EXPERIENCE IS NOT ENOUGH: PERSISTENT WEAK LAYERS IN WESTERN CANADA 2007 – 2010

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ABSTRACT: The winters of 2007/08, 2008/09, and 2009/10 in British Columbia were characterized by numerous persistent weak layers (PWLs). Professional avalanche practitioners with 20, 30, or even 40 years of experience commented they had never encountered such conditions before.

By presenting an overview of prominent layers, fatality records, and select notable incidents involving experienced practitioners, the unusual characteristics of some of the exceptional PWLs are highlighted. Risk management strategies for high uncertainty situations due to low probability/high consequence scenarios are discussed with an emphasis on adjusting conventional thinking and the role of human factors.

1. INTRODUCTION

Persistent weak layers are not atypical in British Columbia. Surface hoar, surface facets, crusts, and facet/crust combinations have long been "business as usual" for recreationists and professionals alike, especially in the interior ranges.

In the last three seasons, however, the number of simultaneously active PWLs in the snowpack (often in close proximity), the wide spatial extent (often spanning multiple ranges), and the unusual avalanche activity alone would make any one of these seasons an exceptional challenge. Three consecutive seasons of such remarkable conditions is unprecedented.

The anomalous events described in this paper all involved experienced practitioners—in some cases teams of practitioners with 60+ years of cumulative experience. These and many other events too numerous to include here, prompted many comments such as, "In 30 years, I've never seen anything like this before." and "I've been riding here 20 years and have never seen an avalanche on this slope."

These comments were found in public avalanche forecasts, various forums for public discussion, professional information exchanges, and numerous personal communications.

Whether a result of climate change (challenging PWL winters are here to stay) or simply a point in a recurring long-term cycle (this has happened before but no-one living today was around to see it) it's important to learn from the last three seasons.

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2. 2007/2008 SEASON SUMMARY

2.1 *Prominent Layers*

- *October 31*: Facets on crust
- *November 24*: Facets on crust
- *December 5*: Facets on crust
- *January 26*: Primarily surface facets, some surface hoar, some crusts
- *February 26*: Primarily surface hoar, some surface facets, some crusts
- *March/April*: Several surface hoar/crust layers

2.4 *Fatalities*

- Eighteen deaths create a notable rise in fatalities after four years of steady decline (Figure 1).
- Fourteen of 18 fatalities are skiing or snowmobiling accidents.
- PWLs are the known or suspected failure layer in all 14 skiing and snowmobiling fatalities.

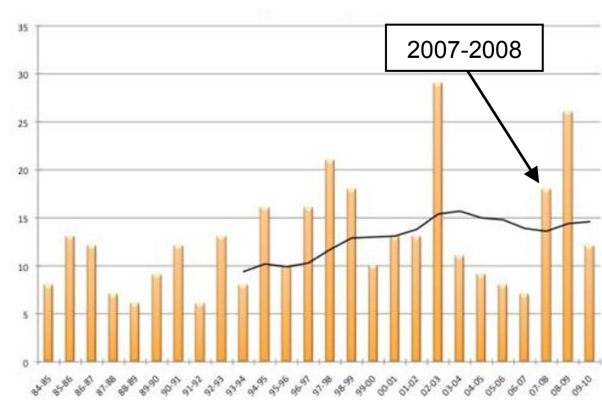
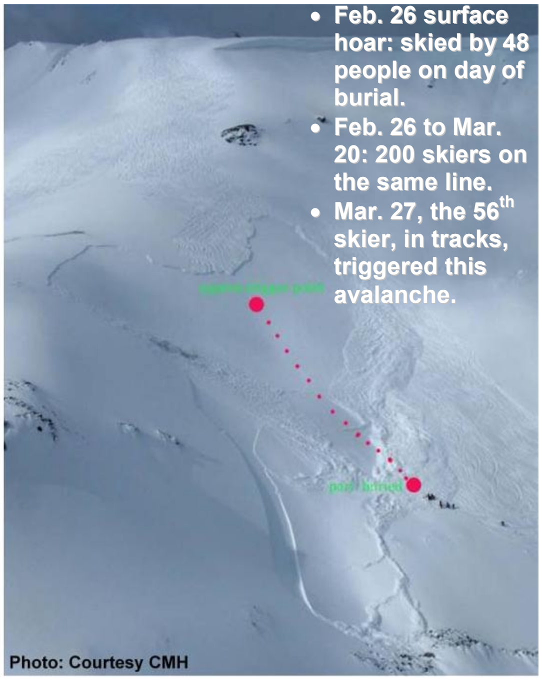


Figure 1: Avalanche Fatalities in Canada, 1984 – 2010 with 10 year trailing average. (Canadian Avalanche Centre, 2010)

2.3 *Surprise! March 27th, 2008*



2.4 *Quote Of The Year*

3. 2008 – 2009 SEASON SUMMARY

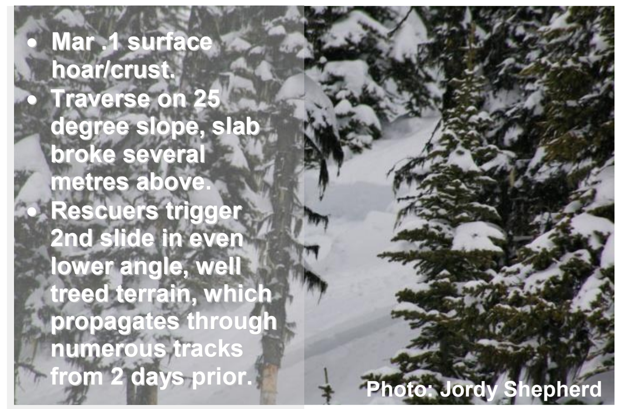
3.1 *Prominent Layers*

- *November 30 (interior ranges) - December 6 (coast ranges)*: Basal facets/crust sandwich
- *December 25*: Surface facets
- *January 27*: Primarily surface hoar, some surface facets
- *February 22*: Primarily surface facets, some surface hoar
- *March 1*: Surface hoar
- *Mid-late March/early April*: A few surface hoar and crust layers

3.2 *Fatalities*

- Twenty-six deaths produce a spike in the statistics (Figure 1).
- Eight dead in a single event on Dec. 28th in the 29 Mile (Harvey Pass) incident.
- The worst winter since 29 died in 2002/03, which also had notable PWLs.
- PWLs are the known or suspected failure layer in 24 of the 26 fatalities.

3.3 *Surprise! March 20, 2009*



3.4 *Quote Of The Year*

4. 2009 – 2010 SEASON SUMMARY

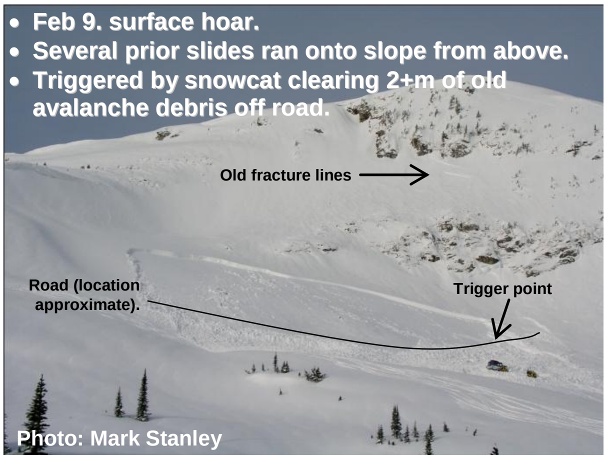
4.1 *Prominent Layers*

- *December 28*: Surface hoar
- *January 9*: Surface hoar
- *January 25*: Surface hoar
- *February 9*: Surface hoar
- *February 23*: Surface hoar
- *March 8:* Surface hoar
- *April 6*: Surface facets/surface hoar on crust

4.2 *Avalanche Fatalities*

- Twelve fatalities belie the seriousness of the winter.
- Two dead, 31 injured in the March 13 Boulder Mountain accident; luck and a quick rescue response prevents a higher fatality count.
- PWLs are the known or suspected failure layer in 11 of the 12 fatalities

4.3 *Surprise! March 14, 2010*



4.4 *Quote Of The Year*

5. RISK MANAGEMENT

5.1 *Universal Strategies* (Klassen, 2008)
A number of traditional strategies were successfully applied in the last three winters. Strict adherence to these conventional practices likely reduced the number of involvements and prevented many incidents from escalating into full-blown injury accidents or fatal events.

In PWL winters, avoid or minimize exposure to:

- Large slopes
- Steep terrain
- Complex terrain
- Slopes with scattered rocks or trees showing or just below the surface
- Convex features
- Unsupported features or snowpacks
- Terrain traps

In addition, it's wise to allow extra safety margins when:

- Spreading out
- Choosing regroup locations

5.2 *Strategies For Deep Slabs* (Klassen, 2008)
Once deeply buried (>200cm) and dormant, PWLs can result in deep persistent slab avalanche problems. In this phase, avalanche activity declines; that is, the probability of an avalanche occurring is low. However, the size and destructive potential of avalanches that do occur tends to increase. (Figure 2.)

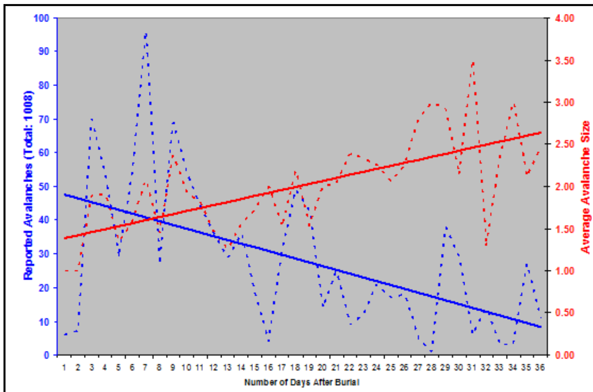


Figure 2. First 36 days of avalanche activity on the Feb. 26th 2008 surface hoar layer. Blue=reported avalanches. Red=Average avalanche size. (Klassen, 2008a)

These situations are often referred to as a low probability/high consequence scenarios. This condition can persist for months and, in extreme, may span seasons. Low probability/high consequence is often accompanied by high uncertainty: determining where deeply buried PWLs exist is difficult and assessing their stability is problematic. Such uncertainties result in low confidence and present extremely complex decision making challenges.

In addition to the techniques discussed in 5.1, techniques specifically suited to deep persistent slab conditions include:

- Minimizing loading (e.g. spread out farther, one at a time more often, smaller groups).
- Minimizing exposure to slopes with potential large triggers above.
- Avoiding shallow or variable depth snowpacks, especially those with isolated trees or rocks.

- Avoiding avalanche terrain when deep slabs become more sensitive to triggering. That is during/after notable weather changes, such as:
  - Rain
  - New snow or wind loading
  - Rapid temperature rises
  - Temperatures above 0^oC
  - Strong solar radiation
- Allowing extra margins of safety when assessing maximum propagation or runout potential. Even mature, old growth timber, pronounced high ground, and features that appear physically disconnected from the slope in question may be at risk of being overrun.
- Allowing extra margins when assessing potential remote trigger points. Deep slabs can trigger from hundreds of metres away.
- Local knowledge of terrain **and** snowpack are critical components when assessing long-buried persistent weak layers.
- Tracking of PWLs is advantageous:
  - Observe and record the locations and characteristics of PWLs while they are still on the surface.
  - Layers are named by the date of burial.
  - Observe and record the changes in PWLs over time after they are buried.
  - Share information and pass it on to others.
- Data and information sharing networks and forums are invaluable in anticipating problems and seeing trends.

5.3 *Human Factors*

At no time do human factors play a greater role in decision making than when dealing with persistent slab, and especially deep persistent slab, avalanche problems.

A significant proportion of serious accidents involving PWLs seem to occur in late winter and spring on blue-sky days. Possible contributing factors are:

- PWLs that formed in the fall or winter are generally deeply buried and the probability of triggering is low so people start to think “it’s over.”
- This is when large, highly destructive avalanches are likely. These slides can overrun what most people consider “safe” terrain.
- It can take several days for PWLs to adjust to stress from new snow or wind loading events. People don’t wait long enough after a storm.
- It generally takes at least a couple of days for non-persistent, storm snow instabilities (which might trigger a step-down avalanche) to settle out. People don’t wait long enough.
- People don’t look up enough, and they tend to underestimate the strength of the sun when assessing warming and solar radiation on slopes or cornices far above.
- There’s less tendency to stop and reassess current, local conditions in good weather. People miss changes happening around or above them.
- People are more willing to push into bigger, steeper, more complex terrain when the weather is good.
- People ride more aggressively on blue-bird days.
- People tend to discount their intuition or “gut feel” more on blue bird days. If something doesn’t feel right, they are more willing to push on a clear warm day than on a cold, foggy, snowy day.

The desire to ride a particular slope can override logic when making decisions in general—this is even more pronounced when PWLs are in the mix because:

a) The time frames can be extremely long.
b) The increasing lack of activity over time instils a sense of false security.
c) “An unstable snowpack doesn’t stink.” (Dietzfelbinger, 2010). That is, on the surface, a slope with the potential to create a deadly avalanche looks exactly the same as one with no instability.

In PWL winters, it’s important to maintain discipline:

- Wait until conditions are right for a specific slope. This may mean holding off for weeks or months, even when there are no obvious signs of trouble. In some cases, it may be necessary to wait until another winter provides better conditions.
- Don’t “carpet bomb” a slope with tracks. Make one pass and move on to reduce the chance of hitting the sweet spot.
- Checklists and protocols (even rules!) help head off poor decisions that are based on human factors rather than a rational approach:
  - For recreationists, a structured decision-making aid is recommended. For example, the Canadian Avalanche Centre’s *Avaluator*™ and *Decision-Making in Avalanche Terrain* fieldbook.
  - For professionals, it means rigorous application of and adherence to established, industry standard frameworks for avalanche hazard assessment and risk management.
- Examine your own motivation and that of others in your group. If you are considering something

that others are avoiding or expressing concern about, examine your motivation again.
- Ensure all members of the group play an active role in all aspects of planning, preparation, and execution of the trip.
- Talk to the others in your group. Listen to what they have to say. Respect their concerns. Make sure lines of communication remain open at all times.

6. THE NEW NORMAL?

In a number of cases, the conditions of the last three years challenged conventional thinking and advanced our understanding of the PWL phenomenon.

Notably, the season of 2009/10 created highly anomalous conditions when a number of PWLs were active simultaneously, some took six to eight weeks or longer before going dormant, the characteristics of the initial persistent slab avalanches were unusual, and high rates of avalanche activity lasted much longer than normal.

Some new thinking that needs to be incorporated into our understanding of PWLs and risk management strategies include:

- Incremental light loads that accumulate over a week or more seem to set up worst-case scenarios, both in terms of the physical characteristics of the snowpack and in the decision making process.
- The initial cycle of notable avalanche activity can begin with loads as light as 25mm of water equivalent.
- Significant avalanches can occur in snow that appears essentially un-cohesive (light dry powder).
- These relatively thin, soft slabs can propagate significant distances encompassing low angle slopes above and around the trigger point, running over substantial terrain discontinuities, and carrying through fairly dense mature timber.
- Thin soft slabs can be remote triggered from surprisingly long distances, hundreds of metres in extreme cases.
- Staying on terrain less than 30 degrees incline (or even 25) is not conservative enough when things are bad; even soft slabs can pull well back into 15-20 degree features.
- The initial round of regular avalanche activity can last two months or longer with few or no interruptions.
- Bed surfaces where avalanches have run are not always safe: significant hangfire avalanches can occur and even the bed surface itself can act as a slab that fails on a second PWL lying below.
- Avalanches on reloaded bed surfaces can occur with less load and less slab property than you might think.
- A third, or even fourth, round of reload avalanches is possible.
- Avalanches can occur on heavily tracked slopes. Even a diligent, disciplined, and meticulous compaction program carried out during a PWL's development and in the early stages of burial may not be enough.

7. CONCLUSIONS

While this experience is still fresh in the avalanche community's mind, the time is ripe to discuss and share traditional and new PWL risk management strategies.

When conditions exceed the knowledge base of the most experienced people in the business, then experience is not enough. In fact, during strange and unusual times, experience may even be a disadvantage because preconceptions can limit the ability to anticipate, recognize, and accept the unexpected or unprecedented.

Experienced practitioners must be open to the possibility that younger, less experienced people may see extraordinary problems earlier and more clearly because their past experience is not clouding the fact that an unprecedented situation is developing or underway.

In an unusual winter your nearest neighbours, to whom you look for similar conditions and trends, may be much farther afield than normal—perhaps hundreds of kilometres away in what is normally a completely different snow climate.

When you start hearing the "I've never seen anything like this before." comments from highly experienced practitioners, consider (sooner rather than later) whether an exceptional situation is developing and whether your experience may be a disadvantage rather than an advantage.

A structured decision-making approach works. Stick with the program and make sure you don't exclude data, information, or opinions that do not support your personal desires or agenda.

Local terrain knowledge is different than local snowpack knowledge:

- The terrain changes very little over time and what you knew about a particular place 30 years ago generally still applies today.
- The snowpack is based on weather, which likely goes through cycles that are longer than human memory. And we may be entering a new era in which the climate itself is changing.

- Perhaps our fundamental notions of avalanche terrain need to be adjusted if the weather and snowpack are beyond our experience.

Better PWL tracking systems are needed. (Davis, 2010) Map or photo overlays produced with GIS technology to visualize the type, characteristics, location, and evolution of PWLs would be ideal but simpler methods may suffice until electronic tracking systems are developed.

In PWL winters patience, discipline, and the ability to honestly assess personal limitations and motivations are perhaps the most important characteristics of successful risk managers and decision makers.

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