Darby Canyon: Swan Slide Path Avalanche Fatality
Saturday, March 10, 2007

SYNOPSIS:

Two skiers (one telemark skier and one splitboarder) were caught near the top of the Swan Slide Path in the Teton Range in Wyoming resulting in one fatality. The two brothers were ascending the ridge on the south side of the path when the slope collapsed under the upper 'skier' and subsequently fractured. The avalanche transported the splitboarder ~200 vertical feet, while his brother, who was caught lower on the slope, was carried ~1700 vertical feet and was buried two to three feet deep. The crown of the avalanche varied in depth from 20cm/8" to one meter/39" deep and followed the ridge crest down for ~600 vertical feet. The avalanche ran from 9980' to 7640' (full track) and was classified HS-ASu-D3.5/R5-O/G.

TERRAIN:

This slide path can be seen from Teton Valley, Idaho and resembles a flying swan in the spring/early summer – hence the name. The start zone of this west-facing slide path consists predominantly of NW facing cross loaded terrain. There are several small limestone rock bands and boulders in the start zone. Most of the start zone averages 36-37 degrees and is 39 degrees at its steepest. The start zone is funnel shaped and channels into a long and narrow track. The track averages between 26 and 30 degrees for the majority of the path and has many small benches and small trees to entrain debris. The last 500 vertical feet of the path consists of two terraces with short (~30') steep steps

between them. The path ends in the South Fork of Darby Creek in a steep-walled terrain trap. Trees on the distant side of the creek indicate that the path has not climbed the other side of the canyon for any significant distance in recent history. In this avalanche the toe of the debris came to rest right on the creekbed and was quite thin by that point (mostly airblast material). Debris covered 2000 vertical feet of the path and varied from 40cm to 3 meters in depth. The average width of the debris across the track was 10 to 20 meters (33 to 60 feet). The run-out angle for this avalanche was 28 degrees (4400' run, 2340' fall).

The pair's uptrack generally stayed to the north of the avalanche track for the lower half of the climb and then crossed to the ridge on the south side of the track for the upper part of the climb. Parts of the uptrack were still visible after the avalanche. Given the hard slab nature of the avalanche it pulled further up onto the ridge beyond the sharp breakovers (convexities) of the start zone.

WEATHER:

The weather leading up to the time of the accident (~1700) was generally cloudy and warm with clearing skies in the late afternoon. Over Friday night and Saturday morning 5-8cm/2-3" of snow fell in the area judging by the powder depth over the most recent crust. (2" of 7% density fell at the Raymer Plot at JHMR and 0.30" of snow water equivalent at the Grand Targhee Snotel – 9 miles north of the accident site). Temperatures during the day at the Targhee Snotel hovered in the low 30's, peaked at 38 degrees around 1500

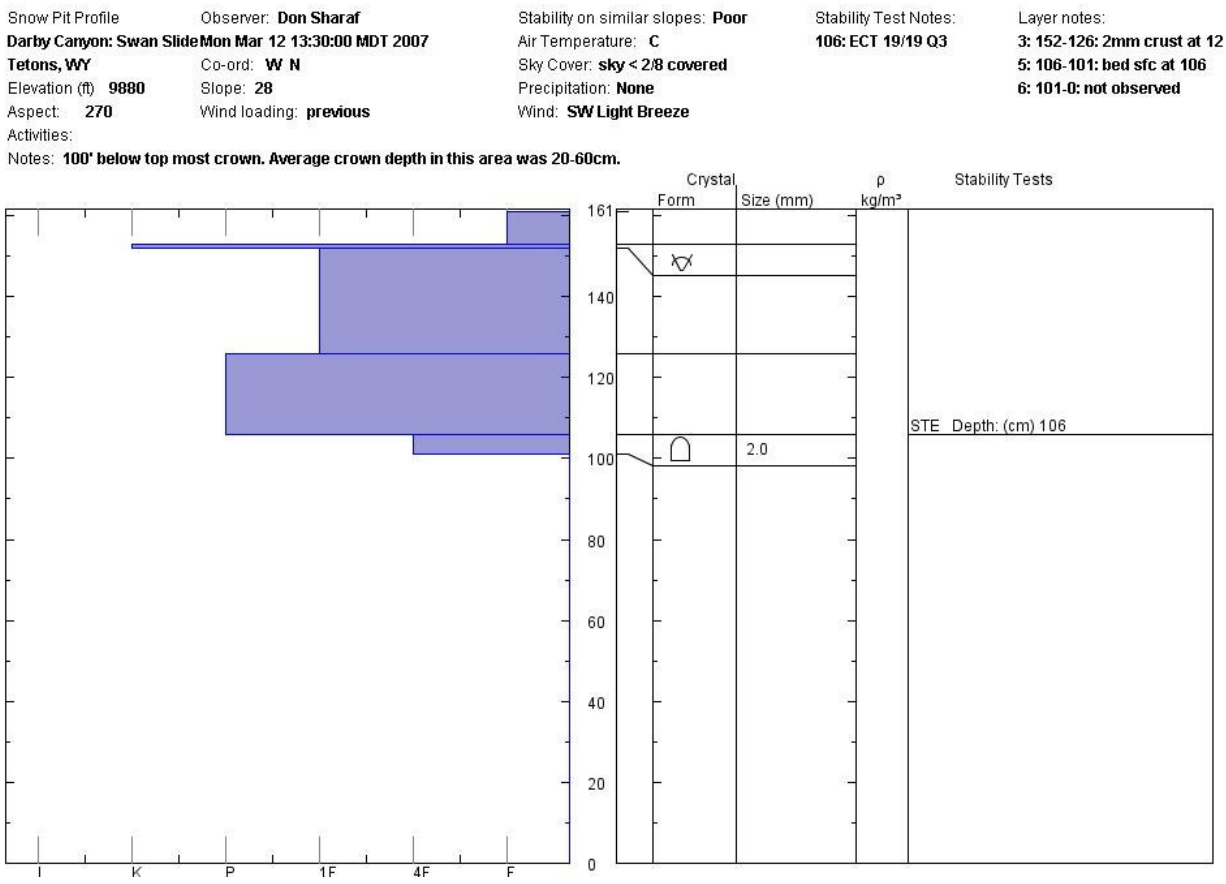
and then declined to 31 degrees at the time of the accident. These are warm temperatures, but it had been significantly warmer earlier in the week (Targhee Snotel: maximum temp of 46°F on March 6 and 42°F on March 7). The clouds were starting to break in the late afternoon, so solar heating may have played a role on this westerly aspect. Ski penetration of the ascent track showed that the snow surface had thawed but the track rarely exceeded 5cm (2") in depth. Prior to March 10, the last snowfall greater than 1" was on March 2nd (5" of 5% density at the Raymer Study Plot). See February and March weather data at the end of this document for more details on the weather history. Weekly weather summaries can also be found at http://www.jhavalanche.org/summaries.php

AVALANCHE:

The general avalanche hazard for the Teton Area on March 10th was Low at all elevations. The forecast is generated by the Bridger-Teton National Forest Avalanche Center and does not incorporate much data or observations from the west side of the range (Caribou-Targhee National Forest). Darby Canyon is not a frequently visited area by backcountry skiers as it generally requires a snowmobile for access, except for a hearty few who are willing to ski 6 miles to get to the summer roadhead. Although there had been recent snowfall, the amount of weight added in the last 24 hours was relatively small. The warm temperatures and sunlight may have played a part in this avalanche, but it was not the warmest it had been in the past week. There was a natural avalanche (observed two days later - on the day we investigated) on a similar aspect and elevation to the start zone at the Teton crest, though it may not have been visible on the day that this accident occurred. It is not immediately obvious that it is a similar aspect to the Swan's start zone.

SNOWPACK:

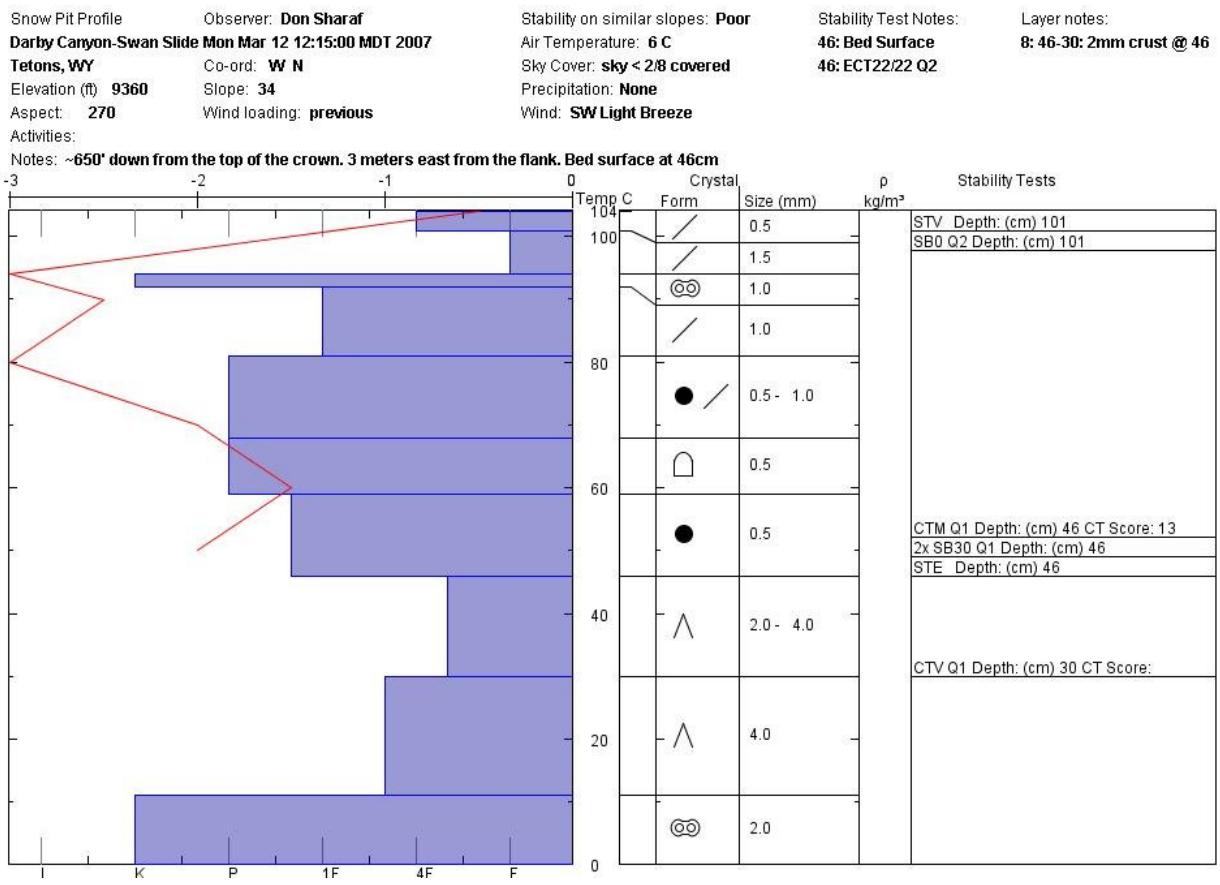
The snowpack in the south fork of Darby Canyon is shallower than in recent years and there is widespread distribution of depth hoar on westerly slopes in the vicinity of the Swan slide path. Two weeks before the accident, two of the authors of this report were digging a westerly snow pit in an adjacent path (at 8500') and they caused a collapse that propagated for three seconds time. The culprit in that case likely was 2 mm facets underlying a crust (buried on February 1), but could have been the depth hoar at the base of the snowpack. When we investigated this accident we found a very similar stratigraphy to the pit two weeks before. The crown on the upper part of the start zone varied from 20 to 60cm thick and is shown in the snow profile below (facets lying beneath a crust with a hard slab on top). Marked as site B on the map at the end of this report.



The lower part of the start zone (9700' to 9300') had crown depths of 30cm to 100cm and averaged 70cm in depth. As all of the NW facing snow had slid off the ridge we dug pits on the westerly aspect on the ridge crest. The bed surface in this case varied: in one site it was the transition of depth hoar to rounds (former facets that had fully made the transition from mixed forms, but still generally had a square shape to them). This pit site is marked as "A" on the map. At another pit site, 100' above, the bed surface was a 1F+ layer of 1-2 mm mixed forms and the weak layer was a 2 cm thick layer of large (2.5-3.5 mm) mixed forms with a thin crust above it. It seems probable that the avalanche initiated beneath the splitboarder in facets lying under a crust in a thin area of the slab. That collapse likely then seemed to propagate downslope and initiate the fracture above the depth hoar a little lower on the ridge. Where the avalanche ran, the bed surface was

supportable for walking, but above the flanks on a lower part of the south ridge, the foot penetration was waist deep. The avalanche tapered to 10-20cm/4-8” where the path became more southerly.

Snow Profile from Pit Site ‘A’



ANALYSIS:

This was a difficult avalanche to predict using simple decision-making frameworks. The red, yellow, green system (*Snow Sense*, Fredston, J. and Fesler, D.,1994,116 pages) requires that you gather information from the snowpack by digging. However, <u>without digging</u> the clues likely would have looked like a red light for terrain, a green light for snowpack (low avalanche hazard, no recent avalanches in view, no collapsing or cracking), and a yellow light for weather (heating by sun and air temp, but less so than in the previous four days).

ALP TRUTh may not have worked perfectly as a prevention tool, though it would have pointed out a need to gather more snowpack information than what was available by passive observation (without probing and digging into the snowpack). Current research points out 92%(+/-3%) of avalanche accidents have 3 or more clues associated with them and 77% (+/-4%) have four or more clues. (McCammon, I. and Hägeli, P. 2004. Comparing Avalanche Decision Frameworks Using Accident Data from the United States, *Proc.Int’l Snow Science Workshop,* Jackson, Wyoming, pp.502-511). The natural

Avalanche observed close to the Teton Crest may not have occurred by the time of the accident and/or may not have been visible in the breaking cloud cover. There was light Loading in the past 24 hours, but less than a 'critical' amount (as sited by Atwater's 10 Contributory Factors research). The Path was well defined – so that would be counted and the path had many terrain Traps (benches in the path and a steep creek at the bottom). The avalanche Rating was low (well below the considerable rating used in ALPTRUTh). There were no Unstable snow signs observed by the skiers (the only collapse was the one that initiated the avalanche), There was Thaw instability, but no greater than what had occurred in the past week. Overall, there would have been three clues in the ALPTRUTh framework and it wouldn't have been a significant red flag on its own without considering other factors. The average avalanche incident has 5.2 of these ALPTRUTh clues as stated in Ian McCammon's Human Factor Research.

The route-finding/track setting for this route was generally pretty good; it mostly utilized the safest route possible for ascending this path. That being said, there is no way to ascend to the top of the run without being exposed to avalanche terrain for significant portions of the up track. The area where the avalanche was triggered was a shallow part of the slab (20-30cm), where it was most likely that the skier's weight would penetrate to the weak layer. A route closer to the ridge axis might have been marginally safer, but lower parts of the ascent route still would have been exposed to the avalanche that occurred. One take-home point for the authors was that if there are no compelling reasons to do so, don't deviate from the absolute safest line on the uptrack. A matter of a few feet can make a big difference.

It has been well researched that snow pits can give misleading information and an incomplete picture given the amount of spatial variability in snow strength across a slope. In this case, however, digging a pit might have been one of the only indications that there was significant instability. All four pits that were dug showed moderate strength, moderate to high energy (as quantified by shear quality), and a weak structure (5 Lemons – McCammon and Schweizer Research). Those findings along with foot penetrations in some areas up to your waist indicated that there was a relatively weak snowpack. Given that the crown profiles were 2 days after the avalanche we would have expected higher stability scores and lower energy, but that was not the case this time.

A final lesson from this tragic accident is that there needs to be an inherent mistrust of snowpacks on low snow years. A simple rule, but a remarkably reliable one, is that deep snow is strong snow and shallow snow is weak. Given the low snowfall this winter, many areas that have been stable in recent years should be held suspect this year. Persistent deep slab instability is a factor in our snowpack this season. With widespread depth hoar, along with well developed persistent weak layers (buried surface hoar and near surface facets from the January dry spell), snowpack stability is less uniform and predictable. In the previous 10 days, there had been numerous natural and artificially triggered hard slab avalanches in lower traffic areas (Mt Taylor into Mesquite Creek, Mike Harris Ridgeline, South Fork of Game Creek, and north facing slopes on Housetop Mountain and Fossil Mountain). These events should be factored into our decision-making.

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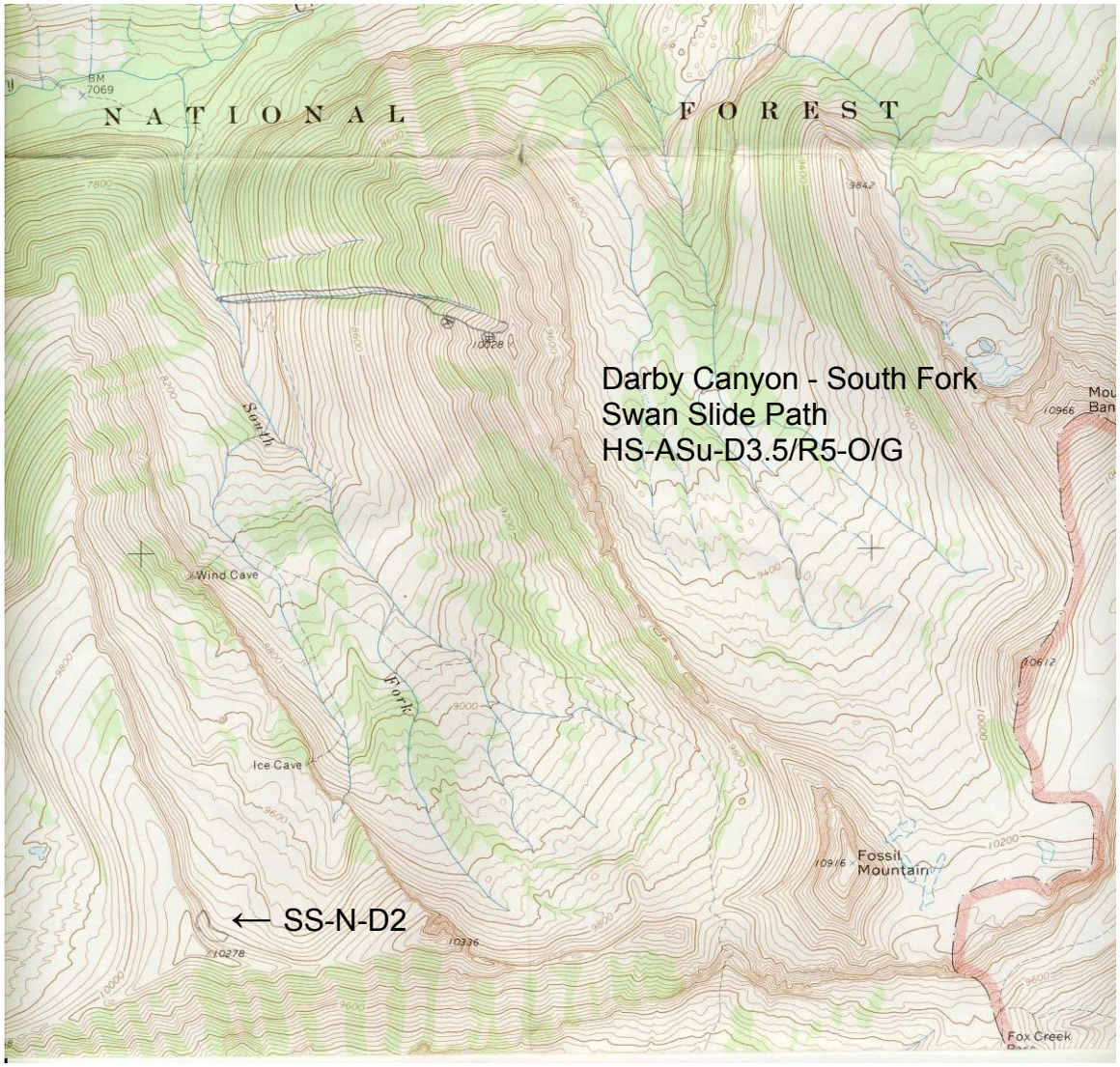
Some details of the accident were taken from the Jackson Hole Daily article by Angus Thuermer on March 12, 2007. This article can be found at
http://www.jacksonholenews.com/article.php?art_id=1529

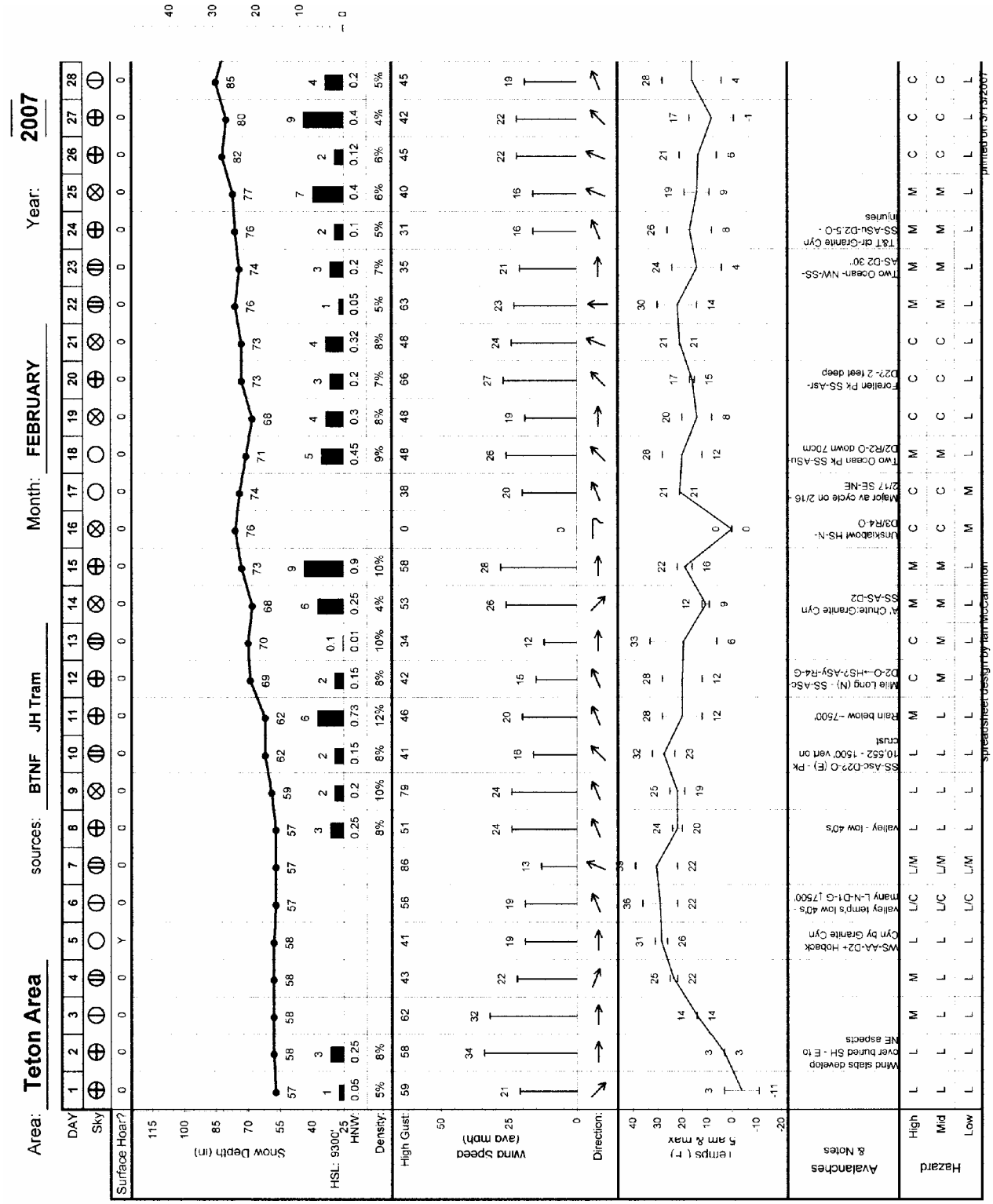
A more complete article is available from the weekly Jackson Hole News and Guide (Thuermer, Wednesday, March 14, 2007) and found online at
http://www.jacksonholenews.com/article.php?art_id=1544
Please note that the facets mentioned in the article were from near surface faceting and not from buried surface hoar (as stated in the article).

Mount Bannon, Wyoming - USGS Quadrangle 7.5 Minute Series



Picture of the Snow Profile from Pit Site ‘A’

February 2007 Weather Data – Bridger Teton Avalanche Center



March 2007 Weather Data – Bridger Teton Avalanche Center