A Publication of the American Avalanche Association®

THE Avalanche REVIEW

VOLUME 30, NO. 3 • FEBRUARY 2012

www.AmericanAvalancheAssociation.org

Heli Blasting at Crystal Mountain, April 3, 2011. With the previous mission producing an R5D4 result within the Crystal ski area, patrollers Paul Harrington and Christina Von Mertens find out how many explosives can fit in the back of a Hughes 500. *Photo by Chris Morin*

see Crystal story on page 21

CRUST THOUGHTS

A rain event on Martin Luther King Jr weekend, 2011, produced a widespread and variable crust that caused avalanche events of different sizes, triggers, and time sequences. See page 20 for the rest of the crust stories.

Story by Karl Birkeland

Much of this issue of TAR is focused on crusts and how they affect avalanche conditions. In particular, Lynne asked readers for feedback on the so-called "MLK crust" formed in mid-January of 2011. I cannot comment directly on that crust event as it was not a big player in the Montana snowpack, and knee surgery around Christmas limited my field time. Despite my lack of knowledge of the MLK crust, Lynne still asked me to comment generally on crusts for this issue, so here are some fairly random musings on buried ice crusts.

When an ice crust is buried, seasoned avalanche practitioners keep careful track of it. We've been trained to recognize that even subtle changes in structure in the snowpack need to be monitored, and ice crusts clearly form dramatic discontinuities. Even if the snow surrounding the crust is well bonded initially, the changes in porosity and conductivity associated with a buried crust might well lead to snowpack weaknesses resulting in dangerous avalanche conditions. Sometimes when an ice crust becomes buried, the crust and the crystals around it become a season-long problem over a large area *(many examples exist, such as Jamieson and Johnson, 1997)*. However, other times a crust will form and be buried, and there will be no weakness whatsoever associated with it. Why the difference?

See story continued on page 20 ➡

The Avalanche Review
P.O. Box 2831
Pagosa Springs, CO 81147

in this issue

Even with crusts, what I call Ron Perla's First Law of Avalanche Forecasting – the only rule of thumb is that there are no rules of thumb – still applies!

—Karl Birkeland, *Crust Thoughts*, pg 20

Crown from Three Way Peak avalanche at Crystal Mountain Resort (see story on next page). *Photo by Chris Morin*

CRUST THOUGHTS

continued from cover

What Makes a Crust Problematic?

In my opinion it is not about the crust itself, but rather what is around the crust. Is the crust bonded to the adjacent layers, or are there facets around the crust leading to poor bonding? The conditions under which the crust forms, and the subsequent temperature conditions through and around the crust, are critically important.

If a wet layer is subsequently buried by a thin layer of new snow, facets may form quickly around that crust through a process called melt-layer or wet-layer recrystallization *(Birkeland, 1998)*. This buried facet/crust combination can be problematic for weeks or even months.

Crusts that exist at or near the surface during cold, clear weather can have large temperature gradients across them as the snow around them facets due to diurnal recrystallization *(Birkeland, 1998)*. While the other snow is faceting, even more dramatic faceting may occur immediately adjacent to the crust. Subsequently buried, this will again form a persistent and dangerous weakness.

We do not yet fully understand how crusts affect the temperature gradients across them. Cora Shea's groundbreaking work at the University of Calgary shows the complexity of the problem using infrared images of snowpit walls *(Shea et al., 2011; 2012; Shea and Jamieson, 2011)*. Cora's work shows some unexpectedly large temperature gradients around even deeply buried crusts. *(see story on page 28)*

Further, sometimes a crust can be warmer than the snow around it and sometimes it can be cooler for reasons we do not yet fully understand. The bottom line is that there is a lot going on at and around crusts in terms of temperature gradients, and much more work needs to be done before we will have a complete understanding of the gradients and the different processes driving those gradients.

Of course, the reason we are so interested in the temperature patterns and gradients is the subsequent metamorphism of the crusts and adjacent snow. Ethan Greene did extensive laboratory work on snow samples with crusts, and he showed how a temperature gradient across a sample results in more dramatic faceting around a crust than in the nearby snow *(Greene, 2007)*. Interestingly, the most pronounced faceting occurred within a crystal or two of the crust. While these effects dramatically (and adversely) affect bonding to the crust, they cannot be easily detectable with our relatively crude field techniques. Similarly, the gradients being investigated with infrared images cannot be measured with the basic stem thermometers we all use.

What Should Be Done?

So, what should we do about crusts? On the one hand, we know that sometime they do not cause avalanche problems. It seems that this is more likely to be the case when they are buried quickly and deeply and where they are largely unaffected by temperature gradients. On the other hand, sometimes they cause dramatic and persistent weaknesses that lead to difficult-to-forecast avalanches for an entire season.

These latter cases typically occur when the crust and the surrounding snow is subjected to temperature gradients, though sometimes these temperature gradients can occur over short time scales. Crusts tend to amplify the faceting process in the snow nearby, and the resultant poor bonding causes avalanche problems.

Unfortunately, recent research shows that our stem thermometers are insufficient to monitor some of the temperature gradients taking place over short distances adjacent to crusts, and our hand lenses and crystal cards do not always allow us to see some of the dramatic changes taking place extremely close to the crust.

The tools that can help us monitor what is going on around the crust are stability tests. Once a crust is buried, we can use stability tests to help us estimate the bonding to the crust and how that changes over time. Certainly, crusts bear watching and monitoring. There is a lot we don't know about crusts, so be sure to note any unusual observations so you can compare what you see with others.

In the near future we may get more opportunities to track tricky crust scenarios as climate patterns shift and crust-forming events become more common in even our less-maritime environments. So, keep track of those crusts. However, don't assume they will always be a problem. Even with crusts, what I call Ron Perla's First Law of Avalanche Forecasting (the only rule of thumb is that there are no rules of thumb) still applies!

Acknowledgements

Thanks to Cora Shea for quickly reviewing this at short notice!

References

Birkeland, K.W. 1998. Terminology and predominant processes associated with the formation of weak layers of near-surface crystals in the mountain snowpack. *Arctic and Alpine Research* 30(2), 193-199.

Greene, E.M. 2007. The thermophysical and microstructural effects of an artificial ice layer in natural snow under kinetic growth metamorphism. Ph.D. Dissertation, Department of Geosciences, Colorado State University, 147 pp.

Jamieson, B. and C. Johnston, 1997. The facet layer of November 1996. *Avalanche News* 52, 10-15.

Shea, C. and B. Jamieson. 2011. A new thermal view. Avalanche.ca 98, 36-39.

Shea, C., B. Jamieson, and K.W. Birkeland. 2011. Use of a thermal imager for snow pit temperatures. *The Cryosphere Discussions* 5, 2523-2556.

Shea, C., B. Jamieson, and K.W. Birkeland, 2012. Hot crust, cold crust. *The Avalanche Review* 30(3) [this issue].

Karl Birkeland is the acting director, avalanche scientist, and currently the sole employee of the Forest Service National Avalanche Center. He loves chasing his two daughters around Bridger Bowl and is hoping that by the time this issue of TAR hits our mailboxes, the early season drought of the winter of 2011/12 will only be a memory.