack was found high up on the deposit and underneath it a completely buried victim. He had died of suffocation.

As the search for the fourth person continued, one skier raced down to the highway to alert the National Parks Warden Service. By 15:30 h twelve men had been flown to the site and were probing the debris. Two avalanche dogs searched without success. Falling snow increased the avalanche hazard to such an extent that the rescue had to be called off at 22:00 h. The storm did not permit a return to the accident site until two days after the avalanche had occurred, when a helicopter was able to fly the park wardens back, but before landing they bombed all slopes affecting the rescue mission. A large avalanche was released that crossed the initial avalanche deposit and search area. After three avalanche dogs had combed the entire area without success, 26 men probed for 2 1/2 h before they located the victim under 4.2 m of snow. She had been buried 51 h.

AVALANCHE DATA

The avalanche was attributed to a weak base of depth hoar in the snow cover overlain by wind-packed snow. The crown of the hard slab at an elevation of 2000 m was 60 m wide and 0.3 m deep. The average incline of the track was 35 deg and the aspect southwest. The avalanche was probably triggered by the skiers, but it started at least 400 m above them. Although it came off a side slope of the cirque, it was large enough to cover the entire bottom of the basin. The deposit had an average depth of 0.9 to 1.5 m, with a maximum depth of 4.8 m. The avalanche released by bombing added another 1.5 m of snow to the old deposit.

COMMENTS

The skiers obviously did not recognize the serious avalanche hazard. They had their rescue transceivers turned off in their packs while skiing in a major avalanche path. The deep burial of one victim made the search difficult for dogs and probers alike. She was located only by probing with two standard-length probes screwed together. It is interesting that other skiers in the area were unaware of the avalanche even though it ran up a boulder they were sitting behind.

Source: Warden Service, Kootenay National Park, and Peter Fuhrmann, Banff, Alberta.

TANGLE HILL, JASPER NATIONAL PARK, ALBERTA 28 FEBRUARY 1979

One mountain climber killed

WEATHER

Observations at Parker Ridge Study Plot, elevation 2030 m

Date	Temperature Max °C	Temperature Min °C	New Snow cm	Snow Depth cm
24 Feb	-12	-25	0.5	123
25 Feb	-5	-15	16	140
26 Feb	-3	-18	36	166
27 Feb	1	-11	2	158
28 Feb	-4	-16	5	156

The snowfall at the accident site on Tangle Hill, elevation 1820 m, generally is less than that observed at Parker Ridge. Tangle Hill is usually swept by cross winds. The snow profile observed at Parker Ridge depicts the structure of the snowpack prevailing in the area (Figure 12).

ACCIDENT SUMMARY

Two experienced rock climbers intending to climb the north face of Mount Kitchener left their car at the Icefields parking lot at about 10:00 h and walked on the highway a distance of about 1.5 km to Tangle Hill where the normal approach route starts. On the highway they met a park warden who informed them of prevailing hazardous snow conditions.

The two climbers had no skis or snowshoes and from the start walked in knee-deep snow for about 200 m. In order to get out of the deep snow they angled up on a wind-blown ridge at a small snowfield, which they started to traverse at the top.

About half way across the hard-packed slab they stopped to put on crampons, and when they were ready to move on again one man dropped a mitt that slid or rolled down the slope. The climber ran down the slope to retrieve his mitt, and was about 20 m down when a snow slab released 3 to 4 m above where they had stopped. He tried to outrun the slide, but his progress was hampered by the loose snow in the lower slope; he was pushed over and transported down with the snow for about 40 to 50 m. The second climber at the top of the slope was able to run over the snow blocks of the moving avalanche and was on the surface unhurt, with his equipment beside him, when the avalanche came to rest. The time was approximately 11:20 h.

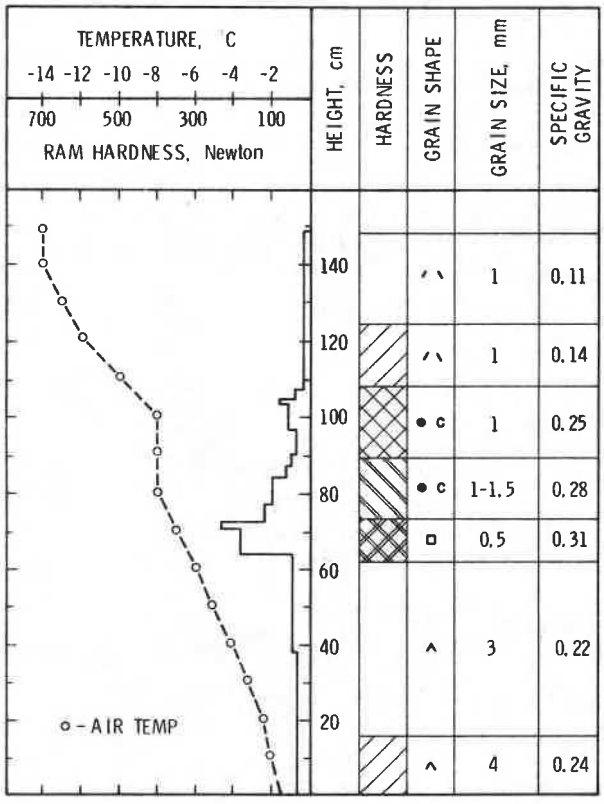

FIGURE 12
SNOW PROFILE AT PARKER RIDGE, 2 MARCH 1979

RESCUE

The survivor could remember the last-seen point and started to probe with his ice axe in line with it. He also dug a number of ditches. After these attempts proved to be unsuccessful he went to the highway for help. Two northbound cars stopped, but the driver of the first did not report the accident at the Tangle Creek work camp about 1 km away or at either the Sunwapta Warden Station or in Jasper. The driver of the second car was not aware of the work camp or the Warden Station to the north and returned south to Saskatchewan Crossing where he reported the acccident to the Banff Park Warden.

In the meantime, the survivor had returned to the accident site where he continued his search by probing and digging. At 13:40 h the Jasper Warden Office received the report of the accident from Banff and the first party was dispatched at 14:00 h, arriving at the scene of the accident at 14:30 h. A dogmaster with a trained avalanche dog arrived by helicopter at 14:45 h. The first party had carried out a hasty search and coarse probing but stopped except for another hasty search in the upper part of the avalanche when the dog arrived.

After about 35 min, at 15:25 h, the dog found the victim buried by more than 2 m of compressed blocks of snow. Cardiopulmonary resuscitation was administered by a doctor for 35 min without result. The autopsy revealed that the man had died of suffocation, probably within 20 min of being buried.

AVALANCHE

The avalanche was a size 2 hard-slab avalanche. The hard windslab was underlain by weak depth hoar. The depth of the crown was approximately 1.5 m on a 30 deg north aspect slope. The search was hampered by the blocky deposit and large boulders at the base of the slope.

COMMENTS

Both men were experienced technical rock climbers, but judging by their equipment and their choice of route they were unfamiliar with winter travel in the Canadian Rocky Mountains. They could have used a safe route across the slope 20 m higher (Figure 13). And with rescue transceivers the survivor could have located his companion quickly and perhaps been able to dig him out alive.

It was unfortunate that the first alerted motorist did not report the accident and that the one who did drove further than necessary. It illustrates that it can take a long time to organize a rescue party even when an accident occurs close to a highway.

Source: Tony Klettl, Warden Service, Jasper National Park.

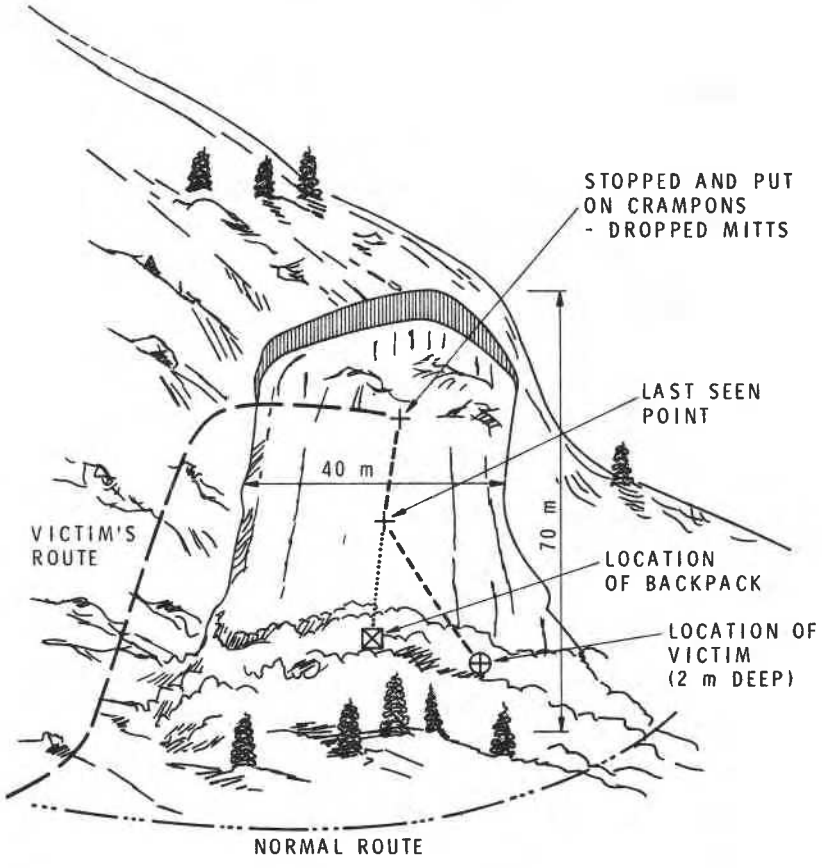

FIGURE 13

SKETCH OF ACCIDENT SITE AT TANGLE HILL

WINDY PASS, GOLD BRIDGE, B.C. 17 MARCH 1979

Three snowmobilers caught, one killed

WEATHER

The five days preceding the accident were mainly clear, with no recorded precipitation. March 17 was partly cloudy with sunny periods and air temperature above 0°C.

ACCIDENT SUMMARY

Seven men left Gold Bridge at 09:00 h with vehicles and snowmobiles. At North Cinnabar Creek they unloaded the snowmobiles and travelled to the headwaters of Taylor Creek, where two cabins are located, and then along a summer trail into the Eldorado Creek drainage. From the Eldorado Creek headwaters they passed through a col called Windy Pass that separates Eldorado Creek, Spruce Lake Creek, and Bonanza Creek drainages.

Just north of Windy Pass they turned west into a narrow channel leading to a small col overlooking Spruce Lake. Three snowmobiles reached the col, but the fourth became stuck in the channel directly below a north-facing steep slope and the three following snowmobilers stopped to help.

An avalanche releasing on the north-facing slope above the waiting snowmobiles buried the man whose machine was stuck and caught another who was 30 m higher. The latter jumped from his snowmobile on top of the moving snow and managed to stay on the surface, but his machine was buried 1 m deep. A third snowmobiler, feeling that something was moving the back of his machine, turned round as the avalanche was starting to cover him. He opened the throttle and was able to outrun the avalanche. The last snowmobiler in the lower area was beyond the toe of the avalanche deposit (Figure 14).

RESCUE

Two of the six surviving snowmobilers immediately went for help to Tyax and Gold Bridge. The other four cut tree branches to be used as probes but found nothing except the buried person's snowmobile, part of which was exposed in the avalanche snow. A helicopter with avalanche rescue equipment arrived about 2½ h after the accident, at approximately 13:00 h. A probe line was established when the rescue equipment arrived and the victim was found by coarse probing in less than 5 min, about 3 m upslope from his machine under 1 m of snow. The victim had a bump on his head but had died of asphyxiation.

An avalanche rescue dog had been called but only reached Lillooet after the victim was found.

AVALANCHE DATA

The slab avalanche started at an elevation of 2135 m on an open, north-facing slope with an inclination of 35 deg. The snowpack at the

fracture line was approximately 1.0 m deep, with some rock visible near the top of the slope. The avalanche fractured from rock to rock in the depth hoar just above the ground.

The snowpack lower on the slope was 1.3 m deep, very hard through the mid-pack layers, with depth hoar underneath (Figure 15). The avalanche rode on top of the strong snowpack layers when it moved downslope. The deposit was 1 to 3 m deep in the gully.

Source: Geoff Freer, Victoria, B.C.

FIGURE 14
VIEW OF AVALANCHE AT WINDY PASS (COURTESY GEOFF FREER)

BR 6786-14

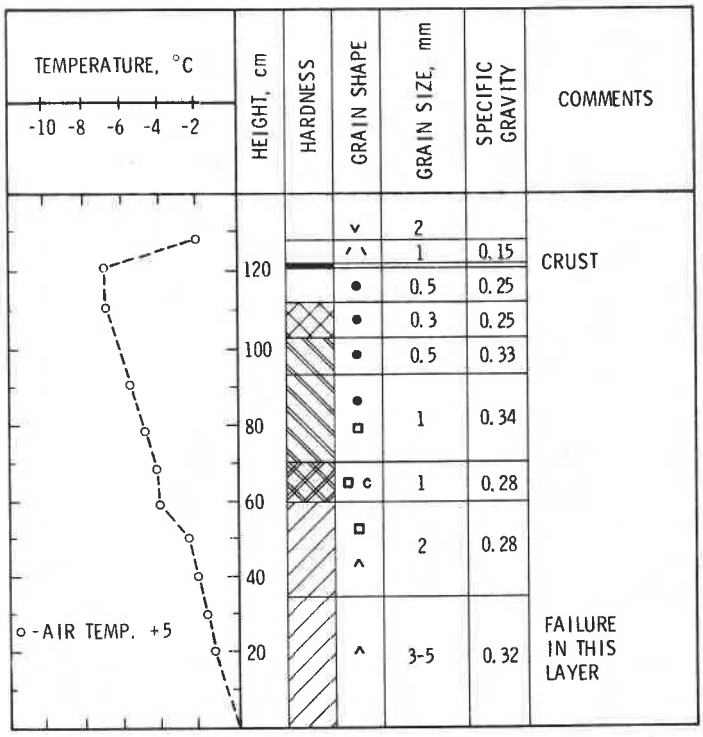

FIGURE 15
SNOW PROFILE AT WINDY PASS, OBSERVED 18 MARCH 1979

MOUNT MACKENZIE, REVELSTOKE, B.C. 15 MARCH 1980

One skier killed

LOCATION

The accident occurred on the same slope as the accident on 23 February 1979.

WEATHER

Following are the 24-h observations at Fidelity Mountain, 1875 m above sea level, 40 km east of the accident site.

Date 1980	Temperature Max °C	Temperature Min °C	New Snow cm	Snow Depth cm
1-7 March	-0.5	-18	8	245-251
8 March	-7	-10.5	1	246
9 March	-6.5	-8	19	265
10 March	-2	-5	33	291
11 March	-3	-6	32	311
12 March	-7	-11	10	310
13 March	-5.5	-10.5	10	308
14 March	-2.5	-9.5	17	314
15 March	-5.5	-10.5	11	316

Large snowdrifts at Mount MacKenzie indicated strong winds from the south previous to 15 March.

ACCIDENT SUMMARY

A group of 14 skiers had been transported by snowcat to the meadow above the timberline at Mount MacKenzie, but owing to large snowdrifts were unable to drive to the usual terminus at the top, elevation 2350 m. The group decided to hike the last short stretch to the summit despite warnings from the "cat" operator.

Before descending from the peak one young man warned his companions not to enter the northwest bowl because an avalanche had claimed a life there in 1979. After everyone else had started to ski down the west face, however, he went to the untracked snow of the slope in question. Entering the bowl from the side, he was caught in the middle when the snow fractured on the steep slope 200 m above him. No one observed the avalanche in motion or the skier being caught. The time was 13:30 h.

RESCUE

After waiting on the west face a few group members skied to the edge of the northwest bowl where they noticed the fresh avalanche and realized that

the missing person was presumably buried under the snow. Not equipped with shovels or other rescue tools, they used their skis and poles as probes. After searching unsuccessfully for 20 min, some skiers were dispatched to summon help from the valley.

The local RCMP coordinated the rescue efforts, and a search dog was flown in from Vernon, approximately 100 km away. The dog team and rescue groups from the Provincial Emergency Program, ski patrol, private heliski groups, and Parks Canada arrived on the scene within 1 h of the accident. Probe lines were worked uphill from the toe of the deposit. Meanwhile the dog was directed to search at the top of the avalanche path, unfortunately an unlikely area of the avalanche path. Not until 17:50 h did the dog locate the victim only 2 m in front of the advancing probe line. Had the probe line continued -- it was called off momentarily to let the dog search -- it would have found the victim. The deposit in this area was about 2 m deep and the skier, who had died of asphyxiation, was buried under 0.6 m of avalanche snow.

AVALANCHE

The victim's tracks were visible across a small avalanche fracture half way down the avalanche path. This would lead to the conclusion that the skier probably triggered a small slab avalanche which, in turn, led to the propagation of a failure near the top of the bowl in deep wind-deposited snow. The dimensions of the avalanche are shown in Figure 16. It ran on a crust formed by warm weather in February (Figure 17).

COMMENT

Some rescuers who had also attended the 1979 accident recalled that the earlier victim was found in approximately the same location. The dogmaster was a police officer in uniform and for this reason his actions were not questioned nor was he advised where to search, although he was not experienced in avalanche search and rescue. Much time was lost when he directed the dog to work first in the wrong areas, for the dog found the burial spot immediately after he was directed to the most likely area. This points to the importance of educating avalanche dogmasters in evaluating flow patterns of avalanches and recognizing most likely burial spots.

Source: Paul Anhorn, Rogers Pass Field Station, Revelstoke, B.C.

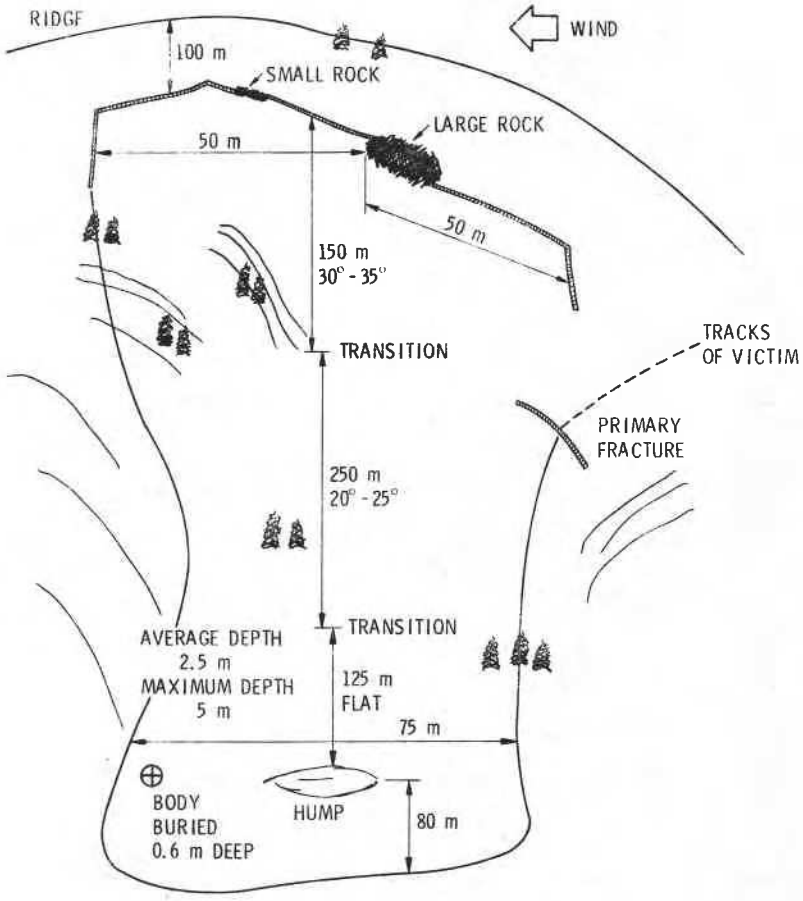

FIGURE 16
SKETCH OF AVALANCHE AT MOUNT MACKENZIE, 15 MARCH 1980

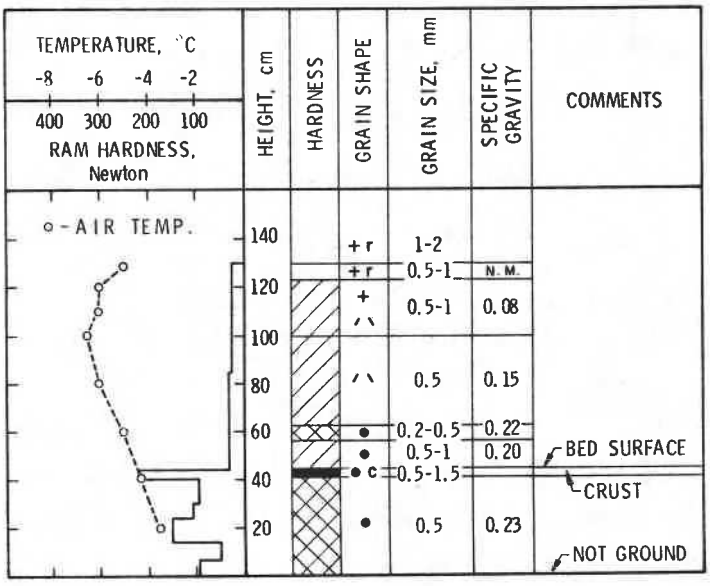

FIGURE 17

SNOW PROFILE AT AVALANCHE FRACTURE LINE AT MOUNT MACKENZIE, OBSERVED 17 MARCH 1980

SLESSE MOUNTAIN, B.C. 8 AUGUST 1980

One mountain climber killed, one injured

LOCATION

Slesse Mountain (2429 m) is 30 km southeast of Chilliwack in the Lower Mainland of British Columbia. The Northeast Buttress of Slesse Mountain is one of the classic rock climbs in the North Cascade Mountains.

ACCIDENT SUMMARY

Between 1 and 6 August several minor snowfalls occurred at higher elevations and light rain fell in the valley. On 8 August the temperature at Chilliwack climbed to 28.5°C, 4 deg higher than the normal maximum for August. It was also warm at the higher altitudes on Slesse Mountain.

On the night of 7 August three climbers had camped at the 7.5-mile mark on Middle Creek Road below the Northeast Buttress of Mt. Slesse. During the morning of 8 August the party observed several small avalanches coming off the pocket glacier at the base of the route. Two members walked up the moraines to the base of the cliffs below the glacier for a closer view of the avalanche activity. The third group member, declining to travel in the run-out zone of possible avalanches, stayed behind.

At approximately 15:00 h, when the two climbers were at the base of the 30-m cliff below the glacier, a large avalanche over-ran their position and carried them downslope for 400-500 m over rough terrain. One climber was buried in the moving snow over most of its run, but he came to the surface at the toe when the avalanche came to rest. He had sustained multiple fractures of one arm, cuts and abrasions, but was able to walk. The other climber, who was also on the surface, showed no signs of life.

RESCUE

The survivor and the third party member went for help to a government corrections camp about 13 km away, unaware of logging crews working close to the accident site. A party of five rescuers left the camp with first aid materials, a stretcher, and ropes. The RCMP were notified at 18:00 h and dispatched a second party that included a police dog and dogmaster trained in avalanche rescue. At the site of the accident the dogmaster immediately noticed the hazard from further avalanches from an adjacent glacier and ordered the rescue party to move quickly to a safer location. Since helicopter support was not available the rescuers evacuated the victim on foot in approaching darkness to vehicles on the logging road. Examination of the victim at Chilliwack General Hospital showed that he had died from multiple head injuries.

AVALANCHE

The climbers were caught at an approximate elevation of 1430 m on a southeasterly slope of Mt. Slesse. The avalanche was a mixture of wet snow

and ice blocks that left a deposit up to 10 m deep and approximately 600 m long. During the night of 8 August several smaller avalanches occurred.

COMMENT

The hazard was clearly evident yet the climbers exposed themselves assuming that only small wet avalanches would occur. Unstable glacier ice, however, contributed greatly to the avalanche mass, and underestimation proved to be a fatal mistake. Ironically the fatally injured climber was carrying a helmet in his pack. It was fortunate that both victims were at the surface when the avalanche came to a stop. Rescue would have been much more difficult and time-consuming if one or both had been buried, because the high hazard from further avalanches would not have allowed a probe line or even a search by the dog.

Source: T.M.A. Barter, Chilliwack, B.C.

MT. ATHABASCA, JASPER NATIONAL PARK 20 AUGUST 1980

One mountain climber killed

On 30 August 1980 a party of three was ascending the normal route (north glacier, saddle, north ridge) on Mount Athabasca, the climbers roped together. A slab fracture occurred below the rope leader about half way up a steep snow slope leading towards the saddle, and when he attempted to hold with his ice axe it pulled out and all three men were carried down by the avalanche. Two men were on the surface when the avalanche stopped, but one had been swept into a crevasse and buried under about 2 m of snow.

Two other climbers starting to climb the Silverhorn Arete came to help and the buried victim was uncovered after about 20 min. Two climbers then set out to report the accident and obtain further help. In spite of attempts at resuscitation, which started as soon as his head had been cleared and continued for 2½ h, the victim could not be revived.

COMMENTS

There were 20 to 25 cm of new snow over a surface of old compacted snow. The fracture line was 20 m long and 0.3 m high on a 35-deg slope. The slide was triggered by the climbers. Shovels would have speeded digging.

Source: Accidents in North American Mountaineering, Vol. 4, No. 5, Issue 35, p. 7, 1982 (Published by The Alpine Club of Canada, Banff, Alberta).

DERICKSON RIDGE, NEAR REVELSTOKE, B.C. 18 FEBRUARY 1981

One skier killed

WEATHER AND SNOW CONDITIONS

Observations at Fidelity Mountain, elevation 1905 m

Date 1981	Temperature Max °C	Min °C	New Snow cm	Precipitation mm	Snow Depth cm
14 Feb	-1.5	-7	15	13	241
15 Feb	-2	-4.5	19	23	255
16 Feb	-2	-4.5	35	33	279
17 Feb	-0.5	-3	31	29	300
18 Feb	-1.5	-4	26	19	311

The snow at the surface was subject to strong metamorphism during a prolonged period of clear weather in January. Heavy snowfall on top made the snowpack unstable.

ACCIDENT SUMMARY

Owing to poor weather no helicopter skiing was possible in Revelstoke from 13 to 16 February. A reconnaissance flight early in the morning of 17 February revealed general avalanche activity and during the day poor snow stability was observed even on short, gentle slopes.

On 18 February the snow was tested by dropping explosive charges in the Jordan Valley, but the slopes had self-stabilized and no new avalanches could be released. During the first three runs in forest glades the snow was settling by collapse (whoomping) and later in the morning it became very heavy. In search of easier ski conditions the lead guide decided to move his skiers above timberline. He chose the "Side Landing" ski run, thinking that the terrain - generally with a low incline and undulating from landing to pick-up sites - would be safe from avalanches. A first group consisting of one guide and nine guests skied the whole length of the run without incident. Half way down the slope the second group observed a small slab avalanche at the side of a ridge. As the guide and one guest were investigating it, an avalanche hit the rest of the party waiting in a depression between two shallow ridges. All eight skiers, who could not escape to the side, were caught and hurled down (Figure 18). The avalanche occurred at 11:45 h.

RESCUE

Coming back over the ridge and scanning the slope quickly the guide noted three partially buried skiers. He realized that four others were missing, buried under the avalanche. The survivors conducted a systematic search with rescue transceivers, finding and uncovering all victims 5 to 12 min after the avalanche had occurred. The last person was found under

1.2 m of avalanche snow and was not breathing; his heart had stopped. Cardiopulmonary resuscitation was immediately initiated and after 20 min of unsuccessful attempts a doctor in attendance injected epinephrine, a cardiac stimulant, into the heart. Within 2 min the pulse returned although the man was still not breathing. The unconscious victim was taken by helicopter to the Revelstoke hospital while artificial respiration continued. In the air the rescuers were finally able to restore his breathing. The patient remained in deep coma, was flown home to Switzerland, and died there six months later without ever regaining consciousness.

AVALANCHE DATA

Unconsolidated deep snow on top of a weak layer caused a dry slab avalanche, which started at the ridge above the helicopter landing. The fracture had an estimated depth of 1 m and a width of 200 m. In the lower, flatter and rugged terrain only surface snow was picked up. An arm of the avalanche was channelled into the area where the skiers were waiting. The aspect of the avalanche path was south.

COMMENTS

The case shows that even if the terrain of a ski run is considered too flat to start avalanches, steep slopes above can release enough snow to bury people. Under unstable snow conditions terrain features such as valleys between ridges become traps and should be avoided.

Once again avalanche rescue transceivers saved the lives of skiers by allowing quick recovery. The fact that 12 min of burial time was too long for the victim proves that survival time is extremely short. This stresses the need for quick action by the survivors.

Source: Jim Bay, Revelstoke, B.C.

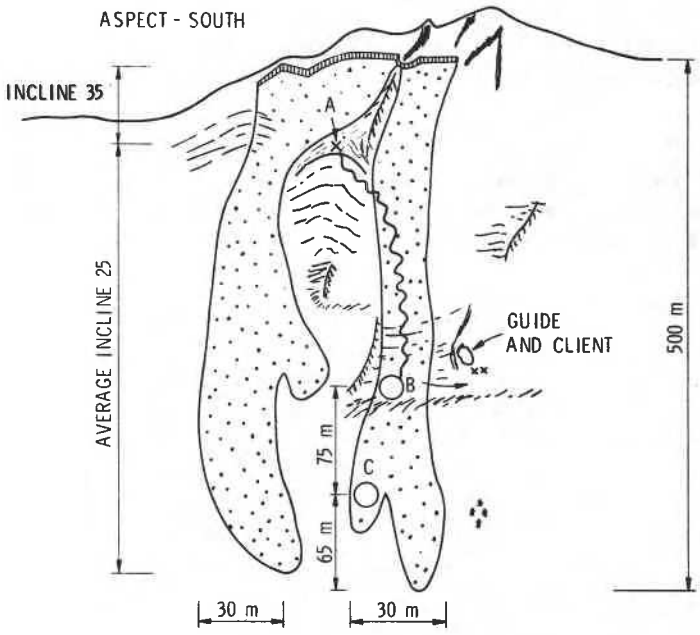

FIGURE 18

SKETCH OF AVALANCHE AT DERICKSON RIDGE
A: HELICOPTER LANDING SITE; THE KNOLL REMAINED UNAFFECTED BY THE AVALANCHE
B: LOCATION WHERE THE SKIERS WERE CAUGHT; THE GUIDE AND ONE CLIENT WERE AT THE SIDE
C: LOCATION WHERE THE BURIED SKIERS WERE FOUND

WATERFALL VALLEY, YOHO NATIONAL PARK 21 FEBRUARY 1981

One skier killed

WEATHER

Observations at Wapta Lake, elevation 1580 m

Date 1981	Time	Temperature Max °C	Temperature Min °C	New Snow cm	Snow Depth cm	Wind km/h
16 Feb	08:00	-0.5	-1.5	10	130	NW 5
	16:00	0.5	-1	2		CALM
17 Feb	08:00	1	-0.5	6	135	SW10
	16:00	1	1	3		SW 2
18 Feb	08:00	1	-2	5		NW 2
	16:00	2.5	-2	0		SW 3
19 Feb	08:00	0	-4.5	5	141	CALM
	16:00	0	-1.5	5		SW13
20 Feb	08:00	-0.5	-3.5	T	139	SW13
	16:00	-0.5	-1.5	0		SW13
21 Feb	08:00	-1.5	-5	0	137	SW13
	16:00	-1.5	-1.5	1		SW10

Surface hoar had been noticed on 5 February at the Lake Louise Ski Area and in the back country. In the two weeks prior to the accident moderate and strong west, north, and southwest winds were observed in the alpine regions of Banff and Yoho Parks.

ACCIDENT SUMMARY

On 21 February a party of four experienced back country skiers skied from the Des Poilus Glacier down to the Twin Falls Tea House and Lower Yoho Valley. The skiers, with distances of 10 to 15 m between them, followed the west arm of Waterfall Creek. Approximately a mile from Twin Falls Creek the party entered a narrow gully. Just as the leader had passed it he heard a noise behind him that sounded like a call. Looking back he saw that a small slab avalanche had fractured from the steep slope just to the west of his ski tracks and that the second party member was missing (Figure 19). The time was approximately 12:00 h.

RESCUE

The three remaining skiers immediately conducted a search with rescue beacons, but could not detect a signal from the victim. They marked the last-seen point and dug three or four holes approximately 2 m deep without

result. At 14:30 h, after failing to find any clues, the party skied down for help. Two of them remained at the Twin Falls Tea House for the night while the leader continued, meeting another party and together reaching the Lake Louise police station (RCMP) at 22:00 h.

The RCMP immediately contacted the Warden Service of Parks Canada, which organized personnel, two rescue dogs, and a helicopter for departure in the morning. At approximately 09:00 h on 22 February the first rescue party arrived on site. It included the accident party's leader, three search persons, and a dog. The second and third parties arrived at 09:20 and 09:40 h. A dog search and random probing were carried out. At 10:10 h one of the dogs gave a signal within a small area and probing confirmed the possibility that the victim was buried there.

At 10:33 h the victim was located in the creek approximately 6 m below the snow surface and under water. The body was evacuated by helicopter at 11:55 h. A medical examination concluded that death was caused by drowning and suffocation.

AVALANCHE

The avalanche occurred on a slope with southeast aspect, an incline of 39 deg at 2280 m elevation. The slab avalanche released on the side of a creek gully, slid on a bed of surface hoar, and had a depth of 0.65 m. The avalanche was 40 m wide and 40 m long. The victim was carried into an open creek hole that contributed to the deep burial.

COMMENT

A warning of high avalanche hazard in the back country was posted in the area at the time of the accident. The party was experienced, but underestimated the avalanche potential of the small gully and the trap it would present to anyone caught. A hazard from further avalanches existed during the rescue and as a consequence the number of rescuers exposed was kept to a minimum. The victim would have had a good chance of being found by his companions, using rescue beacons, if he had not been buried deep in the creek.

Source: Warden Service, Yoho National Park.

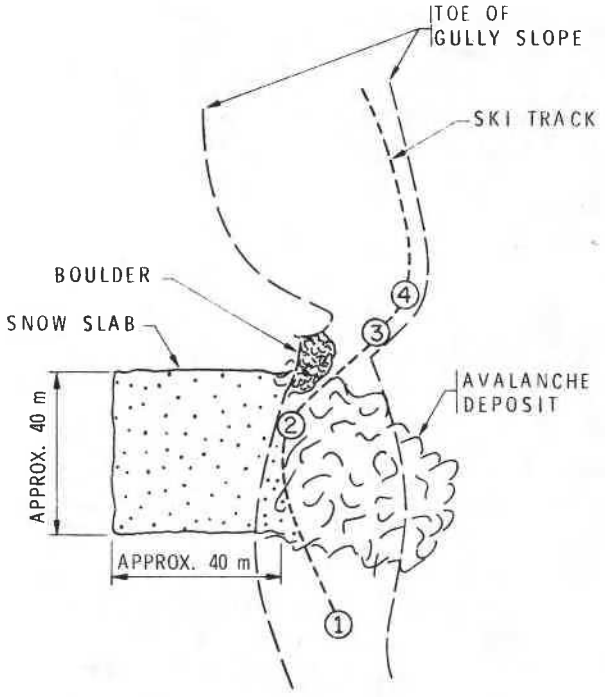

FIGURE 19

SKETCH MAP OF ACCIDENT SITE, WATERFALL VALLEY
◯INDICATES LOCATIONS OF THE SKIERS

BOURGEAU LAKE, BANFF NATIONAL PARK 22 FEBRUARY 1981

One skier killed

WEATHER AND SNOW CONDITIONS

Bourgeau Lake is 6 km north of Sunshine ski area where Parks Canada maintains daily weather and snowpack observations at a study plot 2145 m above sea level.

The winter of 1980-1981 was unusual in the Sunshine area. After heavy snowfalls in November and December it rained at the high elevations in late December. January was unusually dry and had an average temperature of -6°C, well above the 10-year mean of -14°C. The heavy snowfalls followed by warm weather produced a stable base in the snowpack, but a dry spell in February resulted in weak layers at the snow surface and a poor bond for new snow (Figure 20). Few deep slab avalanches occurred during the winter months.

Following are 24-h weather observations at the Sunshine study plot.

Date 1981	Temperature Max °C	Temperature Min °C	New Snow cm	Storm Snow cm	Snow Depth cm	Wind km/h
17 Feb	-1	-4	11	18	164	SE 24
18 Feb	-2	-6	7	24	168	SE 18
19 Feb	-3	-8	3	26	167	SW 15
20 Feb	-1	-7	12	34	174	SW 13
21 Feb	-4	-9	5	36	175	SW 16
22 Feb	-3	-8	T	31	172	SW 6

Snow drifting was observed at the Sunshine study plot on 19 and 20 February. On 22 February light snow fell at the accident site. The avalanche hazard information issued by the Warden Service of Parks Canada at Banff on 21 February read: "High winds have created a high hazard throughout the area. North- and west-facing slopes are particularly loaded and must be avoided. Use caution on all slopes."

ACCIDENT SUMMARY

Four cross-country skiers departed from the Trans-Canada Highway at approximately 09:45 h on 22 February and climbed the Bourgeau Lake trail. The group had lunch at Bourgeau Lake at about 13:15 h and then divided: two skied back to the trail head and two climbed higher through a steep creek bed towards a large alpine cirque west of the lake.

As the latter two skiers ascended a steep slope on the north side of the creek, the second one saw the snow cracking above him and was immediately engulfed in the avalanche and carried downhill. By using a swimming motion he was able to keep his head above the moving snow. When the avalanche came to rest he was partly buried, with his head exposed, about 5 m from the toe of the avalanche. The lead skier was completely buried. The avalanche occurred at approximately 14:30 h.

RESCUE

The second skier was able to dig himself out and immediately began a surface search that he continued for approximately 25 min. Unable to locate his companion, he decided to go for help. The survivor had found one of his skis and worked his way down the trail on it, attempting to signal the other two skiers with a whistle. At the highway he met his fellow party members and together they drove to the Healy Creek Warden Station where they reported the accident to the Banff Warden Office at 16:35 h.

A three-man search party and the survivor left the Banff Warden Office by helicopter at 16:55 h, arriving at the site at 17:10 h to begin a hasty search. A second party, which included a dog and dogmaster, arrived at 17:35 h.

The dog search was unsuccessful and a ten-man team began coarse probing at 18:00 h. At 19:40 h the probe line located the victim, buried face down, head downhill, under approximately 1 m of snow and dead from suffocation. No injuries were visible. An ice mask had formed around the head. The majority of the rescue party returned to the highway on skis, but two park wardens remained at the accident site with the victim and were evacuated by helicopter at 11:00 h on 23 February.

AVALANCHE

The skiers had triggered a size 2 slab avalanche 50 m wide and 150 m long when they crossed the side slope of a gully (Figure 21). The avalanche fractured approximately at elevation 2300 m on a wind roll with southeast aspect and 30- to 35-deg incline. Wind-transported snow appeared to be a key factor in the formation of the avalanche.

With a fracture depth of 0.75 to 1 m, the avalanche ran on a bed of surface hoar. The deposit at approximately 2220 m elevation was about 3 m deep and comprised hard snow blocks that made probing difficult. Old avalanche deposits were visible in the area.

COMMENT

The party was not aware of the high avalanche hazard. The skiers carried day packs for light cross-country skiing, but their equipment did not include avalanche rescue transceivers and only the avalanche victim carried a shovel. With a transceiver and a shovel the survivor might have been able to uncover his friend in a short time.

This unfortunate accident underlines the need for observing basic safety measures when travelling in the back country:

- to be aware of hazardous snow conditions,
- to carry transceivers, shovels, probes, and first aid kits,
- to cross potential avalanche slopes with only one person exposed when such slopes cannot be avoided.

In a critique session by the rescue team the failure of the dog was attributed to the following:

- There were too many distractions. The helicopter landed with follow-up parties too close to the avalanche.
- When a first free search with the dog proved unsuccessful the rescue team began probing in the centre of the deposit, which happened to be upwind of the burial site. The dogmaster then stayed on the upwind side of the probe team, but opposite the location of the victim.

Source: Warden Service, Banff National Park.

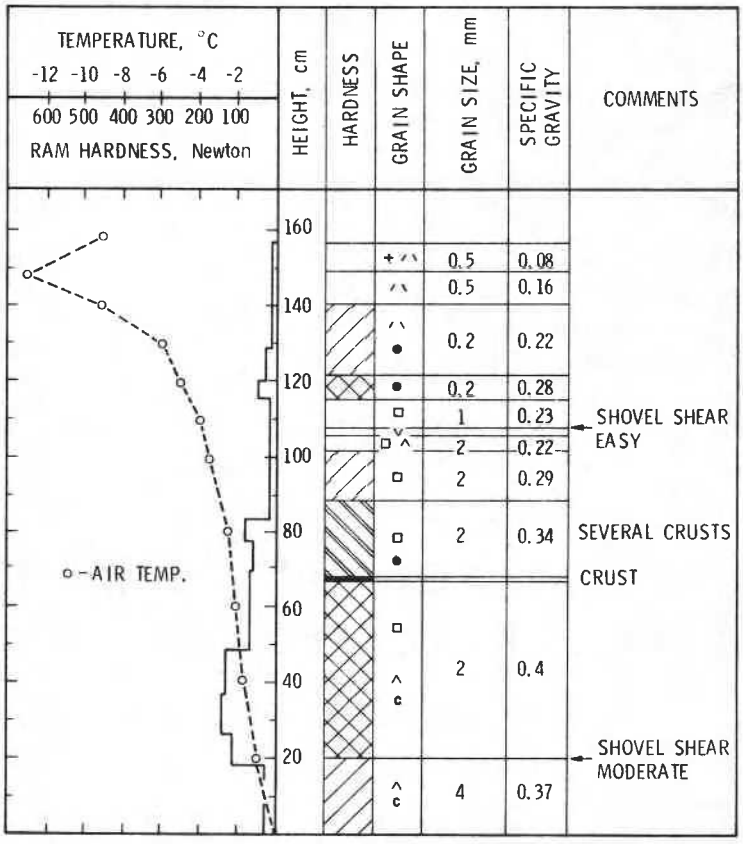

FIGURE 20

SNOW PROFILE AT SUNSHINE STUDY PLOT, OBSERVED 26 FEBRUARY 1981

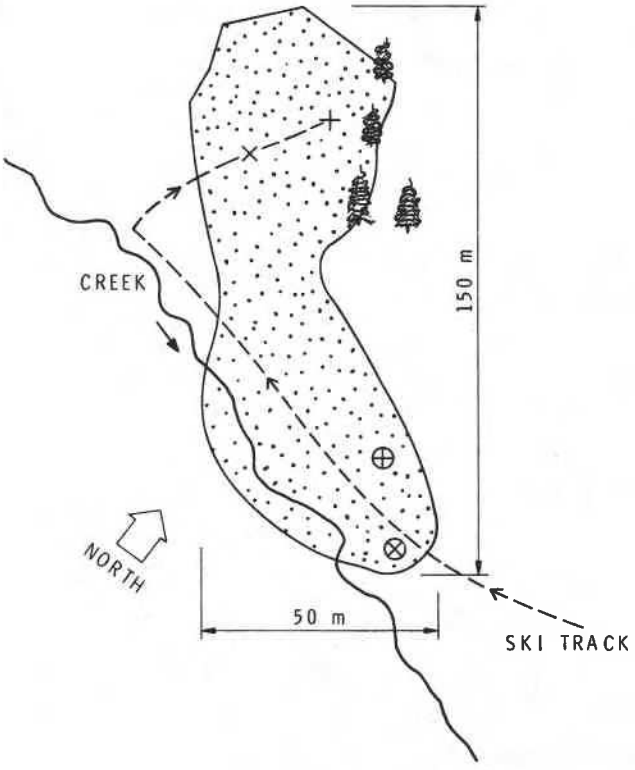

FIGURE 21

SKETCH OF ACCIDENT SITE AT BOURGEAU LAKE

+ ⊕ LOCATION OF VICTIM BEFORE AND AFTER AVALANCHE

× ⊗ LOCATION OF SURVIVOR BEFORE AND AFTER AVALANCHE

MT. THOMPSON, BANFF NATIONAL PARK 22 FEBRUARY 1981

Two skiers killed

WEATHER AND SNOW CONDITIONS

Mount Thompson is above Peyto Glacier near Bow Summit. The snow conditions at Bow Summit were the same as those observed at the Sunshine Area (see accident case at Bourgeau Lake, 22 February 1981) 80 km to the southeast. The snowpack contained a stable base about 1 m deep, a weak layer consisting of surface hoar and facetted crystals, and at the top 40 cm of deep new and partially settled snow deposited in the two weeks prior to the accident (Figure 20). On 22 February the sky was overcast, very light snow fell, the wind was moderate from the west, and at Bow Summit the temperature was between -11 and -4°C.

Warnings of high avalanche hazard for backcountry travellers, owing to unstable snow and high wind, were posted in Banff National Park.

ACCIDENT SUMMARY

On Sunday, 22 February, three mountain climbers with skis planned to climb Mt. Thompson from the Peyto (Peter Whyte) hut. On the previous day they had read the avalanche warning at the Warden Office in Banff. One member of the party left at 09:00 h, slightly ahead of the others, going in a northeasterly direction towards the ridge of Mount Thompson, climbed through broken cliffs to the ridge, and proceeded towards a point where he planned to rejoin the others. The other two climbers intended to ascend the steep West Bowl of Mount Thompson due east of the hut. Their friend on the ridge saw them last at 10:30 h climbing the snow slopes below a broken cliff.

The single climber waited at the rendezvous site for some time, then began to descend the planned ascent route of the other two hoping to meet them. Half way down he was caught in a slab avalanche and carried approximately 150 m down the mountain. He was buried but resurfaced on the way down and was able to dig himself out when the avalanche stopped. In the bowl he noticed two other avalanches that he had not seen earlier in the morning. He waited at the Peyto hut from 12:00 to 16:00 h for the others to return, then skied to the Icefields Parkway, arriving there at 20:30 h. He was able to flag down a passing car for a ride to Lake Louise where he reported his friends as missing to the Royal Canadian Mounted Police.

RESCUE

The search was organized by the Wardens of Banff National Park. At 08:00 h on 23 February a reconnaissance team that included the survivor of the accident party left Lake Louise by helicopter. Avalanches but no signs of the victims could be observed, and it was snowing in the area. Between 08:40 and 09:25 h additional rescue teams and equipment were airlifted to a staging base at Peyto hut. At 08:50 h four wardens with a search dog skied into the West Bowl of Mt. Thompson. As they approached the toe of the first

avalanche they noticed a skipole high up on the debris and a toque blown by wind about 10 m outside the toe of the avalanche.

The dogmaster and dog went on the avalanche deposit and immediately found one victim, and within 5 min, at 09:35 h the other one 6 m away. Both victims were buried 1 m to 1.5 m deep, lying on their backs, head downhill and 2 m from the toe of the avalanche. They were roped together and both had died from suffocation. Their skis were missing and it could not be established whether they were on foot or on skis when they were caught. The bodies were evacuated by helicopter sling at 10:15 h.

AVALANCHE

The avalanche, size 2.5, was approximately 200 m wide and 200 m long and fractured over a depth of 0.3 to 0.6 m. It contained dry snow deposited in the two previous weeks and the failure occurred in the old surface snow below. The slope angle was between 30 and 35 deg, the aspect southwest, and the elevation 2590 m. The depth of the deposited snow was about 2 m.

COMMENT

The stability of the snow was poor and both groups of the party chose bad routes through steep broken slopes. Considering the poor snow stability it was probable that skiers would release avalanches on that type of terrain.

Source: Warden Service, Banff National Park.

HIDDEN BOWL, LAKE LOUISE, ALBERTA 6 MARCH 1981

One skier buried

WEATHER

Observations at Temple study plot, elevation 1975 m, wind measured at 2530 m

Date 1981	Temperature Max °C	Min °C	New Snow cm	Snow Depth cm	Wind km/h
2 March	0.5	-13	-	100	40 W
3 March	-0.5	-9.5	-	98	19 W
4 March	0.5	-8.5	Trace	98	9 SSE
5 March	-3	-6	16	113	19 W
6 March	-4	-16	Trace	110	7 W

ACCIDENT SUMMARY

After ascending to the top of Richardson Ridge from the south side, two friends decided to ski the north-facing "Hidden Bowl." The more experienced of the two tested the slope, recognized the poor snow stability in the bowl, and selected a safer route over a tiny ridge. He informed his partner of his plans, indicating that he would stay on the prominent rib and advising him to ski only on the right side of his track. Safely arrived at the bottom, he watched his friend enter the slope on the side opposite that he had told him to take. He called out instructions to cut over, but before reaching the flatter terrain on the other side of the ski track the skier fell. As he fell a fracture propagated to the ground and approximately 100 m across the slope. The resulting slab avalanche carried the victim all the way down into the flats. He was on his feet, but a last wave of snow buried him completely.

RESCUE

The first skier, having observed the whole incident, had an excellent idea where his partner was buried. He rushed to the deposit and started probing with his avalanche ski poles. On the fourth probe he hit something. Frantically digging 1.2 m down, he hit the buried person's face with his shovel. The victim was unconscious and slightly blue but he recovered quickly. Except for a superficial facial wound he sustained no injuries.

AVALANCHE

The avalanche was 100 m wide and ran for 50 m on a 30-deg slope. The slab had a thickness of 1 m.

COMMENTS

The victim was not wearing an avalanche rescue transceiver, but thanks to a great deal of luck and excellent observation by his companion he was found within 5 min. The case illustrates well the importance of watching a person going down with an avalanche and noting the last-seen point.

Source: Kris Newman, Lake Louise, Alberta.

MT. STEPHEN, YOHO NATIONAL PARK 2 APRIL 1981

Two mountain climbers killed

WEATHER

Observations at Wapta Lake, elevation 1580 m,
at 08:00 h for 24 h

Date 1981	Temperature Max °C	Min °C	New Snow cm	Snow Depth cm	Wind km/h
29 March	4	-1	2	136	NE 3
30 March	3	-3	2	-	SW 5
31 March	4	-2.5	0	134	SW 8
1 April	2	-3	T	133	SW 6
2 April	1	-6.5	1	134	SW 9
3 April	0	-4.5	T	133	SW 11

ACCIDENT SUMMARY

Two climbers had intended to climb Mount Stephen over the avalanche path below the Stephen Glacier and to descend via the west ridge to Fossil Beds. Their tracks indicated that they reached the ridge beside the glacier but then probably decided to abandon the climb and descend by traversing the north gullies below the face of Mt. Stephen. After crossing several hazardous slopes, the climbers triggered an avalanche that carried them down a steep ice gully and over rocks. Both men seem to have died instantly in falling over cliffs.

RESCUE

At 10:30 h on 3 April a friend reported to the Parks Warden Service that the two climbers were overdue. At 11:00 h their car was found beside the Trans-Canada Highway east of Field, and at 11:15 h their tracks were noted below the Mt. Stephen Glacier.

A search by helicopter was begun, but bad visibility and falling snow made the task difficult. At 14:25 h tracks were found entering the starting zone of a recent avalanche (Figure 22), and shortly afterward one victim was seen in the avalanche deposit below. Rescue teams were able to evacuate the body at 15:45 h using a sling and helicopter. At 16:55 h the second body, buried in the avalanche deposit, was located by a Parks rescue dog. The body was evacuated by helicopter at 17:25 h.

AVALANCHE

The avalanche was a slab avalanche of size 2.5 starting at approximately 2250 m elevation on a lee slope with NW aspect. It ran in a steep gully broken by waterfalls. The toe of the avalanche was at 1460 m

elevation. One victim was found on the surface above a waterfall at approximately 1945 m elevation. The second was buried near the toe of the avalanche at approximately 1490 m elevation.

COMMENT

The climbers chose a route that was hazardous under winter conditions, firstly, because of unstable snow and numerous starting zones, and secondly, because of the steep, rugged terrain over which the avalanche fell. The victims sustained injury and death not from the snow but from the fall over rocks. An evaluation of travelling terrain must include consideration of what will happen if an avalanche should start.

Source: Warden Service, Yoho National Park.

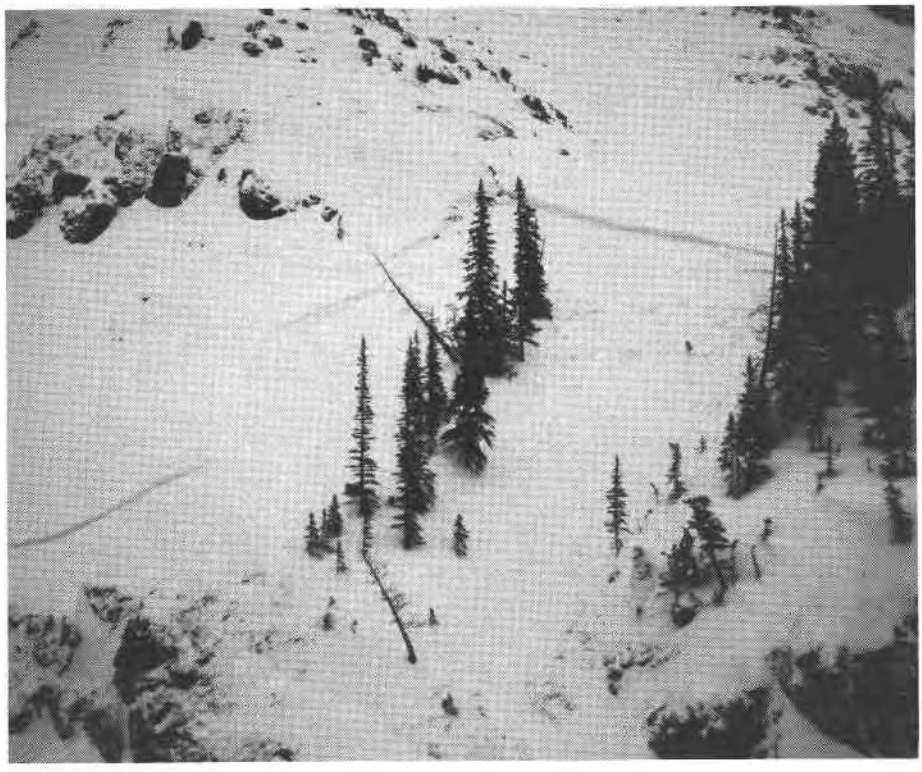

FIGURE 22

STARTING ZONE OF AVALANCHE AT MOUNT STEPHEN SHOWING FRACTURE LINE OF AVALANCHE AND ENTRY TRACKS ON LEFT (PHOTO COURTESY OF SUPERINTENDENT, YOHO NATIONAL PARK)

BR 6786-22

DOGTOOTH RANGE, NEAR GOLDEN, B.C. 8 APRIL 1981

One skier injured

WEATHER AND AVALANCHES

Observations at Rogers Pass, elevation 1315 m
20 km from accident site

Date 1981	Temperature Max °C	Min °C	New Snow cm	Snow Depth cm
4 April	1.5	-8	7	169
5 April	1.5	-2.5	9	170
6 April	-0.5	-5	18	184
7 April	0.5	-7	2	182
8 April	2	-4	3	180

No natural avalanches were observed at Rogers Pass, but several slab avalanches had been released by artillery on 7 April. One very large fracture line was noted on a slope with northern aspect. In the Dogtooth Range a smaller amount of snow had fallen between 4 and 8 April, yet natural avalanches were observed at all aspects and elevations.

ACCIDENT SUMMARY

On 8 April a guide assembled a group of nine for helicopter skiing. Owing to hazardous conditions only gentle slopes, mostly in the trees, were skied. On the second run one skier undercut a small slope and released a slab avalanche. Luckily it ran only about 10 m, although the fracture line was 0.5 to 0.8 m deep. The second, third, and fourth runs of the day all started from the same landing site, but each time the guide would choose a slightly different route on his way down. Some skiers had difficulties skiing in the dense forest, however, and the group was forced more and more into the open with each run. On the fourth descent the guide decided to cross an avalanche slope on a flat bench directly in front of the landing site, but before doing so he instructed his clients to space themselves out. Before the seventh and eighth skiers had reached the ridge on the other side the gap between them had become small and their combined weight released a small avalanche above them. It ran about 10 m, not even reaching the ski track, but the small avalanche triggered a much larger one 100 m above. The second avalanche hit the ninth skier on the slope. As he was carried down he employed a strong swimming motion to bring himself closer to the surface, and when he felt the avalanche slowing down he gave a last thrust and managed to push one hand free. With it he was able to scrape the few centimetres of snow from his face.

RESCUE

The victim's skis were still attached with safety straps. The guide saw them sticking out of the snow, went to them immediately and was able to

scoop the fast settling snow from the chest of the buried person. The victim missed several small trees by inches and injured his back when he hit a rock as he was carried down by the avalanche. Happy to be alive, he neglected to tell the rescuers about the pain in his back, but after being lifted from the hole he realized that he was unable to continue to ski. He was airlifted to the hospital at Golden where a lumbar fracture was diagnosed.

AVALANCHE DATA

The snow deposited during the storm a few days earlier had bonded poorly to a suncrust. The shear failure occurred on this crust, 10 to 40 cm below the surface. The 30-m wide slab avalanche was triggered by a slough 100 m away. The avalanche had an estimated volume of 2000 m^3 of snow, with a maximum deposit depth of 3 m. The incline varied from 35 deg at the fracture line to 15 deg in the run-out zone (Figure 23).

COMMENTS

This case demonstrates the importance of crossing an avalanche slope one at a time. Eight people skiing in the guide's track, had traversed the path safely when the avalanche released, but as a result of proper spacing only one person was caught.

The possibility of injury is always present. Rescuers should exercise special care in checking for neck and back injuries before manipulating a victim.

Source: Paul Anhorn, Rogers Pass Field Station, Revelstoke, B.C.

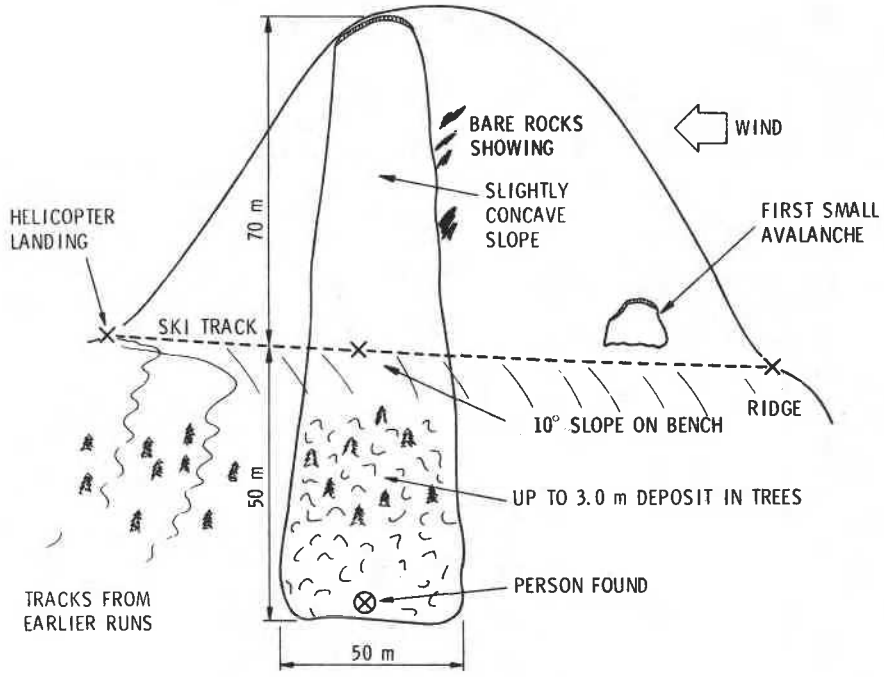

FIGURE 23

SKETCH OF AVALANCHE AT DOGTOOTH RANGE

MOUNT LOGAN, YUKON TERRITORY 29 JUNE 1981

Mountain climbers buried

WEATHER

Frequent storms originating in the Gulf of Alaska deposit large quantities of snow in the Saint Elias Mountains. At high elevations the snowfall is usually associated with strong winds. At the time of the accident it was snowing heavily and wind speeds had been in excess of 60 km/h. More than 1 m of new snow had accumulated.

ACCIDENT SUMMARY

Four climbers were undertaking an ascent of the popular East Ridge of Mount Logan. They had swiftly completed the lower, more technical portion of the route and were negotiating what is commonly referred to as "The Dome," the final barrier to the summit plateau and the summit pyramids beyond. At an elevation of 4570 m they had established a camp on a small low-angled snow bench below the final slope of the Dome. On 29 June a relatively small avalanche swept down on the camp, partially burying two party members outside their tent and trapping two others inside another tent. The partially buried climbers were able to free themselves and rescue the remaining two. Most camping and climbing equipment was swept down the Dome into the cirque 2000 m below, buried in the vicinity, or was beyond repair.

RESCUE

Continued heavy snowfall retarded the climbers' efforts to recover their gear, but they found the team radio, some bivouac gear, one shovel, a stove with approximately three days' supply of fuel and some food. Owing to the danger of further avalanches, they dug a snow cave and were able to establish contact with the Arctic Institute of North America at Kluane Lake at 09:00 h on 30 June. Parks Canada in Haines Junction was, in turn, notified of the climbers' request for assistance. The storm persisted for four days, during which radio contact was maintained at scheduled intervals to check on weather and the climbers' condition. At 05:00 h on 2 July the weather was clearing and by 07:00 h visibility was unlimited. Parks Canada immediately flew some 140 km to the accident site using an Alouette-3 and a Jet Ranger helicopter for fuel support. After a winching operation had been attempted repeatedly without success (the altitude made hovering very difficult), climbing gear, food and other supplies were dropped near the climbers. At approximately 10:30 h, with the weather threatening again, the helicopters returned to Haines Junction. The total depth of new snow deposited by this time was approximately 3 m. The climbers were able to recover and descend in the ensuing storm. They were flown out by fixed wing aircraft on 8 July.

AVALANCHE

The avalanche was a soft slab, breaking 50 to 100 m above the camp. No additional information could be obtained because of poor weather, but it was

concluded that the amount of snow involved was not large since the climbers were not swept any distance. The nature of the terrain and its inherent exposure, however, created a very difficult situation. Another small avalanche on the following day nearly swept two of the climbers away while they were standing outside their snow cave. The Dome is characterized by steep, open, convex slopes of up to 45 deg and is primarily affected by crosswinds and, near the top, leeward loading.

COMMENTS

A relatively minor event was compounded by weather, exposure, and isolation. The decision to request a rescue was justified in light of the situation, but the case also points out the importance of having the capability of self-rescue for all backcountry skiers and climbers. The clear period of weather allowing the rescue attempt lasted only 3 h and was followed by another storm lasting five days. The entrance to the snow cave eventually grew to 3 m long and keeping dry was very difficult for the climbers as the entrance had to be continually cleared.

The changeability of snow conditions as a result of weather is an important consideration in route finding and locating of campsites. Another expedition passing over the same section 10 days prior to the accident did so on rock-hard, wind-packed snow.

Source: Michael N. Demuth, National Research Council of Canada, Revelstoke, B.C.

MOUNT WASHINGTON, B.C. 9 DECEMBER 1981

One ski patroller injured

WEATHER

Observations at Mt. Washington study plot, elevation 1200 m

Date 1981	Time	Temperature Max °C	Temperature Min °C	New Snow cm	Snow Depth cm
7 Dec	08:30	3	-7	17	155
7 Dec	15:30	0	-3	0	155
8 Dec	08:30	-3	-9	0	150
8 Dec	15:30	-4	-7	0	150
9 Dec	08:30	-0.5	-7.5	30	168
9 Dec	15:30	0	-6.5	5	173

ACCIDENT SUMMARY

Early in the morning of 9 December three ski patrollers ski stabilized the snow on the southwest side of Mt. Washington. Strong winds from the southeast had formed drifts and hardpacked the snow on top of the mountain. After successfully cutting loose three small slab avalanches the team headed back across the mountain. The patrollers observed some glide cracks on top of cliffs, but decided it would be too risky to skicut them. Shortly before 10:00 h they reached the top of the south-facing "Powder Face." One by one they skied across the starting zone, but when the third patroller was half way across an avalanche caught him from above. He immediately began a swimming motion, but the snow covered him. Just before the avalanche came to a complete stop, however, he pushed his arm up and felt a tree branch. Wiggling the branch created an airspace and eventually the buried skier could push his glove out of the snow.

RESCUE

The two remaining ski patrollers on the side had watched their partner disappear. After calling him on the two-way radio without receiving an answer they alerted the management in the lodge, and ordered shovels, probes, a toboggan, more patrollers and volunteers, then they switched their avalanche rescue transceivers to receive. One of them walked uphill to the last-seen point, while the other one headed straight down to a large pile of debris. The lower searcher heard a voice on the radio. He asked for two "clicks" if the caller was the buried person. On receiving confirmation he knew that the victim had to be close, and it was only a matter of half a minute until the protruding glove was discovered. The victim had been located within 4 min and another 7 min passed before he was completely removed from the avalanche snow. He had suffered a dislocated shoulder, broken femur, and slight exposure. The injuries were the result of collisions with small trees during the descent of the avalanche.

AVALANCHE

Caused by snowfall and wind, the avalanche occurred on the south-facing side of the ski area at elevation 1500 m. The incline at the starting zone was 50 to 55 deg and dropped 100 m vertically in an open slope between trees. The fracture line had a width of 100 m and an average depth of 45 cm. The deposit was 1 to 2 m deep, 100 m wide and 175 m long. Figure 24 is the fracture line profile observed three days after the accident.

COMMENTS

The ski patrollers used the correct procedure by cross-cutting the slope one by one. Thanks to the two survivors, the victim was quickly found and rescued.

Ski stabilization can be hazardous and should only be done on small slopes that can be approached from above and when only small avalanches are expected. On 9 December, after the deep new snow from the previous day had been compacted into slabs, the Powder Face slope should have been controlled by explosives.

Source: David Cronmiller, Comox, B.C.

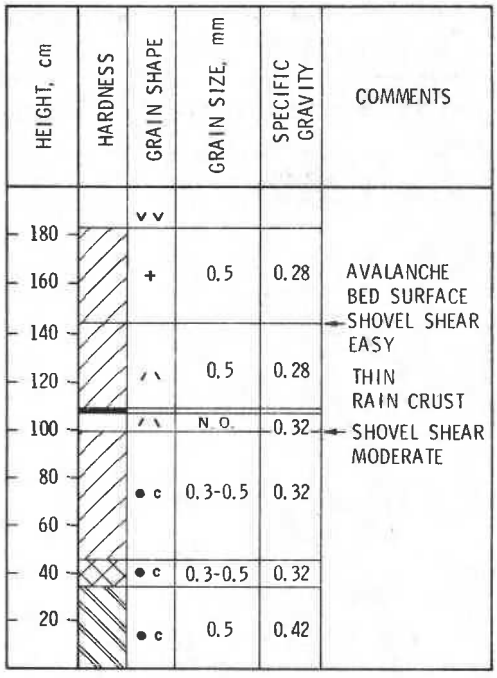

FIGURE 24

SNOW PROFILE AT FRACTURE LINE OF AVALANCHE AT MOUNT WASHINGTON, OBSERVED 12 DECEMBER 1981

WELLS, B.C. 9 JANUARY 1982

Three tobogganers rescued

Tobogganing on the tailings of an old mine near Wells in the Cariboo Mountains nearly cost the lives of three teenagers on 9 January 1982. It was a combination of luck and fast thinking by friends and neighbours that saved them from suffocating in the snow. The three were caught in an avalanche just before they made their way to the top of the 15-m hill.

The first boy was found when his hand popped out from the surface and a friend, a person not involved in the avalanche, dug down and uncovered his face. When freed, the first boy could see a foot sticking out from under where he had been, about 1 m deep in the snow. The second person was directly underneath. As soon as the rescuers had uncovered her face, they started searching for the third missing person by digging a series of trenches in a grid system. From the location of trees the searchers had some idea where to start digging.

The last victim was conscious when found, but had been unconscious for some time before. She had started to push the snow away from her face and had managed to dig an air space. She was buried for about half an hour.

Source: Bridge River-Lillooet News, 27 February 1982.

TERRACE, B.C. 12 JANUARY 1982

One workman killed

LOCATION

The Canadian National Railway and B.C. Highway 16 cross numerous avalanche paths between Terrace and Prince Rupert, British Columbia. Avalanches frequently cover the railway track and highway, interrupting traffic several times each winter.

The accident on 12 January 1982 occurred at Railway Mile 43.5, Skeena Subdivision west of Terrace, in avalanche path No. 69.6, "Rockface" (Snow Avalanche Atlas Terrace-Tyee of the Ministry of Transportation and Highways of the Province of British Columbia).

WEATHER

The Ministry of Transportation and Highways makes daily weather observations at the Salvus Maintenance Depot, elevation 30 m, 11 km east of the accident site, and maintains a remote weather station at elevation 1448 m.

Observations at Salvus Maintenance Depot

Date 1982	Time	Temperature Max °C	Temperature Min °C	New Snow cm	Snow Depth cm
4 Jan	am	-18	-25	-	5
	pm	-15	-16	-	5
5 Jan	am	-16	-21	-	5
	pm	-17	-21	6	11
6 Jan	am	-16	-16.5	24	35
	pm	-11	-16	37	70
7 Jan	am	- 3	-10.5	27	89
	pm	- 4	- 5.5	11	100
8 Jan	am	- 5	- 9	22	97
	pm	- 9	- 9.5	25	126
9 Jan	am	- 8	-10	22	127
	pm	- 7.5	- 9	9	135
10 Jan	am	- 6.5	- 8	6	133
	pm	- 5.5	- 7	4	135
11 Jan	am	- 5.5	- 6	5	135
	pm	- 4	- 6	T	130
12 Jan	am	- 4	- 5	9	135
	pm	- 1	- 4	4	135

Between 7 and 10 January temperatures at the remote weather station were 5 to 10 C deg warmer than those at the Salvus Maintenance Depot. On 12 January they were as follows:

Time	Temp °C
00:00	-5.9
06:00	-3.9
10:00	-2.6
12:00	-0.9
14:00	-0.6
15:00	-0.4
16:00	-0.4

ACCIDENT SUMMARY

Railway employees were repairing tracks damaged by removal of previous avalanche snow when another avalanche struck at 15:45 h. On a warning shout from the watchman the workmen ran for cover, but four men and four vehicles were caught. The powder component of the avalanche blew two men across the adjacent highway to the river ice. A third man was thrown across the highway only and remained on the surface. The fourth one was flung under a 3/4 ton truck, which was also displaced by the avalanche and partially buried.

RESCUE

Railway staff at the site immediately began a random search. Ministry of Highways personnel, trained in avalanche rescue, arrived with rescue equipment 18 min after the accident and organized a search with probes and transceivers. Workmen digging round the lower side of the 3/4-ton truck first found the victim's feet, then his body lying face down beneath the engine 38 min after the avalanche had occurred. There was no snow between the buried man and the engine. He was unconscious and not breathing when found, and was later pronounced dead in the hospital. It was concluded that the cause of death was asphyxiation from being tightly packed between the truck and the snow beneath. It is possible that the victim might have survived if he had not been pushed under the vehicle.

AVALANCHE

The starting zone of the avalanche path is an open rockface with an incline of 40 deg and aspect south 1020 m above the railway. At this path avalanches are funnelled into a narrow gully with 38-deg incline at the lower end. That on 12 January 1982 was moist, with a powder snow component and an estimated mass of 6000 t. The deposit was moderately fine in texture and at the railway line was 2 to 18 m deep and 70 m wide.

COMMENT

Twenty-eight men were working on an earlier avalanche deposit with minimal consideration for further avalanches since this was not a prime

avalanche site. Some workmen, among them the victim, were not wearing rescue transceivers and others carrying transceivers did not know how to operate them.

In a public inquest held on 24 February 1982 the jury recommended that the railway company:

- hire someone with avalanche knowledge,
- develop a safety and rescue program,
- cooperate with the Ministry of Transportation and Highways,
- train and equip men working in avalanche areas.

These recommendations have been complied with. In addition, the railway plans to move the tracks laterally away from the hillside as a means of reducing the avalanche hazard and depth of avalanche snow on the track.

Source: Michael Zylicz, Terrace, B.C.

HEALY CREEK, BANFF NATIONAL PARK 15 JANUARY 1982

Two skiers buried

WEATHER AND SNOW CONDITIONS

Daily weather and snowpack observations are made at the Sunshine ski area, elevation 2145 m and 4 km to the southeast. The elevation is about the same at the accident site.

Date 1982	Time	Temperature Max °C	Temperature Min °C	New Snow cm	Snow Depth cm	Wind km/h
13 Jan	08:00	-8	-13	2 (drifted)	116	W 5
13 Jan	15:00	-5	-10	2 (drifted)	118	SW 24
14 Jan	08:00	-5	-10	9	135	W 16
14 Jan	15:00	-6	-8	2	134	SW 28
15 Jan	08:00	-6	-32	11	141	W 5

The snow profile of 18 January (Figure 25) is typical of that in the area. Following is a testimonial that one of the members of a party of skiers wrote after the accident.

BACKGROUND

On the afternoon of Friday, 15 January 1982 Alex, Bryne and myself shared the dubious honour of being initiated into the real world of avalanche danger. From that experience we learned some valuable lessons about winter back country travel.

At the Bourgeau parking lot we checked our "Pieps" and set out under sunny skies. The temperature was -27°C with little wind, although we did note plumes of snow being blown off the ridgeline to the north of our trail. A few skiers ahead of us had broken trail through 20^{+} cm of new snow. As we knew that the snowpack conditions were deteriorating in the Kananaskis and had heard on CBC radio that the avalanche hazard in Banff was high, we exercised caution when crossing the avalanche slopes between the Bourgeau lot and campground A8. When we stopped for a rest I skied off the trail to test the snow. It collapsed 30 or 40 cm below the surface. "We'll really have to watch it today," I commented.

At the campground we turned north up a creek through the trees. We were breaking trail in deep powder on a creek bed strewn with boulders and logs. Because of difficulties with the skins on our skis natural spacing occurred between members of the group, with Bryne skiing at the fore and myself struggling at the rear.

The terrain changed from low moderately-sloped banks characteristic of a medium gradient drainage to a more steep-sided V-shaped valley with spruce forest and intermittent open stands. At about 100 to 150 m below treeline there is an obvious avalanche track on the west side of the stream, with stunted trees and a break in the forest. Compensating for this we stayed on the east side of the creek bed, and it was at that location that the slope on our side released and buried Alex and myself.

BEING AN AVALANCHE VICTIM

There was very little sound to it. I saw snow tumbling down in front of me and uttered "oh yeah" in recognition of what was happening. In an instant the snow changed direction in the creek bed and came downhill to quickly bury me to my waist and in another half second, totally. I was coughing snow and frantically trying to keep my right hand over my mouth thinking that I was about to die. All of this happened over a period of about 3 to 5 s - I think - and the snow stopped moving. Hearing myself coughing and breathing quickly, I realized that I had to get my breathing under control and assess my situation. That fragment of organization quickly developed into hope as I realized that light was filtering through the snow above me. I thrust my hand upward toward the light and in a few seconds had an airhole to the surface and could see the blue sky. My sense of good fortune was immediately overwhelmed by concern for my two friends and about the snow that might still be on the slope. A few seconds earlier my struggle to survive had been absolutely egocentric and now my mind was struggling with external factors.

There were several problems involved in getting out of my predicament to help the others. Although the snow on top of me was loose, my body was packed in solidly. I had a shallow breath because I couldn't expand my chest and my left arm was packed in. I was still in a standing position. My skis had released, my right foot was packed in snow and my left foot had kicked a hole in the loose snow between two logs. It was impossible to push up through the snow with my feet because my right foot just sank further and my left was in an air space. With my one free limb I widened the hole to the surface to about 45 cm across. In doing so I realized a second problem: where to put the snow I excavated. With my free arm I "elbowed" a small hole at shoulder level, then started to dig at the snow around my chest, shoving that snow into the elbow hole which filled quickly. In starting to dig at my chest I found a most useful tool, a ski pole. Rotating the pole on its axis, I freed it and in doing so freed more of my body, from my chest all the way down to my left knee. As I pulled the pole up, the snow it displaced trickled down the hole and into the air space that my left foot was dangling in. I seized upon this and rammed the pole down three or four times, using an augering motion. In a minute I was able to move my chest and free my left arm, which had the hand through the strap of the ski pole.

I have laboured over this excavation process because (a) the time factor was pressing and it quickly became evident that it would be no "piece of cake" getting out, (b) if one does not have his act together a 20- or 15-min excavation effort could lapse into an hour-long ordeal.

RESCUE

Just as I was really starting to clear snow in a significant way, Bryne's face peered down at me from the surface and upon seeing me registered some relief. He asked me if I was all right and I said "Yes, how's Al?" Replying that he'd uncovered Alex's face and found him conscious and breathing, he pulled me out of the hole.

Bryne had been on the upstream edge of the slide and was buried only up to his knees. He had noted Alex's and my positions and immediately began to probe the snow where he last saw Alex. He then started working with his Pieps transceiver and located Alex quickly with the second lowest and lowest settings. Bryne dug with his hands and found Alex's ungloved hand about 1 m below the surface. He dug further and located Alex's head. Alex asked him to clear his mouth and nose, then Bryne went to find me.

My avalanche shovel was in my pack, which remained on my back. Bryne's was in the trunk of my car. It took Bryne between 3 and 5 min to dig a 1.25 m hole to Alex just with his hands. When I arrived it took a further 5 to 10 min to extract Alex after a hasty body examination. The shovel was required to move the medium hard packed snow that encased his body.

First aid consisted of 1) body examination of limbs, spinal column, chest and pelvic girdle before extraction from the hole; 2) re-warming with space blankets, down jackets and hot tea; 3) re-warming of Alex's right hand in my armpit; 4) psychological reassurance, because Alex displayed symptoms of psychogenic shock compounded by mild hypothermia. Alex's right hand was frozen because he thrust it up in a last effort to contact the surface, and the moving snow took his glove off.

When we thought that Alex was able, approximately 30 to 40 min after the commencement of first aid, we skied back to the trailhead as quickly as possible. Considering our state of physical and mental fatigue, we made good time. Alex was examined at Banff and by his doctor at Canmore. He had second degree frostbite to his right hand and stretched ligaments in one knee.

CHARACTERISTICS OF THE AVALANCHE

The event was a Size 2 avalanche: enough snow to knock down and bury a person but not sufficient to bury an automobile. The snow came off in a definite slab and was dry in consistency. The fracture, 30 to 50 cm deep, occurred approximately 30 m above the creek bottom and the slide was approximately 50 m wide. It is presumed that shock waves given off by the skiing motion triggered the avalanche. The slope incline was 30 to 40 deg. The slope appears to be a grassy, SW facing opening in spruce forest with trees at the top and sides. The entire avalanche stopped in the creek bottom to a depth of 3 m at centre and 2.5 m at the lower edge. A layer of snow remained on the slope after the event, but it was not measured.

Bryne was on the upslope (upstream) margin of the slide and hence was not buried deeply. Alex, being in the direct line of the main flow, was knocked down and buried.

SUMMARY OF MISTAKES AND OVERSIGHTS

1. All members should have been equipped with shovels, transceivers, and probes. Bryne left his shovel behind because I was carrying one. Avalanches are not selective!
2. A group leader should have been assigned. This is a particular problem among close friends because nobody likes to assume a dominant role. Someone, however, has to say, "Well boys, given the signs of snow instability, etc, we should be very cautious about taking this route, perhaps we should agree on another."
3. We learned a lesson about terrain. Avalanche hazard is not confined to obvious tracks or expanses of open terrain.
4. I was caught with my hands through my pole straps and waist belt fastened because I didn't perceive the hazard.
5. When using cross-country gear, cable bindings should be as loose as possible while keeping the boot in place under normal skiing conditions. When I was caught by the snow my skis released, reducing my extraction time from the hole significantly. We had to dig all the way down to Al's skis, which didn't release, to get him out. They may have been responsible for the soft tissue damage to his knee.

THINGS WE DID RIGHT

1. We had Pieps and tested them before setting out.
2. We had adequate resources to warm a hypothermic victim. Our first-aid was fast and efficient.
3. Bryne did an excellent job of systematically locating Alex and me and displayed good judgement in priorities.
4. We were all relatively fit, physically and mentally, and were therefore able to cope with an emergency.

Source: Pat Harrison, Canmore, Alberta.

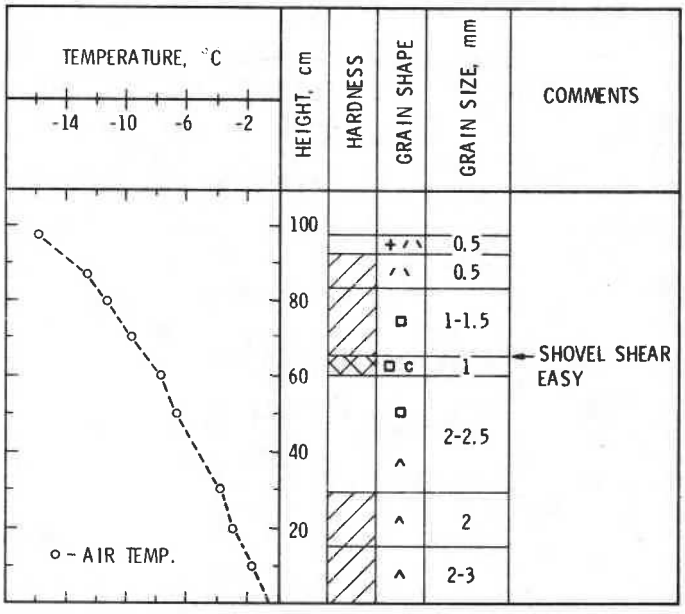

FIGURE 25

SNOW PROFILE AT WAWA RIDGE, SUNSHINE SKI AREA, OBSERVED 18 JANUARY 1982

PURCELL MOUNTAINS, B.C. 18 JANUARY 1982

Two skiers killed

WEATHER

Observation at Bugaboo Lodge
(Elevation 1490 m, 8 km NW of accident site)

Date 1982	Time	Temperature Max °C	Temperature Min °C	New Snow cm	Storm Snow cm
7-9 Jan				Light snowfall	Total 3 cm
10-11 Jan				Light snowfall	Total 6 cm
13 Jan	16:30	+1	-10	0	0
14 Jan	07:15	-2	-3	12	11
	16:15	-2	-3	4	13
15 Jan	07:15	-2.5	-6	4	15
	16:30	-6	-15	0	0
16 Jan	07:25	-15	-22	0	0
	16:20	-18	-22	5	5
17 Jan	07:20	-17.5	-18.5	8	12
	17:05	-10.5	-18	T	T
18 Jan	07:25	-12	-14	1	1
	18:15	-7	-14	0	0

The wind was variable on the days before the accident, with prevailing direction southwest. Except for deeper snow in the upper part of the avalanche path no accumulations of drifting snow were noticed. At the time of the accident the visibility was good and the entire avalanche path could be seen.

ACCIDENT SUMMARY

At 14:45 h a group of skiers landed by helicopter at the top of downhill run "69," which they and two other groups had already skied before lunch. The group comprised a guide and ten clients, and all carried avalanche rescue transceivers.

The guide descended to a small ridge in the centre of the slope, intending to reassemble his group there. As he was walking up the ridge, however, he looked back and saw an avalanche breaking above the group. Seven clients had reached the outcrop, but three were still below in a shallow gully on the left. The guide's warning shout alerted the three, and two of them managed to reach the ridge. Meanwhile, five of the seven

already on the ridge panicked and skied down into the gully on the right. The avalanche, being larger than expected, overshot the ridge so that the five persons there were tumbled in the air and moved a short distance, but they remained on the surface. The skiers in the two gullies were engulfed by the deeper snow. When the avalanche stopped the five on the ridge and one in the right gully who had managed to ski to the far right edge were safe (Figure 26).

RESCUE

The survivors immediately started a transceiver and made a hasty search for the missing four party members in the gully on the right. They found one skier half buried, another whose hand was sticking out, and a third whose hair was just visible on the snow surface. After 13 min the fourth was located by transceiver under about 1 m deep snow. He was facing downhill, face to the side and 0.8 m deeper than his legs. Artificial respiration was initiated immediately, but a physician who was among the skiers pronounced him dead from asphyxiation.

Meanwhile, another group had landed at the top of the run when the avalanche occurred and within a few minutes joined the transceiver search. Twenty minutes after the avalanche had occurred the second group located the skier who had been caught in the left gully. He was buried 1.5 to 2 m deep and had died from a head injury.

AVALANCHE

The avalanche initiated as a failure of a snow slab, with a depth between 0.3 and 0.5 m (Figure 27). The lubricating layer at the bed surface contained facetted crystals and new snow crystals with sectorlike branches. This layer was probably at the snow surface during the very cold weather three weeks prior to the avalanche and was subsequently covered by new snow between 7 and 18 January. The fracture was not confined to the slope and gully above the skiers, but propagated 400 m around a rocky ridge into an adjacent gully and into the moderately steep slope below the helicopter landing site. The avalanche started about 200 m above the skiers at an elevation of 2580 m on a 37-deg slope with south aspect. It ran 1000 m, dropping 420 m in elevation on an average incline of 25 deg. The incline of the run-out zone was 5 to 10 deg, and the snow was deposited to a maximum depth of 2 m, with an average of 1 m. The avalanche snow was dry and fine at the tip of the run-out zone, but chunky with particle sizes of 0.3 to 0.5 m in the upper part.

COMMENT

The guides were aware of the instability of the snow from observing the weather, snow profiles, and a series of natural and explosive-released avalanches on 11, 12 and 15 January. A combination of several circumstances led to the accident in spite of this knowledge.

1) Run 69 was considered low risk because very few avalanches had been observed there in 13 years of regular skiing; it faces the prevailing wind, and an avalanche slope must be crossed for only a short distance.

The ridge between the two gullies was normally a safe place for regrouping skiers.

2) The failure of the snow propagated high and into adjacent slopes. Starting above, the avalanche had a large mass and a considerable speed when it reached the group, so that it over-ran the usually safe ridge. Experience has shown that snow failures can propagate over long distances when the slab overlying a weak layer is relatively hard. In this case the hard layer above the bed surface, evident in the snow profile (Figure 27), could have been responsible for the widespread failure. It was surprising that the hard layer was only 5 to 10 cm thick. Usually failures that propagate over long distances are associated with deep snow slabs.
3) The guides were under client pressure because snow and weather had been unsatisfactory the day before and few long runs could be skied safely on 18 January.
4) The skiers were inexperienced in mountain terrain and not familiar with avalanches. As a result, some of them did not recognize the ridge as the safest place, moved into the gully, and exposed themselves to the deep flowing snow.

The lesson to backcountry skiers is: Be aware that avalanches can break above you and consider the hazard from slopes above.

Source: Paul Anhorn, Rogers Pass Field Station, Revelstoke, B.C.

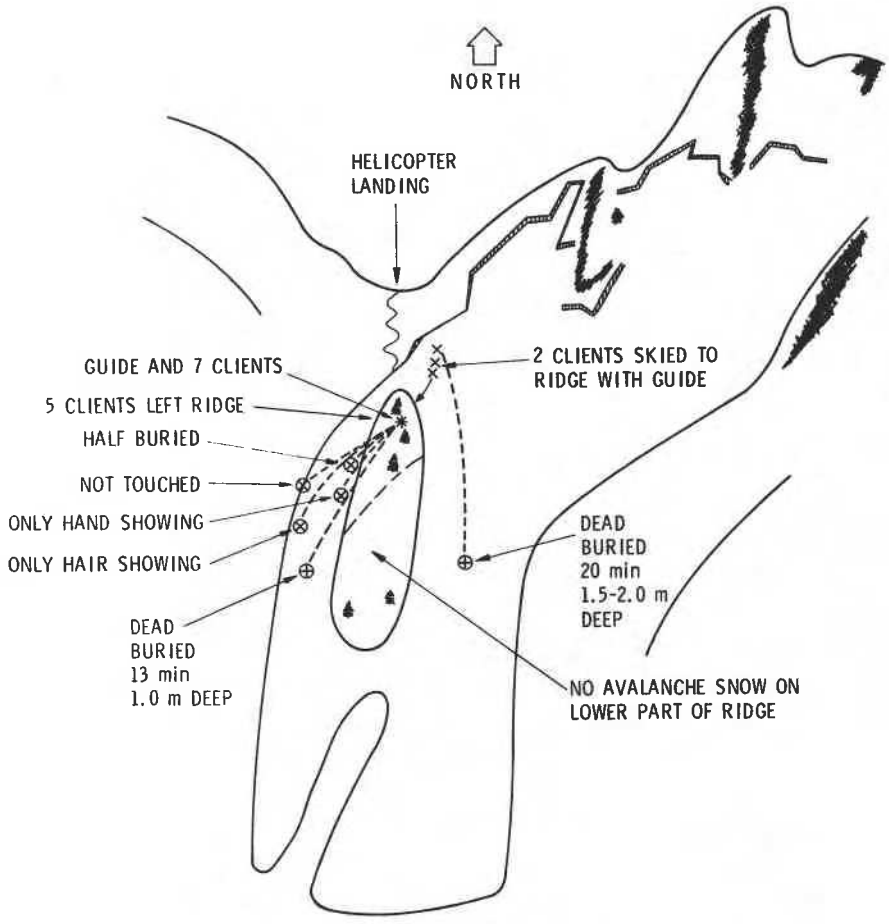

FIGURE 26

SKETCH OF AVALANCHE IN PURCELL MOUNTAINS SHOWING LOCATIONS OF SKIERS

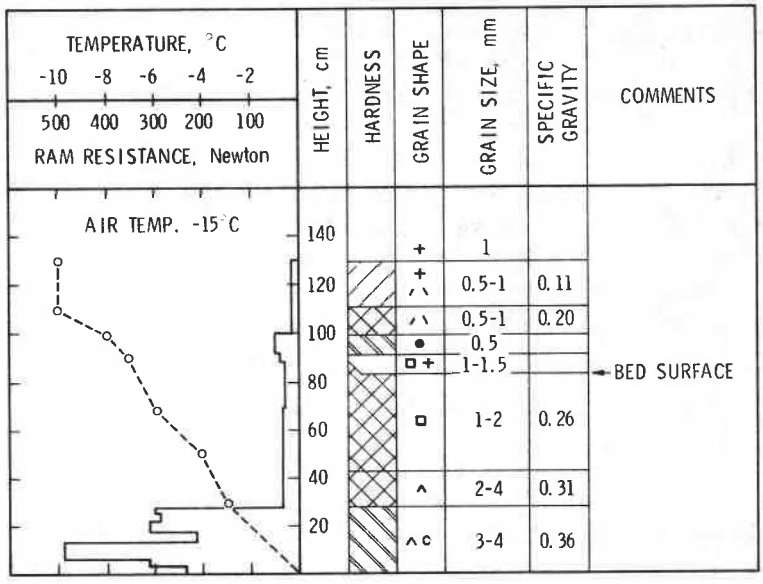

FIGURE 27

SNOW PROFILE AT FRACTURE LINE OF AVALANCHE IN PURCELL MOUNTAINS, OBSERVED 19 JANUARY 1982

CIRRUS MOUNTAIN, BANFF NATIONAL PARK 5 FEBRUARY 1982

One mountain climber killed

Until mid-January the winter of 1981-82 was characterized by colder than average temperatures and below average snowfall, resulting in a weak snowpack (Figure 25). During the remainder of the winter the snowfall was average.

A solo climber left the Cirrus Mountain campground in the morning of 5 February for an ascent of the Polar Circus ice route on Cirrus Mountain. At approximately 15:00 h climber friends noticed a fresh avalanche across the route of the solo climber. When they returned to the trail head in the evening they found his car still there.

After reporting the overdue climber to the Park Warden at Saskatchewan Crossing at 22:00 h, the reporting friends returned to the trail head and climbed along the ice route. At approximately 1825 m elevation they found the missing man at the base of the first ice pitch. His body was evacuated by helicopter at 11:00 h on 6 February.

Analysis led to the conclusion that the victim had triggered a slab avalanche while traversing the top of a steep snow slope at about mid-height of the climb. He was carried approximately 100 m down over a series of moderately angled steps and then over a 25-m waterfall. It was evident that he had sustained significant injuries but was able to drag himself to the top of the next pitch where he fell while setting up rappel anchors, or perhaps the anchor failed during the rappel.

The climber was very experienced, but he had traversed snow deep enough to carry him away. Two or more climbers together probably would have been able to belay and prevent the fall.

Source: Warden Service, Banff National Park.

MARMOT BASIN, JASPER NATIONAL PARK 22 FEBRUARY 1982

One skier killed, one injured

WEATHER

Observations at Marmot Basin, elevation 2067 m

Date 1982	Temperature Max °C	Min °C	New Snow cm	Snow Depth cm
18 Feb	-1	-9	2	106
19 Feb	-3.5	-6	3	110
20 Feb	-2	-5	5	113
21 Feb	-2	-15	20	129
22 Feb	-8.5	-16.5	T	125

On 22 February there was strong loading of the lee slopes in the upper part of Marmot Basin and deep unstable snow layers. In the Marmot ski area the avalanche hazard was advertised as high.

ACCIDENT SUMMARY

Five skiers had reached the boundary of Marmot Basin ski area by climbing and skiing down from the top of the chairlift with the intention of skiing the other side of the mountain. At 12:15 h they triggered a local slump that spread uphill. They waited but saw no avalanche and decided to enter the gully. The first person down had stopped to take pictures of his friends when the uppermost skier heard and saw the area 300 m above him fracture and called a warning. The top three skiers were able to reach the side and hang on to trees as the avalanche went by, but one who had fallen before the warning and the photographer were quickly engulfed and carried down (Figure 28).

RESCUE

After the avalanche, two of the survivors started to search from the top down, while the third went to the ski area for help. On his way he found one injured friend partially buried at the base of the avalanche deposit. After ensuring the victim's safety he continued, reached the road, got a ride to the Marmot office and notified the Park Wardens. The time was 13:00 h. A first party consisting of a dog master with dog, four park wardens, five ski patrollers, two civilian volunteers, and the returning survivor was on the accident site at 14:00 h. It soon became evident, however, that more manpower and additional dogs were needed. The broken trees in the avalanche deposit made searching and probing very difficult. The injured skier, who had a broken leg, was flown out by helicopter to the Jasper Hospital. Finally at 15:55 h the second victim was found by the avalanche dog 0.5 m under the snow and 100 m above the injured person. The victim had died from multiple injuries suffered when he hit trees.

AVALANCHE DATA

The avalanche was a size 4 dry slab triggered by the skiers from below. It started on an open northeastern slope, descended 150 vertical metres into a gully, made a right angle turn and ended 350 vertical metres lower. The total distance covered was more than 1.6 km. The 300-m wide fracture line was 1.0 to 3.5 m deep in drifted old snow on a layer of depth hoar. In the starting zone the average slope angle was 35 deg and in the gully 25 deg. A large amount of tree damage was apparent. In the lower part of the gully the deposited snow reached a maximum depth of over 7 m.

COMMENT

Probing was difficult and time consuming in the very large deposit full of broken trees, and it proved to be invaluable to have a trained avalanche dog in the area. Thanks to him and to the use of a helicopter the rescue was concluded in daylight.

Source: Warden Service, Jasper National Park.

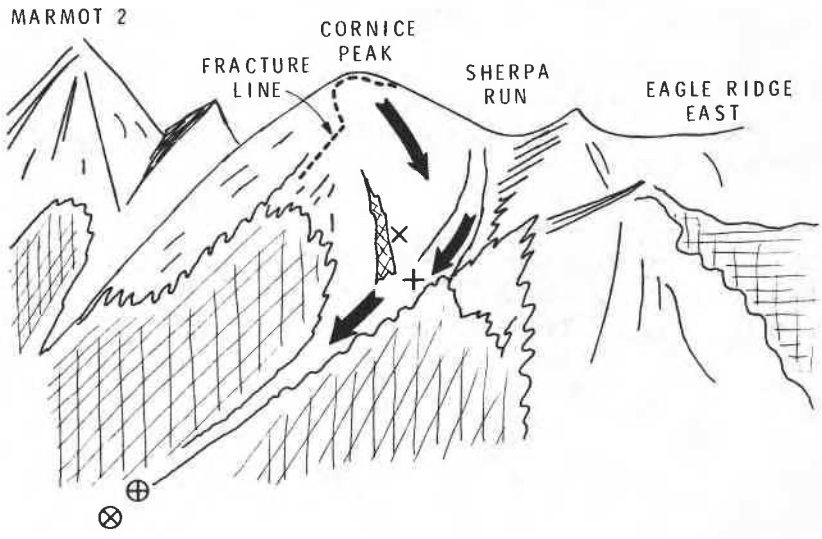

FIGURE 28

SKETCH OF AVALANCHE PATH AT MARMOT BASIN
+ LOCATION OF PHOTOGRAPHER BEFORE AVALANCHE
× LOCATION OF THE FOUR OTHER SKIERS BEFORE AVALANCHE
⊕ LOCATION OF FATALITY (PHOTOGRAPHER)
⊗ LOCATION OF PARTIALLY BURIED, INJURED SKIER
THE SKI AREA IS BEHIND THE RIDGE

MOUNT LOGAN 11 JUNE 1982

Three climbers killed

A party of seven climbers from Colorado was attempting an unclimbed north ridge of Mount Logan. At about 11:00 h on 11 June 1982 their camp at about 4730 m was struck by an avalanche. Two members of the party who were outside their tents when the avalanche struck were swept about 60 m below the camp. They were able to climb back to the campsite and dig out two other members of the party. The four then dug for the remaining climbers, using their hands and whatever tools were available. After another 2 h they discovered the body of one of the missing three climbers. Throughout their search they had found no air pockets or signs of life and at that point decided to see to their own survival as it was storming and they needed shelter.

On 12 June another slide covered the area. Not until 13 June were they again able to excavate at the site to look for their radio, which would be of assistance in saving their lives. They managed to uncover the bodies of two members of the party and the radio, but they never did find the third body.

About 16:00 h on 13 June, as weather was again moving in, they packed up what gear they could and moved down to the point from which they were eventually picked up around noon on 16 June. Three of the surviving four climbers suffered some frostbite on their feet and hands.

There is probably no way to avoid avalanche hazard on this route, and it is not known whether a safer campsite could have been found. It was fortunate that these climbers had a radio and were able to obtain assistance.

Source: Accidents in North American Mountaineering, Vol. 4, No. 6, Issue 36, 1983, p. 17 (published by The American Alpine Club and the Alpine Club of Canada, Banff, Alberta).

BUGABOO, B.C. 19 AUGUST 1982

One mountain climber killed

ACCIDENT SUMMARY

On 19 August 1982 at about 17:00 h a large chunk of rock broke off near the top of Bugaboo Spire in the Purcell Mountains, fell over the east face to a snowfield below, and set in motion a wave of snow. The combination snow and rock avalanche stopped 500 m lower on the Crescent Glacier. The debris deposit was 400 m wide and 100 m long.

A single mountain climber who happened to traverse the snowfield at the moment when the avalanche occurred was engulfed and buried.

RESCUE

Because a climber who had been seen in the area 15 to 20 min prior to the rockfall failed to return to his camp, authorities were advised to conduct a search on the following morning. A team consisting of a dog handler of the Royal Canadian Mounted Police and a member of a cliff rescue group was flown to the site. The searchers assumed that they had to deal with a rockfall only and brought no probes. A second team with an avalanche dog, probes, and heavy shovels was requested because of the size of the area to be searched and the impending danger of continued rockfall. Thirty minutes after a second dog team had arrived the dog located a pair of sunglasses and within a short time a rucksack and the body. The victim was found head down with his climbing helmet crushed.

COMMENTS

It was extremely bad luck that the victim happened to be in the path when the low probability event occurred. Although the avalanche was a combination of rock and snow, the climber was completely buried in snow. The chance of snow burial is present all year round in high mountains, and consequently rescue groups should be prepared for snow avalanche search and rescue.

Source: Gordon Burns, Cranbrook, B.C.

MT. ROBSON 20 AUGUST 1982 (approx)

Two mountain climbers killed

On 25 August 1982 the RCMP at Valemount were contacted by family members and reported to the Jasper Warden Office that two climbers were missing on Mt. Robson. Poor weather delayed a search until 26 August. At approximately 13:15 h the bodies of the two climbers were found by helicopter search in the west bowl of Mt. Robson. They were evacuated by heli-sling by 16:30 h.

It appeared that the victims had descended the west face of Mt. Robson by rappel, using a 9-mm rope, and were hit by an avalanche at about the 3000-m elevation. The lead climber seems to have set an anchor when the upper climber was hit. The rope appeared to hang up on a rock between the two and when the upper climber's tie into his harness failed he was carried down to approximately 2280 m elevation, half way down the snow fan below the bowl. The other climber was found above, tied into the rope, but he had sustained fatal head injuries from falling rock.

The victims ascent route was unknown. They chose a descent route that was exposed to snow avalanches and rockfall and were caught in the midst of it.

Source: Warden Service, Jasper National Park.

MT. KITCHENER, JASPER NATIONAL PARK 22 AUGUST 1982

One mountain climber killed

In the afternoon of 21 August 1982 two climbers departed for an ascent of Mount Kitchener by the difficult Grand Central Couloir route. At 23:00 h they had reached the couloir. At 11:30 h on 22 August they abandoned the climb owing to bad snow conditions and descended the couloir. At approximately 17:00 h they stopped to wait for cooler temperatures, after observing several avalanches running from the central face. At 18:30 h they continued their descent, unroped, on the snow fan below the upper bergschrund at the base of the couloir.

One man was well below the other who was clearing balled snow from his crampons when they heard an avalanche above them. The upper climber was able to reach a safe location on a ledge, but the lower one was carried 60 m down over the icefall and partially buried. When the avalanche stopped the climbers established voice contact, but a second more violent avalanche followed almost immediately and the safe survivor lost contact with his companion. After climbing down around the icefall the survivor located the victim's pack in the bergschrund. He dug down and uncovered the victim's head and shoulders, but he found no signs of life. The accident occurred at approximately 20:00 h.

The survivor walked to the valley and reported the accident to the Warden Service at 22:30 h. At 08:00 h on 23 August a Parks Canada rescue team flew to the site by heli-sling and found the victim buried in a standing position, with multiple injuries and dead from asphyxia. The avalanche was comprised of wet snow mixed with rock debris.

The Grand Central Couloir of Mt. Kitchener is one of the more demanding ice climbs in the Canadian Rockies and is a goal of many climbers. Unfortunately, the upward angling couloir channels avalanches that come from the face and becomes a trap for anyone in it.

Source: Warden Service, Jasper National Park.

LAKE LOUISE, ALBERTA Estimated NOVEMBER 1982

One mountain climber killed

On 25 June 1983 a guide discovered a partly buried body at the junction of the Lower Lefroy and Victoria Glaciers. The discovery was reported to the Warden Service at Lake Louise, and on 26 June Park Wardens dug out and evacuated the body.

Because the victim was wearing hiking boots it was presumed that the accident had occurred in November when the snow was not deep enough to prevent travel on foot. The victim seemed to have been hiking alone. His pack was found tied to the end of a climbing rope. At the other end a loop was tied into the rope, presumably to be clipped into the carabiner attached at the victim's waist. The pack and rope were discovered in an avalanche deposit at the foot of a 35-deg talus slope with a 15-m cliff band mid-way up the slope.

From circumstantial evidence it appeared that the victim was attempting to ascend the short cliff band and haul his pack behind him when he triggered a slab avalanche and was carried over the cliff to the toe of the talus slope. He probably unclipped from the rope and buried pack and attempted to return to Lake Louise. While traversing the toe of a steep moraine he apparently triggered a second avalanche above him that buried him in a V-shaped terrain trap. A poor choice of route and travelling alone when the snow was unstable were the primary causes of this accident.

Source: Warden Service, Banff National Park.

MOUNT SHEER, B.C. 27 NOVEMBER 1982

One hiker killed

LOCATION

The accident occurred at elevation 1600 m in the west bowl of Mount Sheer (1690 m) near Britannia Beach, B.C., and 36 km north of Vancouver. Mount Sheer is in the mountain range that borders the east side of Howe Sound.

WEATHER AND SNOW

The winter climate at Mount Sheer is typical for the Pacific Coast: heavy precipitation, temperatures around 0°C, and depth of snow increasing strongly with elevation. Weather observations at Squamish (10 km north at sea level) and at Whistler Mountain (50 km north, elevation 1600 m), snow profiles observed at the site on 1 December, and statements of witnesses of the accident indicate the snow and weather conditions at the accident site.

On 25 November, two days before the accident, the snowpack was about 130 cm deep and contained layers as follows:

0 - 50 cm from ground: soft snow deposited in the early part of October had changed to 1-mm large facetted crystals under the influence of clear cold weather in mid-October.
50 to 120 cm from ground: hard, dense snow deposited between 25 October and 7 November was well consolidated owing to high temperatures.
120 to 130 cm from ground: several thin layers of snow of variable hardness and different stages of metamorphism had been deposited between 15 and 20 November in a series of light snowfalls.

On the evening of 25 November and in the morning of 27 November 30 to 40 cm of new snow had accumulated, probably with a weak bond to the old surface. During the daytime hours of 27 November the snowfall was light, adding only a few centimetres, but it became heavier in the afternoon and continued for three days. By 30 November the storm had deposited 80 to 100 cm of new snow.

The temperature was low initially, but it gradually rose during the storm. On 27 November the freezing level was at 1200 m above sea level, rising later to about 1500 m. The wind was light from the south.

ACCIDENT

Six boys, age 13 to 17, together with an instructor from a local youth camp were on an overnight trip in the upper reaches of Britannia Creek. They left their packs at Park Lane Lake, elevation 1100 m, and hiked first on foot and later by snowshoe through the large West Bowl with the intention of climbing Mount Sheer. Near the top of the bowl, before reaching the ridge, the leader determined that the snow conditions were hazardous and ordered the group to turn back. At about 16:00 h, when all seven members of the party had started their descent, they released a slab avalanche that

carried them about 200 m down into a shallow gully. The leader observed the boys as they went down with the avalanche and called to them to swim and to fight to stay at the surface.

When the avalanche stopped, four party members including the leader were partially buried and unhurt but two were completely buried. The survivors stated later that fighting saved them from being buried completely. The partially buried boys freed themselves quickly. Because the leader had observed the position of everyone during the descent of the avalanche the other two could be located 20 min later and dug out. One was unhurt, but the boy who was lowest on the slope when it slid was found 20 to 30 min later unconscious, without heartbeat, and not breathing. He was under about 1.5 m of snow. The leader immediately initiated CPR, and ordered one of the boys to descend to Park Lane Lake to call for help on a portable radio that had been left there. The others built a shelter and prepared to spend the night at the accident site. Except for one shovel the party carried no avalanche safety gear.

RESCUE

At about 18:00 h the messenger arrived at Park Lane Lake and made radio contact with the radio operator of B.C. Telephone Company. It took another hour, however, for the message to reach the police at Squamish because radio transmission was bad, the boy was unfamiliar with the radio and had not given a clear description of what had happened. Additional delays occurred in organizing the mountain rescue groups from Squamish and North Vancouver, and when the rescuers were finally assembled at Britannia Beach it was debated whether or not the accident site could be approached safely during the night in the heavy snowfall and rain that had begun. At 02:00 h rescue parties were flown by helicopter to Park Lane Lake and started on skis and snowshoes towards Mount Sheer. The first party reached the youth group at 05:00 h; it included a doctor who determined that the victim of the avalanche was dead. The lack of obvious injuries strongly suggested asphyxiation. The other boys were suffering from various degrees of hypothermia and frostbite, but were able to walk first to a safe area outside the avalanche slopes and, when daylight arrived, to Park Lane Lake. They were picked up there by helicopter at 09:00 h.

AVALANCHE DATA

The west bowl of Mount Sheer contains slopes of variable incline and aspect where numerous avalanches can be expected to occur during heavy snowfalls. The slope on which the party was caught had an incline of 30 to 35 deg, was treeless, and faced northwest. The members of the accident party reported that the soft slab avalanche was 10 m wide and the fracture about 0.4 m deep. This would lead to the conclusion that the 30 to 40-cm deep new snow had started to slide on the old snow, but the fracture might have broken into the deeper weak layer after the initial failure.

The avalanche stopped on an incline of 18 deg in a shallow gully where the depth of the avalanche snow increased to 2 m. No other data of the avalanche could be obtained because heavy snowfall and later avalanches soon

obliterated all evidence. Even the reports of the exact location of the avalanche starting zone were conflicting.

COMMENTS

On the southwest coast of Canada instabilities in the snow are usually confined to the surface of the snowpack and have a short duration. Deep weak layers such as those that developed in November 1982 are observed no oftener than once in three years and are therefore beyond the experience of many backcountry travellers. The leader of the party was familiar with the terrain and had covered the route several times before, both summer and winter. Because there is not normally in November enough snow to produce avalanches, he might have had a false sense of security.

After the accident the party spent the night in the avalanche zone, exposed to further danger. Luckily no other avalanche occurred, but a large one covered the area about 3 h after the survivors were rescued.

The party neglected one of the basic safety measures: spacing out when crossing avalanche slopes. By maintaining wider distances between members it might have been possible to avoid having six people caught in the 10 m wide avalanche.

On 10 February 1983 a coroner's jury ruled that the accident was accidental. Because communication problems had considerably delayed the rescue, the jury made a series of recommendations designed to improve communications between hiking groups, the Royal Canadian Mounted Police, and rescue organizations. Further, it recommended that parties going into potential avalanche areas carry transceivers, shovels, probes, maps and other necessary mountaineering equipment, and that leaders and party members be trained in their use.

Source: Frank Baumann, Squamish, B.C., and Peter Schaerer.

APEX MOUNTAIN, PENTICTON, B.C. 8 JANUARY 1983

One skier killed

WEATHER

Observations at the base of Apex Ski Area

Date 1983	Temperature Max °C	Temperature Min °C	New Snow cm	Total Snow cm
4 Jan	-2	-6	4	85
5 Jan	-2	-3	25	106
6 Jan	-2	-9	1	104
7 Jan	+1	-5	5	106
8 Jan	+1	-7	28	130

Snowfall had ended at 06:00 h on 8 January and at the time of the accident the sky was clear and the temperature estimated at -4°C. Wind was blowing from the west at 20 km/h.

ACCIDENT SUMMARY

At about 10:45 h a local skier was approaching a grove of pine trees about half way down Grouse Gulch to practise slalom when he released an avalanche around and slightly above him. He tried to outski it, but the moving snow engulfed him, tossed him against trees, and moved him down the mountain. He only came to a stop when he was hurled against a pine tree, partially buried and unconscious. On regaining consciousness he started to dig himself out and called for help. Another skier riding on the chairlift heard his voice and alerted the lift operator at the top who, in turn, sounded the alarm with the ski patrol. At that time nobody knew how many people might have been caught in the avalanche.

RESCUE

Twenty searchers, including the badly bruised survivor, were on the site 35 min after the accident. When a skipole was found that did not belong to him, the survivor remembered having seen another skier entering the slope. A searcher uphill found the missing skier when he detected his hand sticking out of the snow. The victim was uncovered at 11:55 h, but although ski patrollers and two doctors tried for 20 min to revive him they were unsuccessful. The buried skier was lying on his back under 0.6 m of snow. An autopsy later verified that death was caused by asphyxiation. The odd skipole matched that of the victim. Later, an avalanche dog combed the entire deposit but found no additional equipment or clothing.

AVALANCHE DATA

The avalanche started at an altitude of 1930 m and ran a distance of 150 m, dropping 90 m vertically. The average gradient of the channelled slope was 37 deg. The skier started the avalanche in the middle of a convex slope in open forest, and although the fracture was only 23 m wide it was 0.9 to 1.1 m deep. The bed surface was on a layer of depth hoar close to the ground (Figure 29).

COMMENT

The slope was not a regular ski run but was popular with expert skiers. Earlier in the morning a ski patroller had skicut the slope above and removed the "Avalanche - Closed" sign, but the lower, steeper, treed slope had not been touched. The danger was still posted in other steep areas. All uncontrolled areas should have remained closed owing to the poor stability depicted in the snow profile (Figure 29).

Source: Ski Patrol, Apex Alpine Recreations, and RCMP Dog Service, Penticton, B.C.

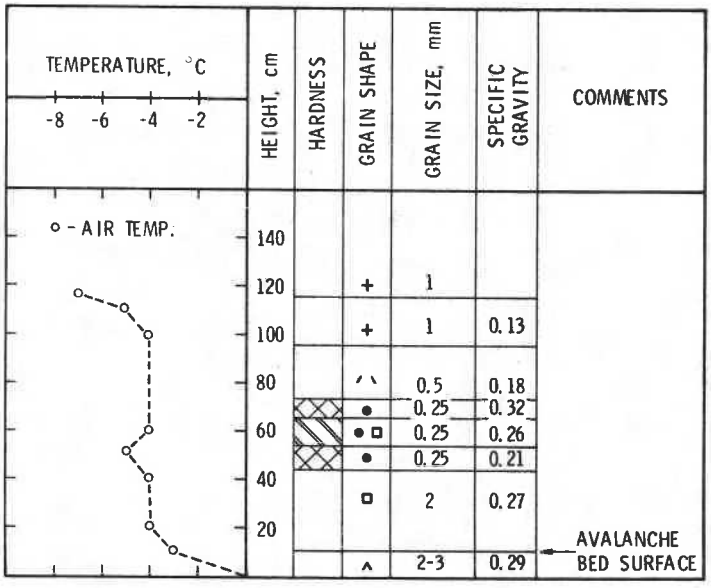

FIGURE 29

SNOW PROFILE AT AVALANCHE FRACTURE LINE, APEX MOUNTAIN, OBSERVED 9 JANUARY 1983

TENT RIDGE, KANANASKIS COUNTRY, ALBERTA 13 FEBRUARY 1983

One skier killed

WEATHER

Alberta Transportation maintains a snow and weather study plot at Mount Buller, elevation 1735 m, 10 km north of Tent Ridge. No significant precipitation was observed there between 9 and 13 February 1983. Air temperatures were as follows:

	Temperature	
Date	Max °C	Min °C
9 Feb	0	-10.5
10 Feb	0	-5
11 Feb	+5	-3
12 Feb	+5	0
13 Feb	+6	-1

Moderate to strong southwesterly winds were observed at the upper elevations along the Spray Lakes valley between 9 and 13 February.

ACCIDENT SUMMARY

At approximately 10:00 h on 13 February five skiers accompanied by two guides, a pilot, and a non-skiing observer left Canmore by helicopter with the intention of skiing at Tent Ridge about 26 km to the south. All skiers were equipped with rescue transceivers. The group was transported in two flights, the second from the Spray Lakes road.

After skiing the first run, one guide took a snow profile and determined that the snow stability was fair at that location. The two groups then made a second run on the same slopes.

A slope known as Grizzly Basin was selected for the third run. One guide moved downhill to check conditions while the second guide and the five clients waited at the top. After skiing part way down, the guide signalled and the skiers descended one at a time to take up a position beside him at the side of the run. The guide then made three traverses of the slope, probing the snowpack with his ski pole. On the third traverse he turned to ski into the gully below, but as he started his descent the slope fractured about 1 m above his highest traverse. He was able to stay on top of the moving snow until the avalanche funnelled into the gully, where the group above lost sight of him (Figure 30). The avalanche occurred at approximately 12:15 h.

RESCUE

The second guide directed the remaining skiers to a rocky ridge adjacent to the slope, then descended the path of the avalanche. When he reached the avalanche deposit he began a transceiver search and approximately 15 min after the avalanche had occurred located the buried guide. By this time the helicopter pilot and the observer had arrived on the scene, suspecting that something was wrong after receiving a broken call on the radio.

Within a short time the victim was uncovered, approximately 1.1 m below the surface and lying at a 45 deg angle downhill, face down. When no injuries were detected the victim was removed from the snow, CPR was administered and was continued during transfer to the helicopter and the flight to Canmore. An ambulance waiting in Canmore transported him to the hospital in Banff, where physicians determined death by suffocation.

After the victim was removed the second guide climbed part way up the gully and ordered the client skiers, who had waited at the top of the slope for approximately an hour, to descend on foot. During the descent the group triggered a second avalanche in an adjacent gully, but nobody was caught. The skiers together with the guide were then flown from the tip of the avalanche to Canmore.

AVALANCHE

The snow failed initially on a layer of surface hoar approximately 40 cm deep (Figure 31), but once in motion the failure stepped down to the ground surface. The crown depth varied from 0.2 to 1.8 m.

The avalanche fractured at the 2395-m elevation on a slope with an easterly aspect and incline of 37 deg. The gully below steepened to 44 deg through a rock band, then opened to a 24-deg slope at the top of the run-out zone. The toe of the avalanche was at an elevation of approximately 2150 m.

The avalanche deposit was approximately 30 m wide, depth varying from 1 to 1.8 m. Several older avalanches were evident in this and adjacent gullies along Tent Ridge.

COMMENT

Ski touring and, to a greater degree, helicopter skiing in the Rocky Mountains require extreme caution. Surface hoar and depth hoar layers often produce a lingering, deep instability and snow conditions vary over the terrain. The guide found fairly stable snow in one area but poor stability on the slope in question. Wind was probably an important factor in the variation of snow conditions. A warning of high avalanche hazard had been issued for backcountry travellers in the adjacent Banff National Park for the three weeks prior to the accident.

Source: Lloyd Gallagher, Canmore, Alberta; Keith Everts, Banff, Alberta.

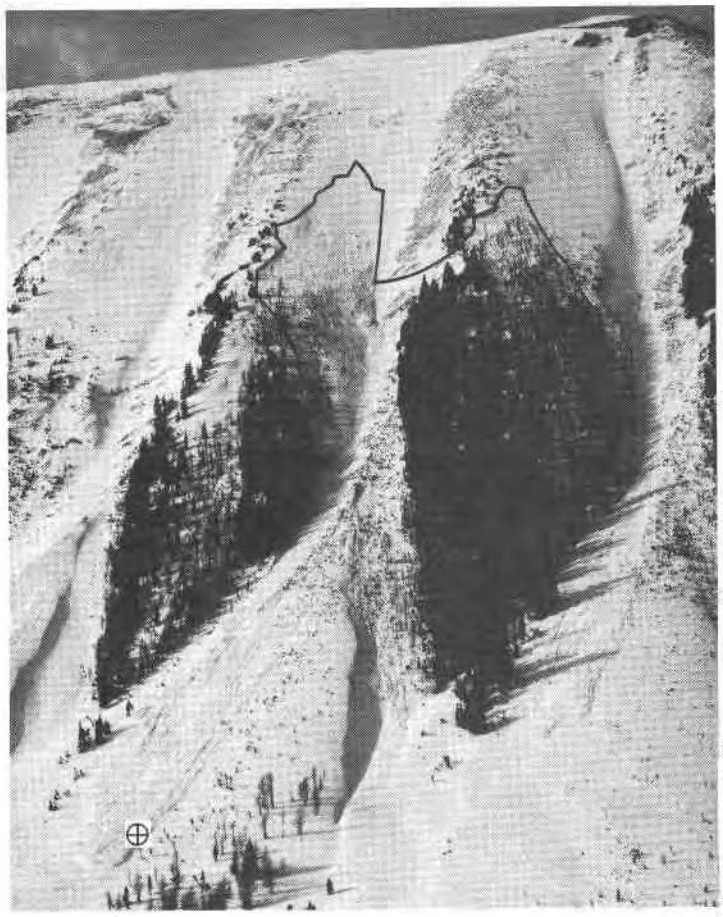

FIGURE 30

AVALANCHE PATH AT TENT RIDGE WITH FRACTURE LINE OF ACCIDENT AVALANCHE AND BURIAL SITE (⊕)
(PHOTO COURTESY JIM DAVIS)

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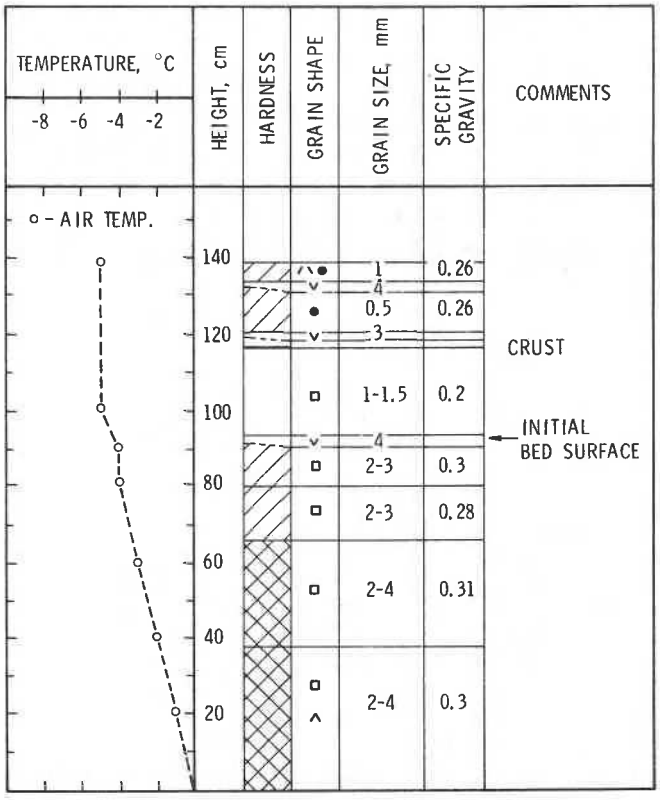

FIGURE 31

SNOW PROFILE AT RIGHT FLANK OF AVALANCHE AT TENT RIDGE (ELEVATION 2355 m), OBSERVED 14 FEBRUARY 1983

ASHLU RIVER, SQUAMISH, B.C. 14 FEBRUARY 1983

One equipment operator buried

WEATHER

Heavy rain and high temperatures, with freezing levels around 2000 m, had plagued the West Coast for several days, causing severe debris flows, flooding at low elevations, and wet-snow avalanches at high elevations.

Observations at Squamish Airport, elevation 59 m

Date 1983	Temperature		Precipitation mm
	Max °C	Min °C	
10 Feb	3	0	56.8
11 Feb	7	1.5	87.0
12 Feb	5	4	61.9
13 Feb	8	4.5	18.1
14 Feb	6	4.5	28.6

ACCIDENT SUMMARY

A D-8 bulldozer operated by an employee of a forest company was clearing avalanche snow from the Ashlu River logging road 42 km by road northwest of Squamish, B.C., at 14:30 h when a large wet-snow avalanche roared down Rab Creek, pushed the bulldozer about 30 m downhill and buried it completely.

RESCUE

Nearby workers from the forest company combed the debris quickly but could find no clues. The search and rescue coordinator at Squamish was notified at 15:15 h. At 16:35 h a rescue team and the RCMP arrived, equipped with probes and a metal detector. After posting a guard equipped with an air horn, the rescuers organized a probe line and instructed other workers to continue to search. Ten minutes later an alert fellow worker, making a hasty search below the last-seen point, detected the buried bulldozer by the fumes from the machine, then heard a voice from the snow below. The exact location of the machine was verified by probing and use of a metal detector. Frantic digging uncovered the top of the bulldozer under 1.5 m of hard, heavy snow. At 16:55 h a smiling and uninjured operator emerged from the partially filled cab to the cheers of his fellow workers and the rescuers. A large air pocket in the cab and rollover cage of the bulldozer had kept him alive for 2½ h despite the heavy, wet nature of the snow. While imprisoned he had tried to dig himself out with his hard hat and jack knife.

AVALANCHE DATA

The avalanche started as a large snow slab in the treeless south-facing basin that forms the head of Rab Creek (elevation 1800 m). The slopes of the basin vary in steepness, but on the average are over 30 deg. The original slab was probably deeper than 1 m and wider than 500 m. The nature of the bed surface is not known. The elevation of the accident site was 350 m, and because of the constricting nature of the creek the wet avalanche debris was 10 to 15 m deep, 100 m wide, and filled Rab Creek for over 1 km, partially damming the Ashlu River.

COMMENT

The avalanche occurred in a well known, obvious avalanche path following weather conditions that could be expected to produce large natural avalanches. Despite the seemingly hopeless nature of the burial, a systematic search starting from the last-seen point quickly located the victim. Probing in the ice-hard snow turned out to be very difficult, but the metal detector would have located the machine within a few minutes if the searchers had not detected it first by smell and voice.

The incident shows that supervisors and personnel working on forest roads must keep avalanche hazards in mind and apply standard safety measures when necessary. They should recognize and mark avalanche paths, evaluate the hazard daily when crews are working in hazardous areas, educate personnel, and have rescue equipment available.

Source: Frank Baumann, Squamish, B.C.

MORAINE LAKE, BANFF NATIONAL PARK Estimated 3 JULY 1983

One mountain climber killed

The victim's body was found partially buried in a wet snow avalanche at the base of the 3-3½ Couloir of Mount Bowlen at 10:55 h on 4 July 1983. The solo climber could have been engulfed by an avalanche or might have started one himself, but it was evident that he had suffered fatal injuries during the fall. His body was evacuated by helicopter sling from the toe of the couloir at 12:15 h on 4 July.

The victim was well-equipped, wearing crampons, and had previously completed numerous solo ascents of major peaks in the Rocky Mountains. The steep north-facing couloir often contains unstable wet snow during the summer and has been the scene of several mountaineering and avalanche accidents (see for example, 20 August 1978). In such terrain even small avalanches can result in injury and death; the couloir is therefore best avoided when moderately unstable snow conditions prevail. On 3 and 4 July the temperatures at Lake Louise ranged from 6 to 17°C and 8.4 mm of rain was recorded.

Source: Warden Service, Banff National Park.

MT. CHARLTON, JASPER NATIONAL PARK 18 SEPTEMBER 1983

One mountain climber killed, one injured

WEATHER

During cool weather in mid-September snow fell at Maligne Lake. At the elevation of the accident site approximately 30 cm had accumulated.

ACCIDENT SUMMARY

A mountaineering party, discussing plans with National Parks staff at Jasper, was informed of marginal conditions in the area. On 17 September three climbers travelled by boat across Maligne Lake to the base of Mount Charlton and climbed to an elevation of approximately 2730 m where they made camp at 18:00 h. The next morning, 18 September, the group left camp at 08:00 h and climbed approximately 300 m in elevation over snow and ice. At the base of a vertical limestone pitch they scouted the area for possible routes, but lack of time combined with hazardous snow conditions made them decide to abandon the climb.

The group descended in steep diagonal traverses in an attempt to minimize slab cutting in the new snow, but at approximately 12:00 h the lead man triggered a slab avalanche in crossing a steep gully. The other two climbers, all being roped together, were pulled from their positions and carried approximately 100 m downslope. The lead climber fell into a large bergschrund and the other two came to rest a few metres above, one partly buried and the other on the surface with an ankle injury.

RESCUE

The injured climber set up a belay and the second one followed the rope into the bergschrund where he chopped through consolidated snow until he uncovered the victim's boot at approximately 14:00 h. A half hour later he uncovered the victim's head about 2.5 m below the snow surface. Mouth to mouth respiration and CPR were applied for about a half hour to no avail. At about 15:00 h the survivors left for their camp, arriving at about 18:00 h.

At 08:00 h on the following morning, 19 September, the two survivors began walking towards Maligne Lake, travelling slowly owing to the ankle injury. They arrived at approximately 16:15 h. The injured man was assisted by Park Wardens and evacuated by boat. At 20:45 h two wardens were slung by helicopter to the accident site to bring back the victim's body.

AVALANCHE

The avalanche was a size 2, soft slab avalanche and fractured approximately 0.3 m deep, removing the full depth of the new snow on a bed of glacier ice. The slope in the gully had a northeasterly aspect and was in the lee of the prevailing wind.

COMMENT

The climbers were aware of the marginal climbing conditions resulting from the new snow, but being experienced they decided to attempt the route. It was most unfortunate that they were caught after turning back, having recognized that conditions were too hazardous. Gullies, bergschrunds, crevasses, and rocks greatly increase the hazard from even small avalanches.

Source: Warden Service, Jasper National Park.

HUDSON BAY MOUNTAIN, SMITHERS, B.C. 26 DECEMBER 1983

One skier injured

LOCATION

The accident occurred in Crater Lake gully, 1 km west of Hudson Bay Mountain ski area at Smithers, B.C.

WEATHER

Observations at Hudson Bay ski area, elevation 1525 m

Date	Time	Sky Condition	Temp °C	New Snow cm	Depth of Snowpack cm	Wind km/h
22	08:00	clear	-23	0	100	N 0-3
23	08:00	clear	-13	0	100	N 15-20
24	09:00	clear	-10	0	100	-
25	09:00	clear	- 9	0	100	N light
26	09:00	clear	-14	0	100	calm

From 23 to 26 December a temperature inversion was accompanied by moderate to strong winds above an elevation of about 1000 m. It was apparent from the extensive snow plumes at ridges and peaks that large quantities of snow were being transported with a rise in air temperature and accompanying outflow winds. By late on 25 December the winds had died down, and on 26 December at the time of the accident the sky was clear, there was no wind, and the temperature was -10 to -12°C.

ACCIDENT SUMMARY AND RESCUE

Two cross-country skiers and their dog had left Hudson Bay Mountain ski area for a day of touring. They were on their way back, ascending a side gully out of the main Crater Lake gully to gain access to the flat prairie just west of the ski area. The lead skier was well up on the edge of the slope and the second skier was below the main slope where it narrowed into a shallow gully. The dog was higher than the first skier, in the middle of the slope on a convex hump within the starting zone when the avalanche released.

The dog was carried about 100 m on the avalanche debris and came to rest on the surface. The first skier was caught by the edge of the avalanche and carried about 10 m, losing both skis, but was able to free himself immediately. The second skier was caught, carried about 40 m farther and completely buried except for one hand, with which he was

eventually able to free himself. He was buried about 30 cm deep, had lost both skis and poles, and suffered bruises and a broken nose (Figure 32).

After an unsuccessful search of the avalanche debris for their skis the skiers returned to the ski area on foot and reported the accident to the ski hill manager.

AVALANCHE DATA

The avalanche was a hard slab and ran on an old slab layer, breaking through to the ground and depth hoar lower on the slope. The fracture line was 0.9 m deep and approximately 50 m wide. The avalanche ran about 50 m vertically over a distance of about 200 m. The slope faced west and was on the lee side of the previous outflow winds; the upper slope had an incline of about 25 to 30 deg.

COMMENT

Both skiers had training in avalanche safety and should have been aware of the instability of the snow by observing obvious indicators: extensive depth hoar following a long period of cold weather and a shallow snowpack, newly-deposited wind-drifted snow, a rise of air temperature, and the release of a small hard slab avalanche on a similar exposure earlier in the day. Safe routes on ridges to either side of the avalanche path were available.

Source: Robin Mounsey, Smithers, B.C.

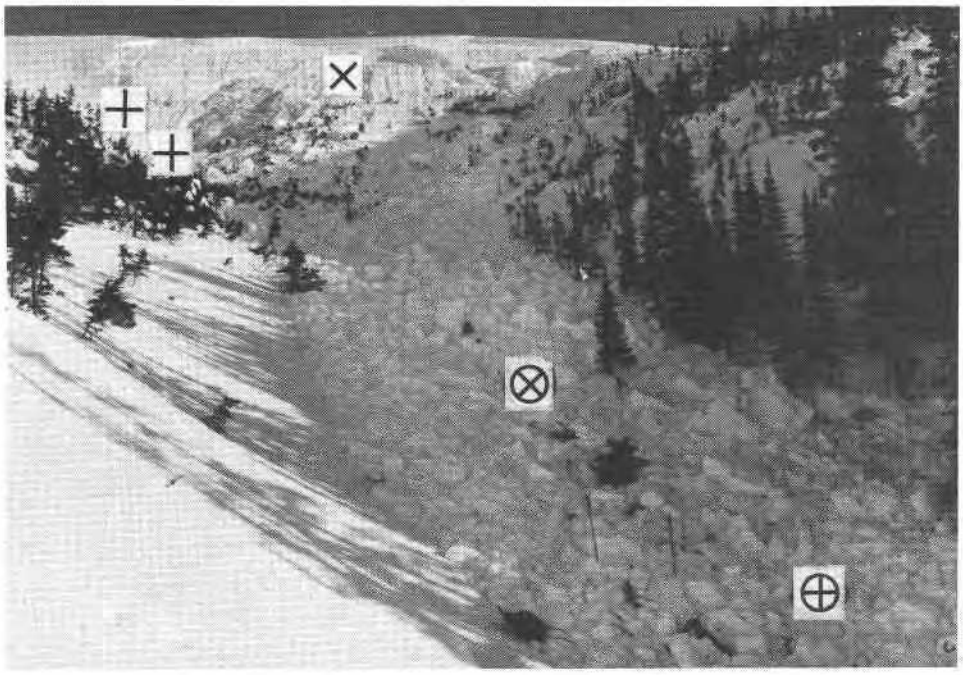

FIGURE 32

AVALANCHE AT HUDSON BAY MOUNTAIN
+ POSITION OF SKIERS WHEN AVALANCHE RELEASED
× POSITION OF DOG WHEN AVALANCHE RELEASED
⊕ LOCATION OF BURIED SKIER
⊗ LOCATION OF DOG AFTER AVALANCHE
(PHOTO COURTESY ROBIN MOUNSEY)

QUARTZ CREEK, GOLDEN, B.C. 7 JANUARY 1984

One snowmobiler killed

WEATHER

Observations at Rogers Pass, elevation 1315 m, 15 km from the accident site

Date	Temperature		Precipitation	New Snow	Snow Depth
	Max °C	Min °C	mm	cm	cm
3 Jan	-2	-4.5	9.5	10	91
4 Jan	0	-3	33	16	97
5 Jan	-1.5	0	49.5 (rain)	1	89
6 Jan	1	-1.5	3.5	5	90
7 Jan	-1	-2	3	3	90

ACCIDENT SUMMARY

The upper Quartz Creek valley is popular with snowmobilers in the Golden area, but it has many terrain traps and people have been caught in avalanches in previous winters. The snowmobilers had always been lucky, escaping total burial by accelerating their machines out of the moving snow.

On the morning of 7 January two snowmobile operators left their four-wheel drive vehicle at the end of a logging road in Quartz Creek and started by snowmobile up a narrow valley between scattered trees. At 08:30 h one rider found himself about 1 km ahead of his partner. He turned back and to his horror found his friend's machine upside down and partially buried in a fresh avalanche deposit. There was no trace of the man to be seen. The survivor immediately returned to Golden for help.

RESCUE

The Royal Canadian Mounted Police in Golden contacted two avalanche dog handlers and the local Provincial Emergency Program coordinator. A helicopter ski guide made his transceivers and avalanche probes available. By 10:30 h a small group of rescuers left Golden, travelling 60 km by jeep, then an additional 4 km by snowmobile, arriving at the accident site at 12:15 h. The rescuers removed the victim's snowmobile and began to dig directly underneath where the unfortunate rider was found immediately. He was under a metre of avalanche snow with the upside-down machine on top of him. It appeared that he had attempted to ride out the avalanche but was tipped over and buried.

AVALANCHE

The avalanche, triggered by the snowmobiler, started below a knoll. It is not known how high the victim was on the slope when the avalanche released. The slab had fractured with a depth of 0.2 to 0.4 m, a width of about 150 m, and ran 400 to 500 m. The bulk of the avalanche snow, including the victim, was deposited in a wide U-shaped depression.

COMMENTS

It is unfortunate that the survivor did not look for his friend before going for help. The machine on the surface was an obvious starting point for a search, and the short burial time would have promised some success for a live recovery. Snowmobile clubs should make their members aware of the dangers in the back country and teach basic avalanche survival skills.

Source: RCMP, Golden, B.C.

CASSIAR, B.C. 26 JANUARY 1984

Aerial tramway damaged

LOCATION

Cassiar at a latitude of 59 deg is in the Cassiar Mountains in the far northern part of British Columbia.

WEATHER

In December 1983 the climate station at Cassiar, elevation 1077 m, recorded an average temperature of -22°C, 5.4 C deg lower than normal. The precipitation in the early part of the winter had been below normal, resulting in a snow depth of only 31 cm on 31 December. This snow had transformed into depth hoar. January 1984 was warmer than normal, with an average temperature of -12°C. During the first week a storm deposited 32 cm of new snow, and another that began on 19 January accumulated approximately 60 cm more by 23 January (the daily observations are incomplete for 19-23 January). Over the next few days the following observations were made at the Cassiar climate station.

		Temperature		New	Snow
Date	Time	Max °C	Min °C	Snow cm	Depth cm
23 Jan	16:30	-9	-18	T	109
24 Jan	08:00	-10.5	-21	2.6	
	16:30	-20.5	-22.5	2.2	104
25 Jan	08:00	-22	-30	2.6	
	16:30	-21	-34	0	104
26 Jan	08:00	-18	-27	7.6	
	16:30	+1.5	-23.5	0.2	105
27 Jan	08:00	+2	-3	0	

It would appear that a temperature inversion existed and temperatures were probably higher in the avalanche starting zone. At snow course No. 4C04, elevation 1390 m, the snow depth was 110 cm and the water equivalent 216 mm on 27 January. This is close to the average for the end of January.

ACCIDENT

Brinco Mining Limited (Cassiar Division) operates an aerial tram from the asbestos mine to the valley for transport of the mine product. The tramway spans several avalanche paths and the support towers are placed

outside their usual reach. At 17:40 h on 26 January an avalanche crossed the line between towers 7 and 8, striking the wire ropes and one transport bucket, derailing the bucket. The wire rope drive could not be shut off quickly enough to keep the derailed bucket from impinging on the tower, and the pull on the wire rope resulted in failure of tower 7. The steel structure broke below the wire rope sheaves, leaving the upper part suspended.

The operation of the tram was interrupted for two weeks until a replacement tower could be shipped to the location and erected. Loss of production for this period meant that employees who were not required were unemployed.

AVALANCHE

The avalanche started at an elevation of 1890 m in rugged, rocky terrain with a westerly exposure and struck the tramline at elevation 1240 m. It slid on the December depth hoar close to the ground and stopped at the tramline on terrain with an incline of 5 to 8 deg. The deposited snow, containing tree debris, was 1.5 m deep and covered an area of 100 × 100 m, the tip reaching 40 m beyond the tramline. The avalanche seemed to have a mixed flowing and powder motion, the flowing component about 4 m deep.

COMMENT

A combination of factors caused the avalanche: weather that favoured the development of unstable snow in December, heavy snowfall, and a high temperature at the end of the storm. Wind might have been a contributing factor, being north and east on 25 and 26 January.

As the tramway wire ropes appear to be high enough above ground to allow the dense flow of the avalanche to pass underneath, only the powder component seems to have impinged on them. The problem of estimating the effect of powder avalanches on suspended wire ropes is often encountered when electric transmission lines are located and designed. Experience has shown that the strength of towers of high-voltage transmission lines is usually adequate if the line is designed for wind loads in association with icing. The hazard to tramways and chairlifts is more serious because the suspended buckets and chairs provide greater attack surfaces for avalanches and the moving wire rope is under additional tensile forces. On 26 January 1984 the tower probably failed from the pull of the wire rope drive and the impact of the derailed buckets. For this reason devices that prevent derailing are often recommended, where such devices can be implemented, for the protection of chairlifts and tramways in avalanche paths.

Source: M.J. Zylicz, Terrace, B.C.
(Not a member of Brinco staff)

FLATHEAD PASS, B.C. 29 JANUARY 1984

One snowmobiler killed, two injured

LOCATION

The accident site is 40 km south of Sparwood, B.C., in the Front Range 5 km west of the Continental Divide.

WEATHER

Observations at Sparwood climate station, elevation 1138 m

Date	Temperature Max °C	Temperature Min °C	Precipitation mm
25 Jan	4.5	2.0	0.2
26 Jan	4.0	-0.5	-
27 Jan	7.0	1.5	trace
28 Jan	7.5	3.5	2.5
29 Jan	5.5	-2.0	trace of snow

ACCIDENT

Three snowmobilers on a day trip in the Barnes Lake area had driven their machines up and down the smooth slope of an avalanche path (Figure 33). While two of them were adjusting their machines in the run-out zone, the third made another run up the track. On his way back, but still two thirds of the way up the path, an avalanche released above him and carried him down, partially burying him.

One of the two riders in the run-out zone had removed the sparkplug from his snowmobile and all he could do was crouch behind his machine before the avalanche hit him. The other jumped on his snowmobile and tried to move to the side, but he too was overrun by the avalanche. The time was 14:00 h.

RESCUE

Another group of snowmobilers was in the area at the time of the accident and with their assistance two victims were freed. The rider who had released the avalanche and been carried down most of the way was in the run-out zone, with a fractured hip and partially buried under 10 cm of snow. The second victim, suffering from internal injuries, was completely buried under 30 cm of avalanche snow. There was no sign of the third man or of his dismantled machine. While two went to town for help, the remaining snowmobilers used branches as improvised probes.

Four hours after the avalanche had occurred the first rescue party arrived. Under the direction of a Provincial Emergency Program

co-ordinator probe lines were set up, located items were recorded, and the probed areas marked. At 16:45 h a Royal Canadian Mounted Police dogmaster arrived with his dog, evaluated the hazard, and requested lighting equipment and food. The site was almost impossible for a search by a dog; a helicopter had landed at the probable location of the victim and the site was littered with lunch remains, urination and pieces of snowmobiles. These factors were corrected as well as could be and an initial search was carried out with the dog.

The absence of eye witnesses was an additional difficulty. The two injured party members had been flown to the hospital and the last-seen location had not been marked. The dog found the buried snowmobile, a buried glove, and several snowmobile parts, then indicated in an area where probing confirmed the buried man. The victim was found at 19:15 h under 2 m of avalanche snow about 2 m from his machine. Lights had to be used for this last part of the search.

AVALANCHE

The slab avalanche started at an elevation of 2160 m on a slope with a southeasterly aspect and 45 deg incline. The average thickness of the fracture was 1.5 m, with an estimated width of 350 m. The hard slab ran a length of 770 m and deposited snow to a depth of 2 to 3 m.

COMMENT

Snowmobilers seem to be attracted by open, smooth avalanche slopes. This was the case on the day of the accident, when tracks could be seen on several avalanche paths. The party was aware of avalanches and the associated hazard, and one of the survivors stated that he had not wanted to push his luck and therefore stayed at the bottom. A snowmobile in the starting zone that triggered an avalanche and a disabled machine parked at the bottom proved to be a fatal combination.

Source: Gordon Burns, Cranbrook, B.C.

FIGURE 33

AVALANCHE PATH OF ACCIDENT AT FLATHEAD PASS
(PHOTO COURTESY GORDON BURNS)

BR 6786-33

REDFERN LAKE, B.C. 11 FEBRUARY 1984

Two snowmobilers killed

LOCATION

Redfern Lake is on the eastern slope of the Rocky Mountains in northern British Columbia. The accident site is 120 km west of the Alaska Highway and in winter accessible only by over-snow vehicle or helicopter. No local snowpack or weather observations were made and there is no station close by to provide regular reports.

ACCIDENT SUMMARY

On 11 February five snowmobilers left a trapper's cabin for an outing in the mountains. By noon they had driven 40 km and were resting below a large knoll. One young member of the party left for some exploring and later a friend followed him around and above the hill. The three men still sitting below the outcrop heard a sound like an explosion and seconds later saw one rider coming full speed down the gully, slightly ahead of a huge avalanche cloud. The avalanche overtook him and he disappeared from sight. The knoll split the avalanche in two, protecting the three men (Figure 34).

RESCUE

One partially buried machine could be seen when the snowdust settled, but there was no trace of the two riders or of the second snowmobile. The survivors searched for 2 h before they decided to go back to the cabin for help and tools. Because there was no telephone in the cabin, one snowmobiler drove an additional 30 km to another cabin where he contacted the RCMP by radiophone. The closest available avalanche dog was in Penticton, 650 km to the south, and was flown to the accident site on the following morning. When the rescuers returned to the scene of the accident they located the second machine by probing with oars, but darkness forced them to abandon their search before they could find either of the missing snowmobilers.

The next morning help arrived in the form of volunteers from the Provincial Emergency Program who brought long copper rods for probing. When the dogmaster finally reached the site at 13:00 h several holes near the snowmobile had been dug and people were random probing. It became evident that a systematic search was necessary. The dogmaster, an RCMP officer trained in avalanche rescue, recognized the hazard from further avalanches and took control, ordering everybody off the deposit. Those who were to work on the avalanche were given transceivers and a quick lesson in their use. A probe line was organized. An avalanche lookout-man was posted with a warning whistle, and all rescuers were told where to run in the event of further avalanches. At 13:30 h the probe line located the first victim approximately 4.5 m from his snowmobile, buried 1.8 m deep and within 8 m of the spot where the rescuers had originally parked their snowmobiles.

The avalanche dog also indicated a spot close to the second machine, but nothing could be identified by probing. As the dog had previously found

other small objects such as gloves and cigarette butts, he was called off to search at other locations. After a time, however, the dog returned and again indicated strongly at the same spot. The dogmaster used his probe and shovel, but after digging about 1.5 m found nothing. With daylight running out more random probing was carried out without success. For a third time the dog returned to the previous spot, pushed probers aside and again signalled. Again it was decided to dig and soon the victim was discovered under 2.1 m of snow standing upright with a few probe marks on his helmet. Like the other buried man, he had died of suffocation.

AVALANCHE

The fracture line was over 400 m long and had an average depth of 1.5 m. The avalanche, triggered by the weight and vibration of the two machines, travelled about 350 m and deposited snow up to 7 m deep.

COMMENTS

It was difficult to locate the second victim by probing because of his vertical position. Several probes had been deflected by his helmet. The dogmaster noted that touching the helmet and being deflected from it felt like striking and pushing through a layer of ice.

The snowmobiler who was driving ahead of the moving snow was terribly unlucky in that the avalanche caught up to him just before he went uphill on the other side of the valley to a safe area. He was found less than 5 m from the edge of the deposit.

Source: J.G. Brewin, Penticton, B.C.

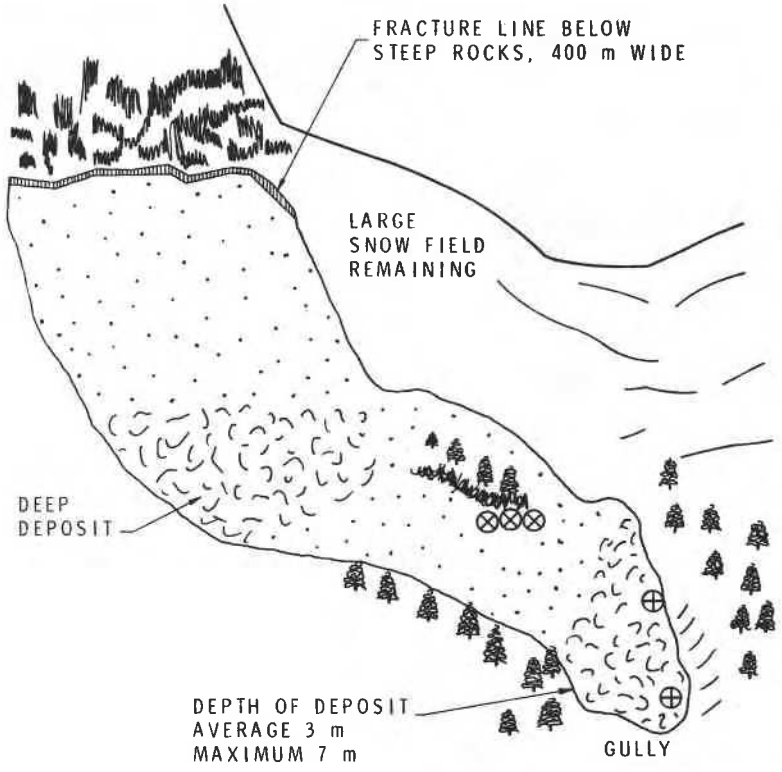

FIGURE 34

SKETCH OF AVALANCHE AT REDFERN LAKE
⊗ LOCATION OF SURVIVORS
⊕ LOCATION OF BURIED PERSONS

WHISTLER MOUNTAIN, B.C. 13 APRIL 1984

One skier injured

LOCATION

The accident occurred on the "Friday the 13th" slope in the Far West Bowl near Whistler Mountain Ski Area, British Columbia. The Far West Bowl is outside the ski area boundary and avalanches are not controlled.

WEATHER AND SNOW CONDITIONS

A thin layer of surface hoar had developed in the first week of April, and between 7 and 11 April a continuous light to moderate snowfall was accompanied by light to strong wind. A total of 50 cm of new snow was deposited in the alpine area of Whistler Mountain, where it was noted that the new snow sheared easily on the layer of surface hoar. Cornice control in the Harmony Bowl on 10 April produced snow slab avalanches on impact of falling cornices. On the morning of 13 April hand charges released several avalanches with a bed surface on the surface hoar.

Wind on the days before the accident had increased the size of the already large, unstable cornices. On 13 April the air temperature climbed rapidly from -9 to 0°C at the Whistler Alpine Office (1830 m elevation). A thin cloud layer added to the warming effect. The Alpine Bowls of the ski area were open and avalanche warning signs for the backcountry were posted at the lift terminals.

ACCIDENT SUMMARY

On Friday, 13 April 1984 two skiers hiked from the T-Bar lift to the peak of Whistler Mountain, probably arriving shortly after 13:00 h. One skier described what happened: "Out of curiosity I wanted to take a look at the snow condition in the Friday slope. I made a few turns and sideslipped down to the south entrance of the chute, then I sidestepped diagonally back up the cornice when it fractured about 9 m from the edge. After it broke I was taken and dragged down with the slide. I think I was on the surface most of the way; it took me under once. When it finally came to a halt I was buried to my waist and quite shaken up. The elapsed time to my recollection was about 10-15 s."

The second skier was not in visual contact when the avalanche released and it was not known how she reacted.

RESCUE

Three other skiers in the Far West Bowl saw someone above the chute called Friday the 13th. They continued their ski run and were resting at the bottom of the bowl when they heard an avalanche and noticed something in the moving snow. When the avalanche came to rest the three hiked uphill, recovered the partially buried victim, and sent one member of their party for help. The rescuers assumed that the victim's companion was buried in the avalanche.

At the Whistler Alpine Office the alarm was raised at 13:39 h and the first search party arrived on site at 14:03 h. A helicopter with a dog handler and dog arrived one minute later. A hasty search was carried out for 15 min, and although no articles or signs of a skier were discovered the dog searched for another hour. At 14:43 h the first victim, who had sustained a fractured pelvis, was transferred by helicopter to the base of the ski area.

While searching the debris, a party found the ski tracks of the victim's companion apparently heading back to the ski area. They reported this to the Rescue Leader who dispatched them along the tracks with a description of the missing person. In addition, the missing person was paged in the ski area. At 15:14 h the victim's companion was found skiing on the Gondola Run 3 to 5 km from the avalanche deposit.

AVALANCHE

The falling cornice with the skier started a slab avalanche on the 50-deg inclined slope. The fracture line had a depth between 0.3 and 0.5 m and a width of 50 m. The avalanche started at elevation 2103 m and the tip was at 1830 m.

The avalanche was a size 3 and the debris covered an area 65 m wide, 250 m long, and was between 0.25 and 2 m deep. The victim was recovered partially buried in the centre towards the toe of the deposit.

COMMENT

The injured skier was lucky to survive the avalanche with a partial burial only. It is difficult to understand the reaction of his companion. On her descent she must have seen the avalanche or the victim, yet she skied back to the ski area and continued skiing on the organized runs. A parallel to this is the accident on 20 February 1979, where the partner did not see the avalanche nor even ponder the fate of his skiing friend until later in the evening. The buddy system seems to break down close to ski areas and familiar terrain.

It may be of interest that the avalanche path was already named Friday the 13th, the accident occurred on Friday, 13 April at 13:00 h, and it was the thirteenth season of skiing at Whistler for the victim.

Source: Kel Fenwick, Whistler, B.C.

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