Avalanche Hazard Evaluation at Ski Areas

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ABSTRACT

There is a lot of literature written about avalanche hazard evaluation and forecasting, but it's seldom from the perspective of a ski area avalanche worker. Because of the large area of avalanche terrain that they deal with, back country, heli-ski and highway forecasters usually have to rely on weather and snow pit data from limited areas and interpret it for large areas, when making their avalanche hazard assessments.

Many avalanche books address avalanche hazard evaluation from the perspective of back country skiers, focusing on the slopes an individual wants to ski. This is similar to ski areas, except ski area workers have the advantage of using explosives and knowing the history of the slide paths, both short term and long term. Ski areas have to be very thorough in there assessments and hazard reduction procedures because the slopes will be opened to numerous avalanche triggers who have little or no avalanche knowledge.

INTRODUCTION

Back country and highway forecasters use snow and weather data from remote and or limited sites to formulate their avalanche hazard assessments. As a result their forecasts are broad based and general, usually giving probabilities or degrees of hazard. When ski areas open a slope the avalanche hazard is always considered minimal, frequently this requires mitigation efforts. At ski areas, weather data is used mostly to determine if the avalanche workers need to come in early or not. Then the avalanche hazard assessment, and hazard reduction work if necessary, is performed by the individual control teams who are out on the snow, looking at and skiing the individual slide paths. At ski areas, avalanche hazard assessment and avalanche control work are many times one and the same.

EXPERIENCE AND COMPUTERS

There is a lot of attention being given to computers these days. In day to day avalanche work at ski areas the main use of computers is for storing and retrieving weather and snow data. Nearest neighbor and other types of programs that try to predict avalanches may be useful for back country and other types of general forecasts, but aren't of much practical use at ski areas. The most potential for using nearest neighbor programs at ski areas may be in alerting the avalanche workers to possible old snow or deep slab instability. New snow hazard is relatively easy to evaluate and a much more reliable assessment can be made by humans who are out on the snow.

Herbert Simon an early artificial intelligence practitioner and now a Nobel Laureate at Carnegie Mellon, predicted in 1957 that a computer would beat the world chess champion within a decade. It's now 40 years later and last February Deep Blue failed to beat world chess champion Garry Kasparov. Custom-built for chess by a team of IBM scientists, Deep Blue has 32 microprocessors that give it the ability to look at 200 million chess positions each second. But brute computation is not what human grand masters use to approach the game. Studies have shown that in a typical position a human player considers on average only two moves, that he intuitively recognizes from past experience as leading to the best outcome. As In chess, intuition is what avalanche workers rely on when making stability evaluations. Obviously without past experience, a persons intuition won't be worth much.

General avalanche experience, along with experience at a particular area, are important aspects of avalanche hazard assessments. Being able to observe individual slide paths on a daily basis throughout the season is an advantage ski areas have, because of there relatively small area. It is very beneficial for an avalanche worker to have seen a particular slide path the day before when making a hazard assessment. It is difficult to determine if wind loaded snow is from the previous night or from one or two days ago, if you haven't seen the path for awhile. This time difference is very important, because as everyone knows most avalanches occur during or shortly after a loading event. It's also valuable to know that certain paths have slid on a certain layer. While other paths have not and would be suspect. On an even longer term it helps to know were a particular slide path usually fractures. This is why experience at a given area is so valuable. If you've observed a number of slides on a particular path over the years you get a feel for where and when it will slide. You learn where some of those "sweet spots" are for different conditions.

Studies have shown that recognition primed response is the primary way people make decisions during a stressful situation, as in doing a control route when it's snowing and blowing and everyone is wondering, "when's it gonna open". Or when you're skiing in the back country with a bunch of friends who are looking to you for guidance and you come to a steep slope. You've got to decide if you should cross it or go three miles around by a safer route.

Recognition primed decisions are when your brain recognizes the current circumstances as being similar to a situation you've been in before and steers you in a direction that worked out well in the past, or steers you away from a response that didn't work out well in the past. A lot of this process goes on in the subconscious mind and is sometimes referred to as a sixth sense, or intuition. This intuition is our brain recognizing a pattern in our memory. This pattern is a sequence of neurons firing in a certain order. This is similar to a computer, except our brains have the ability to recognize similar patterns, were as a computer only recognizes exactly what it's been programed to identify. Also, our brains automatically discard data it deems unimportant to the problem at hand. Were as a computer can become bogged down in endless calculations if it's program isn't channeled to exclude unimportant data. This channeling of the program to stay focused on an individual problem is the hard part and depends on the skill, knowledge and experience of the programer, and this is what determines if it's a valuable program or not.

So in this regard, when dealing with numerous variables which have a compounding effect on each other, a human brain can still outperform a computer. But the key here is experience. Just as a nearest neighbor program isn't worth much without many years of data, either is our intuition worth much without a lot of data, or experiences logged in our memory banks. Even though a computer may soon beat the world chess champion, the avalanche game, which is infinitely more complex than the finite game of chess, will still be relying on humans.

SNOW PITS

There is always the question of whether it's better to dig extensive "data pits" or to dig hasty pits. For a given amount of time it's more valuable to dig numerous hasty pits because you get a better perspective of the conditions which sometimes vary greatly over short distances. It is important to dig enough data pits so you feel comfortable knowing how the different layers are changing. Also it's important to record data pits for future reference.

At Big Sky, with a continental snowpack, the main concern during most of the season is the temperature gradient, facetted grain layers. The main contributing factor, as to varying TG development in a given area, is the depth of the snowpack. With this in mind it's a good idea to probe around to find a spot with a representative snow depth to dig a pit in . Also, to save time on a large path, a few pits can be dug in different locations at varying depths for a reference. Then by probing across the slope and at different levels you can get an idea about the varying TG conditions by noting the depth of the snowpack at each probe site.

Snow pits aren't very reliable in formulating stability evaluations. Explosives and ski cutting are more reliable. The problem with getting stability information from snow pits is the inexact science of shear tests.

The author has observed that shear tests conducted on the crown face of deep slab avalanches many times didn't reveal the sliding layer as the easiest shear. Shear tests all share common problems that make them unreliable:

- They only test a small area.
- The load or stress is applied unnaturally fast.
- When a column is isolated the stress caused by the uneven creep and settlement of different layers in different areas of the path is removed.

The natural stress that is imparted by the surrounding snowpack is removed when a column is isolated. You still have the stress which is caused by the weight of the overlying snow. But this may not be representative of the overall interrelated stress of the whole slope. Explosives and ski cutting are more accurate because the inclining snowpack is in it's natural state when these tests are performed. With explosives and ski cutting you eliminate one (#3) and part of another (#1) of the three problems listed above.

EXPLOSIVES AND SKI CUTTING

Ski areas have the opportunity to use the more reliable methods of explosives and ski cutting along with the inputs of snow and weather data to evaluate snow stability. These more reliable methods are necessary because of the desire to have slopes open on a daily basis. Ski areas are able to accomplish this because they have the required manpower to continuously monitor a relatively small amount of avalanche terrain. The workers aren't somewhere else trying to figure out what's going on in the starting zones. They can just go there and find out what's happening with the snow and weather at a particular slide path. During a storm, or if it's getting wet during the day, the avalanche workers can keep ski cutting suspected avalanche slopes. Many times this will reduce the hazard enough that the slope can remain open. If the hazard becomes too great the area is closed, either temporarily to allow control work (avalanche hazard reduction), then reopened, or left closed until conditions improve. This would usually be the following day, when full routes would be done using explosives and ski cutting to both evaluate, and mitigate the hazard as needed.

The basic procedure of bombing or shooting a slope and then ski cutting and opening it are pretty straightforward. It doesn't matter which is the weak layer or what type of crystals failed, or even whether it avalanched or not. As long as the hazard is deemed low enough, the slope is opened and everybody goes skiing.

But you can learn more about stability from explosives and ski cutting than whether it slid or not. If a slope doesn't slide after being tested with an explosive it is generally thought to be safe for skiers. It is assumed that the explosive imparted more stress into the snowpack than skiers will. There is the consideration of post control releases, which won't be addressed in this paper. If an avalanche is released with an explosive or by ski cutting, stability can be evaluated by observing the crown line propagation characteristics.

If the fracture line propagates horizontally across the slope for a long ways the slab would be less stable than one where the fracture line propagated across the slope at a downward angle. If only a circular area around the charge was released, and it just took out the area directly below, it would indicate more stability than one that propagated to the sides. If only a circular area around the charge was released and it rode up on the snow below, it would be more stable yet.

If the explosive didn't cause an avalanche, it can still be observed whether it caused tension release cracks or not. Tension release cracks without an avalanche indicate a cohesive slab without a weak enough sliding layer to cause an avalanche. By examining the depth of the crack it can be determined which is the potential sliding layer. By observing the number and location of the tension release cracks it can be determined where the tension zone is.

CONCLUSION

Ski areas employ some different techniques than back country, heli-ski and highway forecasters, for evaluating snow stability. Explosives and ski cutting are the primary tools used for evaluating new snow stability at ski areas. Where as explosives and snow pits are the primary tools used for evaluating old snow stability at ski areas.