PRACTITIONERS VIEW ON QUICK STUDY OF SNOWPACK: HOW TO EXPLAIN THE VOCABULARY FOR POLE PROBE TESTS AND SLOPE CUTTING

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ABSTRACT: As practitioners and heli-ski guides in the Chugach Mountains of Valdez, Alaska we ski cut slopes to mitigate the volume of loose snow avalanches (sluff). We determine if results of slope cuts are probable or not through pole probing the structure and hardness of the snowpack. This includes the top 120cms of the snowpack as this is a common length of a ski pole. We are introducing a new vernacular that clearly describes pole probing and its correlation to slope cut results. Our adage includes data codes used to quickly and easily decipher the structure of the snowpack as well as describe varying degrees of loose snow avalanches. Depths of different hardness are also quantifiable.

In a right side up snowpack hardness increases as depth increases. A right side up pole probe with an impenetrable hard layer 45cms down is expressed as PPRU45I. The value after the shorthand represents the depth at which the pole probe becomes impenetrable. Furthermore, slopes with upside down pole probes, where changes in hardness become inconsistent, necessitate a snow pit. We include both CT and ECT as the snowpack may demonstrate a failure in compression but not in shear.

We have also elaborated on the existing slope cut data codes used in table 2.12 on page 55 of the 'Snow, Weather and Avalanches: Observation Guidelines for Avalanche Programs in the United States' (2009) to include quantifiable amounts of loose snow avalanches.

Daily we experience a variety of snow conditions on different aspects and elevations. Creating a dialogue based upon pole probing and slope cutting has improved our efficiency and communication regarding snowpack structure, sluff management and spatial variability.

1. INTRODUCTION

Many winter mountain travelers throughout the world have realized the significance of how deep their skis or snowboards sink into the surface as they travel through snow covered mountains.

Once ski poles were introduced, mountain travelers had another tool to use to gauge the textures and hardness of the snow surfaces as they traveled. Ski pole phrases became common in ski language to describe the days conditions: soft, right side up, upside down, hollow, etc. These phrases have been used in mountain cultures across the world to describe the quality and quantity of the snow encountered and the immediate reaction to the snow after traveling across a specific slope.

The methods for evaluating snow slope stability have become more complex as we have realized the balance between stability and instability can be delicate and the sequence of failure may be unpredictable.

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Backcountry ski use has been on a constant increase for the past 40 years with new user groups exploding the number of winter travelers in the mountains. Mechanized ski travel has become more popular with more user groups, especially skiers and snowboarders. Backcountry travelers are now making more than one run a day increasing the need to communicate conditions with as many field observations as possible, thereby giving the users a better understanding of surface stability. The use of machines to assist in the uphill ascent has turned us into upside down mountaineers and taken away our ability to evaluate the snow at a pace that gives us time to weigh our decision one step at a time. Hans Moser once wrote about the difference and speed of evaluation of snow and slope stability and how different heli-skiing is than the traditional speed of mountaineering (Moser, 1976). All of these methods of quick snow observations and field evaluations will evolve as the level of activity and the numbers of use will demand better methods and communications. The activity has been created before the descriptive language developed to describe the environment and methods used to analyze conditions and stability.

The Alaska Rendezvous Heli Guides (ARG) work in an environment where there is a need to communicate information regarding snowpack structure in a quick and concise way. The ARG guides have developed a method to rapidly and accurately communicate more information about the snow surface structure and it's reactivity to ski cutting and slope stability.

2. POLE PROBE TESTS

Ski pole probe tests reveal a lot about snowpack structure and are commonly used to identify changes in hardness. These hardness changes, along with variations in snow texture, impact stability. Pole probing to differentiate between these layers allows skiers to use their ski pole like a penetrometer. For a long time penetrometers have been used extensively by both researchers and practitioners. Haefli developed the Swiss Ramsonde from penetrometers used in soil mechanics to measure the mechanical hardness of the snowpack [*Bader et al.*, 1939]. Later snow penetrometers aimed to increase the efficiency and objectivity of measurements [*Bradley*, 1966; *Schneebeli and Johnson*, 1998]. A ski pole is a quick and inexpensive penetrometer accessible to practitioners.

A common length of a ski pole is 120cms and enables one to get a sense of the structure correlating to the depth of the deformation caused by a skier or a snowboarder on a slope [*Föhn*, 1987]. Pole probes also help immensely in determining varying amounts of spatial variability [*Schweizer et al.*, 2008]. For example, probing with a ski pole can quickly tell a person that a wind slab caps the top of a slope before rolling over into softer snow farther downslope. Of course, ski pole probing cannot detect thin weak layers such as surface hoar.

When the guides probe, they use both the handle of the ski pole as well as the basket end. The basket provides some resistance and to the guides, becomes roughly representative of ski penetration. The handle end offers less resistance is more representative of boot penetration. The guides have noticed these depths correlate. Before stepping out of skis to dig a pit, guides will probe with the handle end to see how far their boot will penetrate and often times these depths will be the similar. Doing so instantly gives a lot of information regarding the snowpack. Backcountry travelers also gain this type of information as they skin up or make their first ski cut across the top of a slope. While skinning or traversing a skier or snowboarder is constantly using their ski poles in unison with ski penetration. These two actions help to give a person the idea of how much impact a skier or snowboarder might have on the snowpack as they travel along the slope. This learned information helps backcountry travelers identify how consolidated the snow is and the variations of hardness as well what layers exist. The person can then use their ski pole to probe deeper than ski penetration to further examine the snowpack.

Pole probe tests are commonly used among practitioners to get a sense of snowpack structure. However, not much nomenclature exists to clearly communicate the results of what is determined through pole probing. Practitioners sometimes refer to the snowpack as being positive or negative or upside down or right side up when speaking about the stability of a snowpack. It is similar to when practitioners used to refer to shear planes as being dirty or clean before such terms became formalized as shear quality or fracture character [*Greene et al.*, 2010].

A right side up snowpack is defined as snow hardness increasing as depth increases. Snow hardness is defined as the resistance to penetration that has the dimension of force [*Pielmeier and Schneebeli*, 2002]. At ARG, a right side up snowpack that becomes impenetrable at 45cms, for example, is expressed as PPRU45I. The I represents an impenetrable layer. If one were to express PPRU110 solely, the results are interpreted to mean the snowpack increased in hardness up to 110cms and the practitioner did not encounter an impenetrable layer.

An upside down snowpack is defined as one in which a change in hardness becomes inconsistent as depth increases. An upside down snowpack in which the hardness decreases at 60cms, for example, is expressed as PPUD60. The first weak layer discovered is the only one represented in the acronym.

This paper is as much about ARG guide methods as a new vocabulary for ski pole probing. When we find an upside down snowpack, our protocol is to move along the slope until more consistent pole probes are found and head in that direction. In the absence of this, a pit is dug. Guide procedure for a full data pit is at least 180cms across and 120-150cms deep. This allows enough room for one

Shovel Shear, two Compression Tests [*Jamieson*, 1999], and one Extended Column Test [*Greene et al.*, 2010; *Simenhois and Birkeland*, 2009].

It is also important to note while experiencing right side up and consistent pole probes, pits are still dug to ensure the guides aren't missing anything. Sometimes this may be a Hand Shear Test [*Greene et al.*, 2010] allowing a guide to detect surface hoar or change in crystal size, for example, as these may be overlooked in a pole probe test.

After a day in the field, ARG protocol calls for completing a Guide Daily. This is how the guides collect and catalogue manual snow and weather observations. For many years, a checkmark had become sufficient for filling out the pole probe section indicating that one or many were performed throughout the day. However, this gives very little information regarding the snowpack. With the new system, the guides can now quickly and easily describe the results of pole probe tests to include depths of strong and weak layers, changes in hardness and the consistencies of these pole probes as well as information regarding spatial variability.

3. SLOPE CUT TESTING

Experienced practitioners are familiar with slope cut testing [*Greene et al.*, 2010] and know that it is an important tool in discerning valuable information regarding snowpack stability. In ARG's region of Alaska's Chugach Mountains guides deal with a variety of snow conditions. One of the most prevalent is loose snow, which is referred to as sluff. For guides at ARG it is important to quantify the amounts of loose snow (sluff) that one deals with. It is recurrent and exists on almost every ski turn on almost every run. Sometimes it occurs solely on the surface and travels little distance with little speed. Other times it may entrain snow from deeper layers and travel great distances with a great amount of speed and destructive force. It may also exhibit characteristics ranging between these two extremes. It is valuable for guides to communicate these results in a distinct and expeditious manner. It is now common practice for guides at ARG to express the term Avalanche Loose and it's data code SCL [*Greene et al.*, 2010] to include a qualitative estimate of the amount of loose snow (sluff). The amount of loose snow (sluff) is categorized using the numbers 1-5 (Table 1.1).

QUANTIFIABLE AMOUNTS OF LOOSE SNOW (SLUFF)
SCL1- Minimal, loose snow (sluff) stops on top of slope and entrains only surface snow.
SCL2- Loose snow (sluff) stops mid slope. May entrain surface snow only or include deeper layers.
SCL3- Loose snow (sluff) travels to, or almost to, slope transition.
SCL4- Loose snow (sluff) travels past slope transition with speed and lots of volume.
SCL5- Loose snow (sluff) travels to slope run out with speed and lots of volume.

Table 1.1

Our guide protocol for dealing with sluff is as follows. The guides' first slope cut is a shallow, less committing one above the apex of the slope and is done cautiously. The second slope cut is done with a type of pedaling motion, while at the same time jumping up and down. It is the most aggressive and is done in a fashion to cut the legs out from underneath the section of snow traversed in the first slope cut. The thought here being if it is sensitive the snow will move with this second most important slope cut. The third is done at a steeper angle (45^0) and is fast as the guide is low on the slope now and is concerned for their personal safety as they move toward an island of safety. A guide does not want to get caught too low and too slow on a slope as this brings on a greater opportunity to take an unwanted ride. These slope cuts are all done with jump turns as opposed to "kick turns". The guides believe a jump turn applies more weight and allows you to keep your speed, thereby making it less likely to be involved in an avalanche. An important note is that ski cutting is obviously only effective for instabilities that are at and relatively near the surface and not for deep slabs.

4. CORRELATING SLOPE CUT AND POLE PROBE TESTS

At ARG a new vernacular has been adopted in the last year regarding slope cut and pole probe tests allowing guides to clearly communicate and to begin correlating these results. Many pits in ARG records from March and April 2012 correlate PPRU's with SCL1 and SCL2. Some of the pits correlate PPUD with SCL2 as well. These are just examples and one can think of cases with PPRU's with very large loose snow avalanches (sluffs). One can also imagine cases of PPUD's with no loose snow avalanche (sluff), but very dangerous buried weak layers.

Most of the data correlates PPRU's with SCL1 as seen from the examples above. ARG does not have many correlations of PPUD's correlating with greater than SCL2 as methods lead guides to skiing elsewhere when PPUD's are encountered. Even in the name of research guides do not see fit to ski a slope indicating instabilities just to see if more data for research can be gathered.

We have just begun documenting the correlation of these results and of course, welcome any other data that may further expound upon these pragmatic views.

5. CONCLUSION

The ski pole probe test used to determine the depth and impact of ski and boot penetration is a valid comparison. Extrapolating information from pole probe tests to possible slope cut results is a rudimental method used by heli-ski guides to negotiate their groups descent. With so many spatial variables, elevations, aspects, terrain features and snow textures, conducting full data pits or even test pits at all these junctures can be impossible and require more time than one has available. For the guides, his language expounds on common practice and has become a way of implementing data codes used to quickly and easily decipher and communicate information regarding snowpack structure. Practitioners use their knowledge and skills to evaluate snow conditions and snow stability. These pole probe and slope cut tests are only an additional tool to help make decisions based upon snowpack structure. Of course, one cannot see crystal type and size or detect the presence of surface hoar.

Possibly more study can be made of standard basket size and standard pressure on which to insert the ski pole as it relates to ski deformation. Classification of loose snow avalanches 1 through 5 is a natural progression in terms of release size. ARG hopes the mountain and science community will consider this work in future editions of printed materials. We also believe experienced mountaineers and guides have more of this type of intuitive information that can be quantified and synthesized into a formal cognitive language beneficial to all mountain travelers.

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