New Initiatives in Controlling BC's Snow Hazard

Craig Pulsifer

When it comes to snow-covered terrain, British Columbia doesn't have much of what you'd call a middle ground. Each year, deep snowpacks in our province's vast backcountry ranges kick off upwards of 200,000 large avalanches — many of which measure in the tens of thousands of tonnes — that account for 80% of those occurring across the country.

In the blink of an eye, these thundering express trains of snow can cause widespread environmental destruction, obliterate constructed facilities and, tragically, take a human toll: in the last 30 years, almost 260 avalanche fatalities have been reported, an average of eight to ten per year. In terms of natural hazards, few are more dangerous in this province.

BC's unforgiving climate and topography — and the attendant threat posed by snow avalanches to natural and manmade resources and public safety — means that professional engineers and geoscientists with expertise in snow and avalanche science increasingly are being called upon to support land use decisions and policy.

Preeminent among this group is Dr David McClung PGeo, a world renowned avalanche scientist who holds the recently established NSERC-FRBC-CMH Chair in Snow and Avalanche Science in the Department of Geography at the University of British Columbia.

Under the auspices of this Chair, McClung's research is directed primarily towards analyzing the interaction of avalanches and forest cover, and developing risk-based decision methods for logging in steep terrain. Another research focus is the development of computer-assisted avalanche forecasting methods for the province's popular heli-skiing industry.

Researching a Moving Target

McClung, who grew up in the flatlands of Dakota, steered his career path towards avalanche work back in 1971 when he joined the University of Washington's Avalanche Group while completing a PhD in geophysics. There he fell under the mentorship of Dr Edward LaChapelle, Professor Emeritus of Geophysics and an acknowledged pioneer in snow science.

Doctorate in hand, McClung left Washington in 1974 and spent three years working with the Norwegian Geotechnical Institute. He subsequently came to Canada to work with Environment Canada and, later, the National Research Council. While with the NRC, McClung worked with Peter Schaerer PEng and in 1993 they coauthored the *Avalanche Handbook*, a definitive resource on the subject for both layman and professional. In 1991 McClung turned his sights to UBC, where he initiated snow and avalanche research in the Department of Geography.

In 1998 the Natural Sciences and Engineering Research Council (NSERC), together with Forest Renewal BC (FRBC) and Canadian Mountain Holidays (CMH), offered a $900,000 grant to UBC to further avalanche research. The University had only to look in the Geography Department to find McClung, head of the Department's Avalanche Research Group, for their appointment to the five-year Chair in Snow and Avalanche Science.

Combining industry and government funds for snow and avalanche research sets the work of the UBC Chair apart from similar work in Japan, Scandinavia and the alpine countries of Europe: it's the first position of its kind in the world.

"Canadian industry has kept avalanche research alive," says McClung, who makes no apologies for the fact that the target of his research is set through the practical sights of commercial supporters. "In fact," he says proudly, "we don't function like typical academic groups doing studies for the sake of curiosity. Instead, we look at things that are of interest and use to industry."

Types, Triggers and Aftermaths

Snow avalanches fall into two categories: loose and slab failures, both of which can be dry, moist or wet. Loose avalanches occur when granules of unpacked snow begin, from a small point, to run downhill like loose sand. As the falling snow cascades downhill, it builds mass, spreading into a wide V-shaped fan. This event can be triggered by as little as snow falling from an overhead tree, and is usually confined to the surface layer.

Slab failures are typically more massive and destructive. Storm events and changing weather conditions leave a layered footprint in the snowpack profile.

Left: **Avalanche expert Dr David McClung PGeo of UBC is researching ways of mitigating the damage caused by snow avalanches like the one that hit BC's Gowan Creek area in 1999 (facing page). The avalanche, which started above the clearcut, destroyed 11 ha of forest cover (see inset) and crossed three inactive roads before stopping just above the main logging road. (Photos facing page by Frank Baumann PEng; photo left by Craig Pulsifer).**

Above: An avalanche that originated in a clearcut at Nagle Creek, BC destroyed $400,000 in timber and ripped out soil cover down to bedrock (Roger Laurilla photo); *right:* a controlled release avalanche in Rogers Pass illustrates their destructive potential (Parks Canada photo).

Layers vary in temperature, crystal structure, liquid water content, hardness and strength, meaning that weak layers can form deep within the snowpack. If the upper layers are overloaded by precipitation — or suddenly loaded by a collapsing cornice or a passing skier — the weak layer at the base of the slab can act as a failure plane to propagate shear dynamic fractures. Tension fractures then develop that cause the whole slab — which can range from the size of a car to a city block — to dislodge and careen downhill.

Apart from the risks posed by avalanches to the environment, constructed facilities such as transportation corridors and ski areas, and human safety, the damage they leave in their wake is a particularly critical problem in forest management. There are at least 10,000 clearcuts in BC affected by avalanches, which can initiate in the clearcut itself or descend into it from above. In the process, they can destroy valuable standing timber, rip out soil cover down to bedrock and, in the longer term, prevent the regeneration of new forest cover.

Old and New World Methods

For over 30 years, most avalanche forecasting has used engineering first principles to determine stability. This approach assumes that significant forces acting within and upon the snow mass can be identified and that they are representative of the entire area in question. If the internal strength of the snow mass is greater than the load forces applied to it, then no avalanche would be expected. This approach can then incorporate factors of safety into the equation to increase confidence levels when making decisions as to whether or not a particular slope poses an avalanche risk.

European scientists continue to use forecasting models based on measurements of physical properties of the snowpack, but McClung questions the validity of this approach to deal with stability problems for which the temporal and spatial distribution of weaknesses is always unknown, even though they are macroscopic in size. Slope stability tests are, after all, only spot checks, and the constantly changing material properties of snow make it a difficult substance to nail down.

"There's an element of uncertainty with respect to avalanche prediction because you can never know where these weak areas are, so this casts the whole question of snow stability into a risk-based concept," he explains. "Modern work on avalanche release and management has to reckon with the fact that there is always a residual amount of uncertainty.

"We're now moving away from the classical approach because it excludes important properties such as the relative hardness of layers within the slab, the characteristics of the weak layer beneath it or the kind of dynamic load — a skier or snowmobile, for example — that is crossing it." Rather than forecasting stability, McClung says, "we are now exploring ways to describe instability."

Stable/unstable, tomāto/tomäto ... is this a case of semantics? McClung doesn't think so. "Suppose you're in the backcountry and see a cornice fall on the slope below but nothing happens. That's pretty interesting because you can surmise that things are stable at that particular spot. But if the cornice falls and an avalanche kicks off, that's *very* interesting," he says, eyes widening, "because then you are *sure* there are instabilities. That's the way it is with quality indices for stability: they're interesting, but inconclusive about avalanche release."

In essence, what it comes down to is that you are never completely sure when an avalanche will let go until after the fact.

An Avalanche of Data

UBC's Avalanche Research Group, headed by McClung, is now developing a decision support system to predict the magnitude, frequency and dynamics of avalanches in forested and harvested terrain.

Over the past two years, his team has built regional databases for the Columbia and Coast Mountain ranges using historical data gleaned from avalanche paths along BC highways, air photo interpretation, mapping and field reconnaissance. The data are complemented by McClung's own surveys of 300 sites selected from among 10,000 logging-related avalanches estimated to exist in the province.

As the data roll in, some interesting preliminary results are spilling out. One of the more optimistic observations is that forests in BC's high elevation forested areas have yet to reach the deteriorated state of the western European alpine.

"Right now, the treeline in the Swiss Alps is 200 to 400 metres lower than it was 150 years ago," says McClung. "They cut it and because of poor growing conditions, it wasn't able to grow back. As a result, man-made avalanche defenses have had to be placed above Swiss villages.

"All the same," he warns, "here in BC we're now logging on higher and steeper ground, so the present avalanche research is very important." McClung also notes that forecasting must account for findings that the Coast Mountains have deeper snowpacks — and thus more loading — while the Columbia Mountains tend to favour the formation of more weak layers.

The "flagging" of this tree's uphill branches was caused by the turbulent dust cloud of a giant avalanche originating in the clearcut above (Dave McClung photo).

McClung is finding that, as far as the Columbia and Coastal ranges of BC are concerned, using a statistical approach to determine avalanche probabilities is both objective and useful because it is based on observed data from historic occurrences on a regional basis.

These results can be applied to problems associated with logging-related avalanches. Magnitude and frequency predictions will be used to assess risk to resources inside cutblocks such as fragile soils, plantations and roads. Similar predictions can be applied to protect offsite resources such as standing timber, creeks, roads, railways and even residential dwellings located below the blocks.

Professional Practice Aspects

McClung places snow avalanches in the general category of mountain slope hazards — along with debris torrents and landslides — affecting BC forests. As such, he says, "professional engineers and geoscientists are ultimately going to be more involved in making decisions about land use planning with respect to those hazards, particularly when they affect facilities such as roads and heli-ski runs."

Peter Weir PGeo, a geohydrologist working in the BC interior, concurs. A well known snow safety and avalanche expert, Weir is developing the *Handbook for Management of Snow Avalanche Prone Forest Terrain* to assist forest managers operating under the Forest Practices Code.

Weir notes that standard avalanche training courses for recreationists and technicians, combined with practical experience, can teach the basics of snow safety, including how to interpret weather, snowpack conditions and snow stability for the purpose of daily avalanche forecasting and control in the initiation zone. "But," he cautions, "they only touch on air photo interpretation and mapping, and don't deal with the mathematics and dynamics of avalanche runout."

For mountain guides, heli-skiers and ski patrollers, daily or even seasonal issues of avalanche risk can be dealt with by avoiding the area. Engineers and geoscientists, however, increasingly will be called upon to make decisions affecting public resources and facilities that must consider event return periods of 30, 50, even 100 years or more.

To young engineers and geoscientists thinking of entering this line of work, which he characterizes as "the most exciting field you can imagine," McClung offers this sage counsel: "Models are only half the battle, experience is the other half and it's highly prized. If you don't have it, the only rational approach is to work alongside someone who does: get involved with experienced land use professionals."

As a specialist with almost 30 years of experience in the science of snow and avalanche research, there's more than a snowball's chance in ... BC that McClung is right. ◘

Craig Pulsifer is a freelance writer and photographer based in Salmon Arm.

Dr David McClung PGeo will be presenting a session on snow avalanche research as part of the professional development program at APEGBC's 2000 Annual Conference, being held October 19-21 in Whistler. More details will be available in the upcoming conference brochure.