THE Avalanche REVIEW

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Open by Summer

CHINOOK PASS WASHINGTON

Story & Photos by John Stimberis

Chinook Pass, Washington (1656 m), is home to State Route 410. The WSDOT keeps the mountainous section of SR 410 closed throughout the winter due to excessive snowfall and avalanche hazards. Each spring the WSDOT avalanche crew from Snoqualmie Pass arrives to assess the avalanche hazard. This is a place where our crew gets back to the roots of what we do. No computers, phones, or traffic to deal with and limited weather information to get us through the day. Chinook Pass is where we put the skins on the skis and head for the ridges to search out the ideal conditions to make avalanches.

A crew of four or five equipment operators work below us and they depend on our sound judgment and observational skills to keep them safe throughout the day. They in turn reward us with the occasional hot dog lunch. The equipment operators often comment on how "crazy" we are for skiing uphill with packs full of explosives, but when you see the terrain they work in, you might reconsider who the "crazy" ones really are. Imagine spending the better part of your working day in an avalanche path, mid-track, during the spring, on a SE slope!

Overall, this is a fun and challenging project. We get a chance to operate in a remote setting, rely on our avalanche skills, and when the conditions are ripe, make a big mess! Throw in a tan and lots of exercise hiking all those bags of ANFO up the hill and I think it is a great way to finish the snow season.

above: The terrain east of Chinook Pass reveals the highway located mid-track through the valley.

left: Two WSDOT Avalanche Forecasters head out for a day of work.

below: The occasional hot dog lunch is the reward for keeping the equipment operators safe. TAR wonders if the missing ISSW weiner met his end in this manner?

in this issue

The elements of consequence and likelihood are linked, and if you fail to recognize this, you are running on faith.

—Martin Volken, The Hazard Evaluator, p13

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from the executive director

Last year at this time, I was up to my ears in snow and avalanches. In December '08 it looked like that was going to be the story again, but the snowfall and avalanches have eased which makes full-time highway avalanche forecasting and AAA executive directoring a little easier to manage. December '08 was very memorable throughout the Mountain West. I know all the memories may not be good ones, but that's the way it goes in our business. Mother Nature can make even our best efforts look insignificant. Our path is one that provides for a lifetime of learnings. It's a valuable and fulfilling path.

AAA has yet to feel the effects of the current economic situation, but I'm sure we will sometime. In TAR 27-3, Janet did a great job of describing where AAA is now and where we plan on going in the near future. As the AAA business manager, I feel we are in a solid position right now and into the near future. We continue to gain members and subscribers which are the largest sources of our income. Because we work with so many volunteer or part-time paid persons who all have full-time avalanche jobs, we haven't been able to really overextend ourselves operationally and financially. We remain committed to our core member benefit: producing a top-quality *Avalanche Review*.

Our second tier of services – producing SWAG; providing AVPRO, Instructor Certification; providing grants for practitioner and academic research; supporting Professional Development; and the new Avalanche.org – are all projects that we have carefully evaluated to make sure that we can fulfill the criteria that Janet outlined as 1) Is it fiscally sound, 2) Is it do-able given our lean infrastructure, and 3) Is it sustainable? I don't see the necessity for any reduction in services or member benefits right now or in the near future.

The rise of regional professional development opportunities is an area that we really want to support. How to select and fund these seminars will be a major topic at the upcoming governing board meeting scheduled for late April in Summit County, Colorado. There are eight sections and we would like to be able to provide some support to events in each, but the question of how to do this remains. Our support in the past has been piecemeal, and the board will be seeking an organized, sustainable, and equitable approach for future funding.

I apologize for the late distribution of the 2009 AAA Membership Directory. Our long-time, reliable printer was a victim of the recent economic downturn and the search for a new printer was not an easy one.

By the time you read this, another season will almost be in the books. I wish you an enjoyable spring and summer, and for those of you heading to the southern hemisphere another safe and successful winter. Thank you all for your support of AAA and our profession.

—Mark Mueller, executive director

from the editor

The drone of the bagpipes still rings in my ears from last night's celebration of the too-brief shining life of another friend lost to the mountains. We'll all make the journey someday, but the ones who flame the brightest seem to leave the soonest. The struggle to make sense out of loss makes me want to dig deeper, work harder, and play smarter – to do the real work to inspire myself and others to make better and more considered decisions – in not just the snowy backcountry.

This issue of *The Avalanche Review* offers a selection of tools for making better snow and avalanche-related decisions. Over time the theme evolved to explore a better understanding of likelihood of fracture initiation and propagation, balanced by a more considered approach to assessing potential consequences. On the likelihood side, Karl Birkeland and Jürg Schweitzer were kind enough to clear up my confusion (and to collar Bruce Jamieson for his well-informed input) about the multitude of research on fracture propagation. I figure that if I need a concept from ISSW clarified, then some of my readership may need it as well. Sarah Carpenter brings us down to earth with a practitioner's viewpoint of propagation propensity, while Ron Simenhois and Ian McCammon expand on different aspects of the topic and offer us glimpses of areas for possible future research.

In the decision-making section, Martin Volken sets the tone with his deceptively simple likelihood / consequences tool, while Bruce Tremper provides insight into rewriting the avalanche danger scale, an effort to bring greater clarity to the general public on how to use forecast-center advisories. Drew Hardesty's argument to add an X to the moderate scale shows us that better synthesis can be achieved through discussion and debate, input and perspective from a variety of users with different levels of expertise.

In our Crown Profiles section, Ian Wilson evaluates the consequences from a chain of decisions that led to the Sunburst avalanche of February 2008. TAR first presented this accident report in 27 / 1, and it is well worth publishing Ian's subsequent thorough personal review. You'll be fascinated by part two of Jerry Roberts's San Juan history and photos, and delight in some eye candy from crack photographer John Stimberis, whose views of Chinook Pass grace the cover of 27 / 4.

One thing that struck me in this issue is how Ed LaChapelle's *The Ascending Spiral* continues to spark revelations, using new language and hard-earned insight to order information into new systems. Carefully listening to one another's ideas, experiences, and opinions balances thesis with antithesis. Salting the synthesis with a pinch of luck, as Kevin Devine reminds us, can be the most unpredictable yet crucial spice on the rack. I leave TAR's readers with an enjoinder to never stop thinking and considering your decisions, their likelihood and consequences, on snow and off.

This issue of TAR is again 32 pages. Thank you to our many contributors, and especially to those whose stories I had to bump due to space constrains. Hopefully TAR 28 / 1 will bring you fascinating stories such as a photo spread from Matt McKee and Glenn Vitucci's adventures at the Pimenton Mine, an avalanche-trigger's perspective from Little Water Peak in the Wasatch, a fond remembrance of Hal Boyne, an update from Sylvan Pass in Yellowstone, plus the avalanche center summaries from this remarkable season.

I am off for the month of April to the Alps, out of my Teton backyard into unfamiliar terrain and conditions, where I plan to keep in mind the Eskimo saying, "When you come into new country, listen a lot."

—Lynne Wolfe, editor

Kolob Canyon *photo by Dan Powers*

mailbag

RE: Snettissham Powerline Avalanche, TAR 27-3

The use of 40#AP explosive bomb should create a crater. The unconfined use of an explosive may be the best that can be done. I would like to call attention to an easy-to-fabricate explosive device that can be a more efficient use of explosive. The device was developed in the early 1990s by staff at the Henderson Mine, Empire, Colorado, to fragment oversize rock. (Don Bachman is familiar with this area.) A plastic funnel is filled with a cap-sensitive explosive and shaped to maintain the cone shape, and aluminum foil holds the explosive in place. A cap is easily inserted into the explosive through the spout. Stand-offs can be used but are not necessary. This device does work.

I am 73-years old, and when it comes to avalanche work rarely do we have access to all the devices that may work, but whenever explosives can be confined, the effectiveness is improved. A naturally occurring fracture might cover 200' in two milliseconds – about the blink of an eye. The eye cannot transfer an image that quickly. So those actively involved accomplish creating fractures to eliminate a hazardous condition using hand-deployed devices, cannons launching a projectile, and good old foot stomping. Some designs to produce better products need to be made. Some firm like Scandia National Labs would be helpful if grant money could be applied. Another might be USDOT research money that comes to the states. Lots of ideas but no money.

—Harry L. Siebert, Dolores, CO

metamorphism

Hal Boyne, Life/Pro AAA member, passed away unexpectedly January 26, 2009, at the Veterans' Hospital in Denver. Hal's work in snow was primarily as a researcher beginning with the Bureau of Standards (now the Nation Institute of Standards and Technology) in Boulder during the mid-late 1970s when he and colleagues developed a remote sensing radar application which could discern varying density and SWE in a snowpack. This work has continued under the recent refinement of HP Marshall. Hal's career after he retired from the Bureau took him to CSU where he headed up a snow hydrology program and collaborated with Kelly Elder of the USFS in many years of field work. Look for a more in-depth memorial to Hal from Kelly Elder in the October '09 issue of TAR.

Best of luck to **Kelly Elder**, who had both his knees replaced with bionic ones in mid-February.

Glenn Brand Passes Away

Long-time American Avalanche Association professional member Glenn Brand, 78 years old, died of a heart attack on November 18, 2008. Glenn joined the American Association of Avalanche Professionals (now American Avalanche Association) in the mid-1980s. Glenn's involvement in avalanches was the result of avalanche-rescue work he performed around Aspen in the 1960s and 1970s as a founding member of Mountain Rescue Aspen. Glenn's interest in avalanches was prompted as a young boy when famed Swiss mountaineer and avalanche expert Andre Roch first came to Aspen in the 1930s and stayed at his family's guest ranch along Castle Creek. Roch's visits continued, and the friendship grew over the decades.

Glenn's interest in avalanches and especially rescue was helpful to the mountain rescue community as Glenn quietly attended many national and international avalanche conferences and passed along avalanche information and news to the rescue community. In 1979 Glenn and his brother sold the family ranch, and Glenn moved to the east side of the mountains to Evergreen, Colorado. After 15 years of mountain rescue work around Aspen, Glenn joined Evergreen's Alpine Rescue Team in 1979. In 2004 the Mountain Rescue Association recognized Glenn for his 40 years of service. This year would have been Glenn's 45th year in mountain rescue.

aaa news

New Look for Avalanche.org

The American Avalanche Association has partnered with WWAN and avalanche.org to provide new graphics and a layout that benefits both professionals and the public. Special thanks go to Chris Lundy for overseeing the project and to Dan Judd & Dan "Howie" Howlett, who have been the brains and workers behind this key US avalanche Web site for so many years.

Professionals throughout the industry sent impressive photos for the flash slide show on the home page. Avalanche-course providers who use AAA professional members for instructors are listed in the education resource pages. In addition, all professional members can be identified through the professional pages, so keep us updated as your jobs change. Now it is easy and professional to promote your affiliation with the AAA.

All the current WWAN pages are in the professional drop list at the top of the home page, including employment listings. Future projects include updating the avalanche library and a member access directory.

ATTENTION Avalanche Course Providers

For the new avalanche.org site, avalanche-course providers will need to resubmit information to be listed in the new and improved course-provider directory. In order to be listed, they need to have someone on their staff be pro members of the AAA.

Please submit your organization name; location; phone; email; Web site; and courses taught (Intro/Awareness, Level 1, Level 1 refresher/ASAW, Level 2, Level 3).

Email your info to clundy.avalanche.org@gmail.com.

—Thanks, Chris Lundy

what's new

Northwest Blaster's Seminar

Story by Patty Morrison

One of the choppers that Hi Line Helicopters provided for Blaster training.
photo by Craig Wilbour

Last fall the Washington Avalanche Control Council and the Association for Professional Patrollers joined together to put on a two-day Blaster's Seminar. 42 people from the Northwest, Canada, and Alaska participated in this sharing of what's happening in the world of explosives. Our host for the seminar was Hi Line Helicopters, Inc., of Darrington, Washington.

The first day was spent inside with a wide variety of presentations including a product information share from Dave Sly of CIL/Orion and Rob Onslott of Orica. Seems that most of the Northwest has switched to buying pre-made cap and fuse (Mildet from CIL/Orion) in order to reduce the amount of duds. Sly says that shipments have been crossing the border with greater ease than in the past. I also discovered that CIL/Orion donates money to the AAA for educational purposes. Orica, who used to be Atlas, has decided to return to providing explosives for the avalanche community after a 10-year hiatus. As many of us recall, most explosive companies were spooked by liability potential as a result of the Big Sky incident and how we ignite our fuses.

In response to these ignition concerns, Paul Kunze of McCarthy Industries has created the Snow-Cap Electronic Initiation Timer System. Interesting in concept, this device is a small electronic unit designed to connect to a standard detonator. The unit is then activated via a handheld device in the field. It'll be interesting to see if it can be cost effective, practical, and efficient for work in the field – it still needs a lot of field testing.

We heard from various folks from the Washington State DOT, and John Stimberus gave a great review on explosive properties. He posed the never-ending question of the importance of detonation velocities concerning types of snow. Craig Wilbour shared Snoqualmie's innovative and creative use of trams. He gave great tips on what kind of hardware to use and even where to purchase it. Mike Stanford gave an informative and entertaining overview of types of explosives/artillery and their delivery systems. He included everything from blaster boxes to helicopters to tanks.

After lunch, Chet Mowbry from Crystal Mountain ski area launched into the discussion of size and placement of shots. Keeping in mind there is no exact science, considering the ever changing variables such as snow, size of area, cost, timing, and previous history. Seems his most important message is, "Don't get stuck in a rut." Sometimes multiple small shots on the slope might be more effectual than one big placement. Jon Andrews of Stevens Pass ski area tackled the topic of acceptable risk and blast-site security. In many ways, nothing has really changed over the years other than perceptions, attitudes, and a more litigious society.

In the last session of the day, I gave a quick summary and overview of the Washington Administrative Code. Nice to realize that over the years, the state has been listening to the avalanche community and has taken many suggestions from the field to create these guidelines. Evan Woods led a discussion with the opening question of "When to make the decision to use explosives?" Great discussion with many factors again at play as stated in Chet Mowbry's talk.

The day ended with a meeting of the Washington Avalanche Control Counsel. Rob Gibson feels it is important to incorporate into a nonprofit entity, communicate via a Web site, and be a resource for not only the professional community, but for backcountry users as well. Jon Andrews has taken on the huge task of contesting the new state legislation requiring all licensed blasters to be fingerprinted and have background checks once a year, in addition to the three-year federal cycle. This is time-consuming and costly to the license holder, with no increased safety or security.

Day two of the seminar was all about heli-blasting instruction. In Washington, heli-blasting requires a separate endorsement for licensed blasters. This endorsement requires five heli-blasting missions and a written test. We learned and practiced heli-protocol for lighting and throwing 50-pound explosives (sand bags) out of the helicopters. The owners and pilots of Hi Line Helicopters were exceptionally patient and graceful with us. Especially considering that the most challenging part of the whole experience was directing the pilot to the "small" target and actually hitting it.

Overall, it was a great seminar, packed with a lot of good information. I look forward to the next one.

Patty Morrison is an avalanche forecaster at Stevens Pass ski area and the Northwest representative to the AAA board of directors.

corrections

The photographer for the second photo in Doug Krause's story, *The Lull*, on page 13 of TAR 27/3 should have been Mike Hamilton, not David Dellamora.

I figure it's easier to get stronger than to become a better skier.

—Mark Staples, avalanche specialist with the Gallatin National Forest Avalanche Center and new owner of a pair of super-fat, reverse camber skis, which happen to be pretty heavy to lug uphill.

Instructor Josh Hirshberg debates the drop-in point with his class during an AIARE Level 2 course in Patagonia.

Book Review:
Staying Alive in Avalanche Terrain

second edition
Bruce Tremper

Review by
Lynne Wolfe

By now I am sure that most of you have seen the second edition of this useful and well-written book. It's obvious that Bruce did his homework and that he was busy collating material right until printing date, as the second edition has the latest information up to ISSW 2008, including the PST and ECT (although not their scoring schema). This homework has made the second edition an excellent textbook for a level-two avalanche class, or for my three-week avalanche forecasting class, or even as a long-term guidebook for improving personal decision-making.

What I like more than anything – more than the avalanche porn shots, more than the helpful "Hot Tips" (the sidebars and graphics for the visual learners or casual browser), more than even the insightful quotes from a wide range of professionals (not all avalanche-related) – is Bruce's writing tone. He's clear and descriptive, willing to give you a couple more sentences in order to make his point, willing to try (and usually succeed) with odd-ball metaphors. But best of all he is truly funny and self-deprecating, introducing us to snow crystals since we'll soon be "gossiping" about them, and in stability evaluation, telling us that all the reasons not to make a decision based on one piece of information are the same reasons not to get married after the first date. I like the admonishment to never go first; it's a subtle address to the ego portion of human factor, as is his bow to the Zen view that "the journey is the destination." Read carefully, and you'll be entertained as well as educated.

The book is a companion to the AAA's education guidelines for avalanche courses, gives tips and insight to the beginner, to the aspirant ready to go to "avalanche boot camp," useful still for forecasters and educators. He has taken the time to incorporate lifetimes of advice and pithy quotes from a wide range of avalanche-savvy travelers; I find a new one to savor every time I open the book. As I re-read the second edition in preparation for writing this review, I found myself commenting on tips, metaphors, quotes, graphics; noting them for future thievery in my own classes and presentations, marked with a yellow sticky "scan this." Bruce included a quote from me; I borrow from him as well. Hopefully that makes us all better teachers, helping our students to see more clearly, make better decisions. And isn't that the goal?

AIARE in Patagonia

Story and photos by Erik Sweet

Level 2 course snow pit in Chapelco, September 2008.

Hi. My name is Erik, and I grew up in Littleton, Colorado. I have lived and played in Patagonia since 1988 and have worked as owner and guide of my own mountain guiding business, Patagonia Xperience, for the last 10 years. Last winter season here in the southern hemisphere (which is opposite to the seasons in the northern hemisphere) I organized the first AIARE avalanche courses run in the Argentine Patagonia.

After taking a Level 2 AIARE course in Aspen in 2007 with Aspen Expeditions, I felt that the AIARE courses would be an excellent educational structure to bring down to Patagonia, where no one was providing any kind of organized, professional avalanche education.

Aspen Expeditions was interested in sending a certified instructor down, and I convinced the resort administration in Chapelco ski resort of the necessity of organizing and holding avalanche education courses for the public as well as for ski resort employees.

The 2008 ski season brought an unusual amount of avalanche activity to the area and there were a number of fatalities, as well as non-fatal events. Avalanches ran where they had never been seen before. A major avalanche accident involved two young men, both long-time residents of our small mountain town. Both survived, but one suffered multiple injuries that took more than six months to recover from.

Joshua Hirshberg from Aspen was brought down to San Martin de los Andes by Chapelco, which paid for his round-trip ticket. Josh taught three courses during his three-week stay. He also skied the Lanin volcano with new friends on one of his few days off. Lanin is an emblematic mountain in the area – the highest mountain in Patagonia at 3776m.

In addition to conducting two AIARE Level 1 and one Level 2 Patagonia courses, Josh taught two AIARE Level 1 courses for the ski guides at Las Leñas ski area in Mendoza.

Instructor Josh Hirshberg Describes the Course

Chapelco and the adjacent out-of-bounds areas were the perfect venue for the terrain part of the classes. Steep terrain with myriad features made for rich, high-quality learning experiences. The enthusiastic attitudes of resort personnel made for a friendly and relaxed atmosphere during the three courses. The weather was great, and the snow was good, so we were a group of happy campers.

When the possibility arose to teach AIARE avalanche courses in Argentina, I knew this was an opportunity that I could not pass up. Teaching these courses provided rewards and challenges unique from any course I had previously been involved with. It was clear from the enthusiasm and impressive level of mountaineering experience of the students that there was a true desire for formal avalanche training. This made for very dynamic and interesting courses.

There were many memorable moments and course highlights during my time in San Martin. One that stands out occurred on the morning of a tour day for the Level 2 course. Our class consisted of accomplished mountain guides, patrollers, ski instructors, and experienced recreational skiers. This particular morning we were dealing with a temperature inversion, rapid warming, and intense solar radiation. We stood at the top Chapelco Ski Resort discussing which of our previously outlined routes we should take into an adjacent backcountry bowl. The combination of human factors and changing conditions set the scene for a great group decision as to which entrance we should take. As Erik and I were in the middle of facilitating this heated bilingual group decision, we observed a wet loose avalanche release adjacent to the more sun-exposed entrance into the bowl. This was a perfect observation to bring to the class and our decision-making process, indicating that this entrance was not the safest.

In the course wrap-up, a number of students thought that this group decision was one of the high points of the course. I feel fortunate to have had the opportunity to make these courses happen and look forward to seeing their evolution in the future.

Future of Avalanche Education in Argentina

Avalanche-awareness talks as well as beacon search, probing and shoveling technique clinics have been taught to the general public in Chapelco for the last five winters by myself and my partner in crime, Julian Carielo, also a mountain guide. Together we have formed the Argentine Avalanche Information Service, a Web page dedicated to providing weekend snow condition and avalanche risk reports for the five major ski resorts in Argentina this coming season. We have been the primary movers and shakers in an ongoing effort to bring world-class avalanche education to Patagonia.

We are looking to bring the AIARE folks down again in 2009, hopefully expanding the venues beyond Chapelco. Another front we are working on is making the Level 2 AIARE curriculum the avalanche education standard for the Argentine Mountain Guide Association (AAGM) in much the same way this is done stateside with AMGA. This will be a long process, but in the meantime we expect to keep making inroads in awareness and education of the fascinating world of avalanches and winter safety.

I would like to extend an invitation to anyone interested in coming down our way and giving us a hand with whatever knowledge and expertise you would care to bring. We have plenty of room for a sleeping bag! Just drop me a line at erik@PatagoniaXperience.com or check out our Web site at www.Snowproject.com.ar to see what we're up to. (You will need to be able to read in Spanish!)

A Few Rounds, Crusts & Facets Join AIARE ITC Forum in Stanley, Idaho

Story and photos by Kirk Bachman

One of the country's cold spots, Stanley, Idaho, was the scene for an early-season AIARE Instructor Training Course, held December 16-18, 2008. Attendees included avalanche instructors and ski guides locally from the Sawtooths, Sun Valley, and McCall area as well as a Utah ski patroller, a Teton avalanche instructor and guide, Montana-based ski touring outfitters, and an outdoor club organizer from Washington. Interest in gaining exposure to an emerging collaboration on US avalanche education through the American Institute of Avalanche Research and Education was the common bond, though respected differences of opinion often highlighted lively conversations, as attending avalanche instructors resembled the early season snowpack: a few rounds, crusts, and facets.

As an avalanche educator always searching for a metaphor to better convey concepts to students as well as emphasizing the importance of being observant when it comes to traveling in avalanche terrain, it strikes me how curiously similar we are to the complexities of the snowpack we study – how 'bout that for the "Human Factor?"

The AIARE Instructor Training Course was facilitated by course leader Brian Lazar and hosted by Kirk Bachman of Sawtooth Mountain Guides. AIARE provides a unified method for presenting Level 1, Level 2, and Level 3 avalanche education. This course focused on Level 1 fundamentals with discussions on what to emphasize. While there is a consistent body of AIARE teaching curriculum and a toolbox geared around AAA guidelines and outcomes, AIARE's message to ITC attendees is to use these tools as resources which support the curriculum, but develop a program which best supports the context of where you run your courses and what best meets the needs of your audience.

Whether ultimately, as an individual avalanche educator, you choose to join the AIARE organization may well depend upon the resources available to you. AIARE has made a positive contribution to a broad-based body of avalanche education resources to assist in developing a more consistent stream of courses taught in the US as well as a number of resources to embolden the toolbox of individual instructors.

The Sawtooth Instructor Training Course actually spent very little time focusing on the " Level 1 Course Cookbook," but instead focused on industry updates on beacon technology, methods for better teaching companion rescue to L1 students, how to address risk management and student awareness, and the limits of avalanche training. Attendees who came to the course with actual experience in avalanche education likely drew the most from the discussions, while a novice avalanche instructor most likely realized the need to take the provided workbooks and instructor manuals home to begin the study of how to become an avalanche instructor – by being mentored by elders within the industry and through on-going collaboration.

Kirk Bachman is a AAA-certified avalanche instructor and director of the winter program at Sawtooth Mountain Guides.

The Sawtooth Range provided a dramatic background for early season avalanche course instructor training.

Two "rounded grains" at the ITC forum included (l-r): Marty Rood of Payette Powder Guides-well-rounded and Chantel Astorga of Snowbird Ski Patrol-beginning-round. However, note space between grains as Stanley cold weather appears to work faceting processes on both.

The Fine Line: A 16mm Avalanche Education Film

The greatest snow sports athletes joined the world's leading avalanche professionals to present a new movement in avalanche education. *The Fine Line* is a cinematic journey that unites the cutting edge of winter action sports with youth education about responsible backcountry usage. Along with massive avalanches, epic riding, year-long time-lapses, crazy true stories, cable-cam cinematography, and Alaskan helicopter action, educational materials are made clearly visible. This engaging, educational, and inspiring DVD can save lives.

The Fine Line DVD contains one powerful feature film and four instructional films – a terrific resource for any avalanche education endeavor. Folks are calling this the best snow film of the year, and avalanche educators worldwide are finding it a very refreshing addition to their instruction. For film clips and to order, go to www.rockymountainsherpas.com.

Don Sharaf teaches a class to the AvPro students on a sunny day before they head up to Francie's Cabin.

AvPro Enjoys the Summit Huts

Story and photo by Brad Sawtell

In February 2009, AAA partnered with the Summit Huts Association, located in Breckenridge, CO, by utilizing the amazing classroom surrounding Francie's Cabin. Francie's is one of four huts in the Summit Huts system and is located south of the ski area in the Crystal Lakes Valley. The valley is surrounded by several 13,000' peaks including Peak 10, Mt. Helen, and Crystal Peak at the head of the valley.

The terrain accessible from the hut makes for an ideal classroom when teaching avalanche courses, and it's hard to beat waking up and stepping out the door into your classroom. Much of the terrain is quite steep, making it an excellent location for more advanced avalanche courses like the AvPro, where students can test advanced route finding and snowpack assessment skills. Francie's Cabin sleeps 20, has a wood-fired sauna and a Beacon Basin training course, supported by Backcountry Access. For more about Summit Huts, go to www.summithuts.org.

Huge thanks to the Summit Huts Association Board of Directors and Mike Zobbe for helping make this opportunity available. This is a great example of two nonprofits working together for the sake of educating others. Additional thanks goes to White River National Forest-Dillon District, Vail Resorts – especially the Breckenridge ski patrol and snow-safety team, various staff at the Colorado Avalanche Information Center, and Dr and Mrs John Warner (who provided lodging for the instructors). Lastly, the course could not have been a success without the students!

Brad Sawtell is CAIC forecaster for the Summit County area in Colorado. He is also AAA Education Committee co-chair and on the board of Summit Huts, where his hard work was instrumental in bringing the AvPro course to Francie's Cabin.

Canadian Backcountry Lodges Share Information via New Web Site

Story by Tannis Dakin

Backcountry ski lodges in and around Golden, British Columbia, have developed a Web site to share weather and snowpack information. If you're traveling to the area, check out www.wisegoat.ca for up-to-date information. You can view data regarding snowfall, wind, snowpack depth, temperatures, and synopses of conditions including snowpack tests. Avalanche events are also listed along with a narrative.

Dan Curry of Avert Online Snow Science Systems developed the reporting system. He modified his existing platform of a data collection and business management system to fit the needs of the backcountry lodges perfectly. It's easy for the public to access and use, providing valuable information to many backcountry travelers in our area. We strongly recommend that backcountry skiers check out the avalanche information provided the Canadian Avalanche Centre as well. Their Web link is provided on the wisegoat home page.

The site is an efficient and cost effective way of sharing information. The lodges own and store the data, so it is available for use in tracking trends over time. At the end of the year all data is graphed and printed. This will be useful in monitoring climate change. The lodges are able to freely share their data with the public (not done previously). Over 17,000 skiers accessed the site last season.

The information posted on wisegoat will usually be collected and submitted by lodge staff or trained group leaders. Since we accept submissions from many different people, however, you can view the qualifications and professional accreditations of the submitter and judge the information accordingly. Morning weather is taken from a study plot and field conditions are radioed in at the end of the day with an afternoon stability rating.

Users are required to agree to a release of liability, waiver of claims, and assumption of risk agreement prior to access. Check it out!

Tannis Dakin is the proprietor of Sorcerer Lodge, just northeast of Rogers Pass, BC.

Book Review:

A Wall of White: ***The True Story of Heroism and Survival in the Face of a Deadly Avalanche,*** Jennifer Woodlief

Creative submission by Sue Miller

December 21, 2008 I settle down on the couch after a busy week to crack open this book, *A Wall Of White*. It is snowing pretty hard outside my house on the west side of the Tetons – a good accompaniment to the book and its topic. I'm psyched to learn the details of the Alpine Meadows, California, avalanche in 1982.

12/23 The book is written quite dramatically, with sentences such as (referring to the patrollers), "Every one of them seemed to thrive on doing hazardous work for subsistence pay simply for the right to the adrenaline rush that came with saving lives." Avalanche phenomena and snow science are presented to the lay audience rather awkwardly; it appears the author has researched these topics but has little practical experience. Kind of reminds me of trying to watch *Cliffhanger* – I could not, as a mountaineer, get past the opening scene.

12/24 We hike up Mt Glory on Teton Pass to check out snow conditions this morning, ahead of the next storm. We see a couple of large slabs that have released at high to mid-elevations in the last day or so; snow stability is definitely poor, with shooting cracks that penetrate deep into an unconsolidated snowpack. Later, I pick up the book again and wade through rather dryly written biographies of the various people soon to be involved in the avalanche. Each biography ends with omens and portents of evil. I listen to the wind howl outside the house as the storm intensifies.

12/25 A historic day in the Teton avalanche bulletin, with a hazard rating of Extreme issued for mid and high elevations – the first I can remember in a long time. It is snowing like the dickens and we have a quiet holiday at home. The book is finally getting into the events immediately preceding the big avalanche. Snowing hard for days at Alpine Meadows, too. It's getting a bit surreal.

12/27 I get out for a short foray to Teton Pass. Trail breaking is hip deep and nearly impossible. We ski down a ridge that someone has tracked; how did the first skier get down at all?

12/28 I'm reading the last of the book, about the actual avalanche. It is catastrophic and sweeps through buildings and the base area. Several people are caught, both ski patrol and visitors – a father and daughter are buried deeply while walking across the main parking lot and perish. I am sad to hear of a local skier who is caught in a slab avalanche, inbounds at Jackson Hole Mountain Resort. He was quickly found but did not survive.

12/29 One of my friends was caught in the Headwall avalanche that wrapped around the gondola station/restaurant. He's fine. My partner skied up Mt Taylor in huge winds and warming temperatures and found debris piles of two R5 slides, one of which came down while he was up on the mountain…I wonder what confluence of time and place conspired at Alpine Meadows, at Jackson Hole Mountain Resort; what fate placed the people who died in exactly the wrong spot at that particular moment in time? Avalanches, and other forces greater than us, are part of our reality.

12/30 Finally a reprieve from storm and wind. I step outside and breathe deeply, glad to look forward to another day in the mountains.

Sue Miller is a long-time guide for Jackson Hole Mountain Guides, where she runs the avalanche education program. She also tracks nesting and reproduction of bald eagles in the southwest portion of the Greater Yellowstone Ecosystem.

ISSW set for October 2010 in California

The International Snow Science Workshop 2010 will take place at The Resort at Squaw Creek in Squaw Valley, California, October 21-27. Work is well under way to make this a successful gathering of the avalanche community. The easy access to Squaw Valley from Reno-Tahoe International Airport as well as the ease of driving there ensures that this could perhaps be the largest and most interesting ISSW to date.

The venue is ideal for our purposes. The speakers, exhibitors, posters, and sponsor booths will all be in one area and on one floor of the resort. Breaks will take place there also, so the action during the day will be centralized. Every effort is being made to make the event convenient for participants, exhibitors, and sponsors.

The ISSW 2010 Organizing Committee is well aware of the restraints that our current economic crisis is having on the community. We are working to offset some of the expense of attending ISSW. Registration will be reduced for participants who also book a room at the resort. We are endeavoring to provide transportation to and from Reno-Tahoe International Airport for resort guests as well as local transportation to Truckee and Tahoe City, so registrants won't need to rent a car. There will be no charges for the field trip day regardless of the activity one chooses with the exception of the golf tournament. We will try to find other offsets for expenses everywhere we can. Our negotiations with the resort are ongoing to reduce room rates where possible.

The home page is up at issw2010.com and will be routinely updated. Look for early registration deals, transportation information, and a wealth of field trip options.

—Russell Johnson, ISSW 2010 Chair

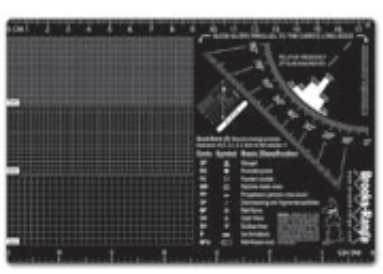
New Products to Impress Your Friends

Tested by some of the world's top mountaineering, avalanche and backcountry professionals, some new products from Brooks-Range Mountaineering Equipment (www.brooks-range.com) promise to wow your friends while "roughing it" in the snow.

Brooks-Range Fixed Blade Saw

This saw is ideal for building shelters, isolating Rutschblocks, and cutting cornices in the snow. It is lightweight and has aggressive saw teeth for the toughest jobs. The 22" (55cm) saw is made of high-quality anodized aluminum. The rubber-coated handle can be connected to the Brooks-Range Backcountry Shovel shaft as well as telescoping ski poles to increase the reach to more than 5' (2m). The saw features offset blade teeth which cut a .25" (6mm) wide slot in the snow, which prevents the blade from binding and freezing while sawing. MSRP: $24.00

Brooks-Range Folding Saw This 18" (46cm) saw folds to 11" (28cm), is made of high-quality aluminum, and easily attaches to the telescoping Brooks-Range Shovel shafts, ski poles, ice axes, and just about anything else for extending its reach. The Folding Saw has a rubber-coated handle and can be used for cutting wood or snow, avalanche science work, or winter shelter building. This saw is ideal for backpackers because it is packable, lightweight, and features aggressive saw teeth for the toughest jobs. MSRP: $49.00 *(look for a review of this saw in TAR 28/1)*



Snow Crystal Card This snow-safety tool will help adventurers make informed decisions about the snowpack. The card is printed with information on snow crystal types; is sized to easily fit in a field book, pocket or snow study kit; and is made from textured aluminum that preserves the shape of the snow crystal during analysis. The card also doubles as an inclinometer by using the attached string and weight. The Snow Crystal Card has a laser-etched 1mm, 2mm, and 3mm grid; inclinometer increments of 1o; crystal and snowpit "prompt legends;" and a standard/metric ruler. MSRP: $9.95 *(look for a review of this card in TAR 28/1)*

Current Trends in USA Explosives Use for Avalanche Control

Story by Bill Williamson

Most of the ski areas in the US that use explosives to mitigate avalanche hazard were recently sent a survey, and 45 were included in the report. The AAA Ski Area Committee reviewed the survey results to describe the type, frequency, and method of explosive use; illustrate the ski industry's notable safety record; and provide demographics on who is using explosives in the industry.

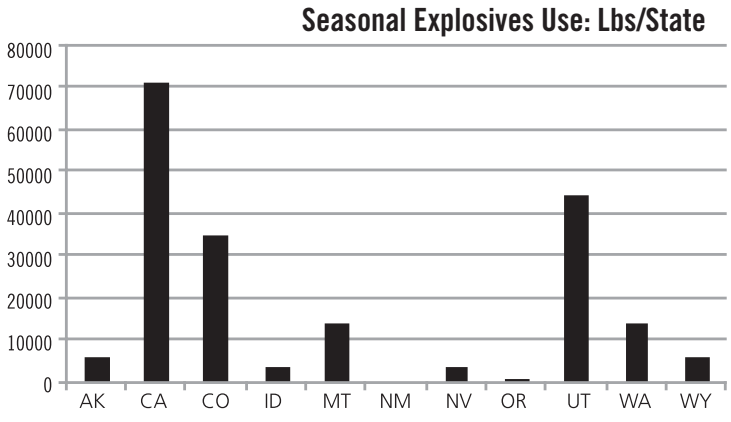
The following data is excerpted from a presentation recently given to the ISEE (International Society of Explosive Engineers). The presentation also included a brief history of avalanche-oriented explosives use and the very basics of what and how they are used. This was the Society's annual international convention and its members consist of manufacturers, regulators, contractors, and users from all over the world, in all aspects of explosives use. In past years, the ISEE has been very critical of how explosives have been used in our industry, but heightening their awareness of our safety record and making training an emphasis has eased those feelings. At the presentation, we were again criticized by some members for our techniques and other aspects of explosives use, but were defended by influential members of the ISEE that included its president and manufacturer's representatives.

Our safety record and the strong emphasis on explosives use training in the avalanche industry has created these strong allies. Every avalanche program director and every explosives handler/user needs to understand that if another accident occurs within our industry, these allies will have a difficult time defending us further, making acquiring explosives extremely difficult if not impossible. It's all of our responsibility to make sure that preventing future incidents is a priority via thorough training and consistent practices for everyone.

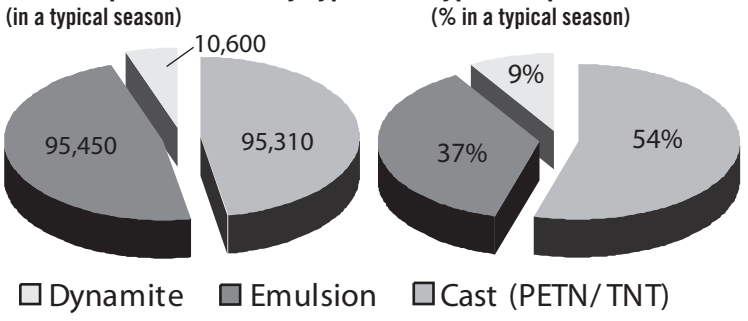
2008 SKI AREA SURVEY PARTICIPANTS

ALASKA: Alyeska, Eaglecrest. **CALIFORNIA:** Alpine Meadows, Heavenly Mountain Resort, Kirkwood Mountain Resort, Mammoth Mountain, Sierra Summit, Sugar Bowl, Squaw Valley. **COLORADO:** Aspen Highlands, Aspen Mountain, Arapahoe Basin, Breckenridge Ski Resort, Copper Mountain, Eldora Mountain Resort, Keystone Resort, Loveland Ski Areas, Monarch Mountain, Powder Mountain, Steamboat Ski & Resort, Telluride, Vail, Winter Park Resort. **IDAHO:** Brundage Mountain, Schweitzer Mountain Resort, Sun Valley, Tamarack Resort LLC. **MONTANA:** Big Sky, Bridger Bowl, Moonlight Basin, Yellowstone Club. **NEW MEXICO:** Angel Fire Resort, Teton Pass Ski Area. Nevada: Las Vegas Ski & Snowboard Resort, Mt. Rose Ski Tahoe. **OREGON:** Mt. Ashland, Mt. Bachelor, Mt. Hood Meadows. **UTAH:** Alta Ski Area, Deer Valley Resort, Snowbasin Resort Co., Snowbird. WASHINGTON: Crystal Mountain, Stevens Pass Ski Area. **WYOMING:** Jackson Hole Mountain Resort.

Seasonal Explosives Use: Lbs/State

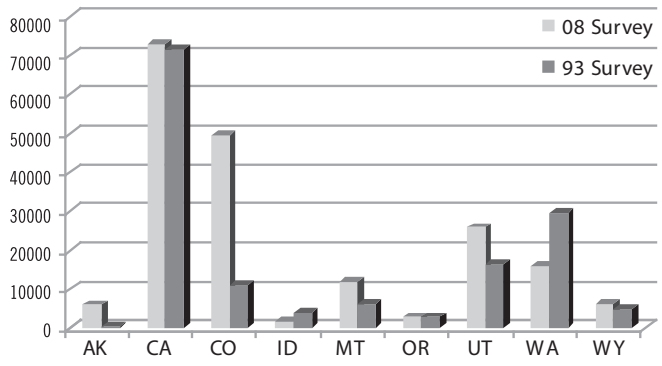


Lbs of Explosives Used by Type (in a typical season)

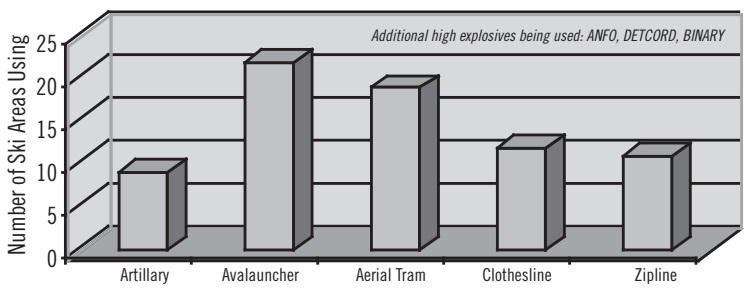


Type of Explosives Used (% in a typical season)

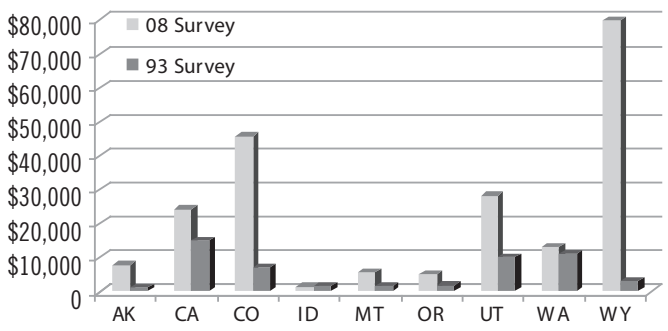
Lbs of Explosives Used (in a typical season) *15 yr comparison*



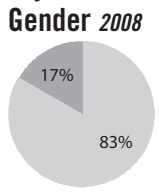
Additional Methods of Delivery



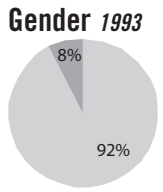
Avalanche Education: Annual $ by State *15 yr comparison*



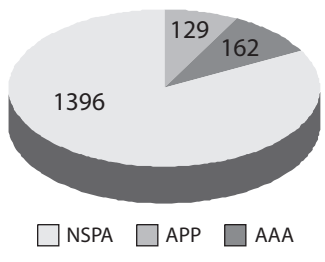
Avy Worker Gender *2008*



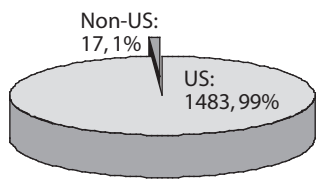
Gender *1993*



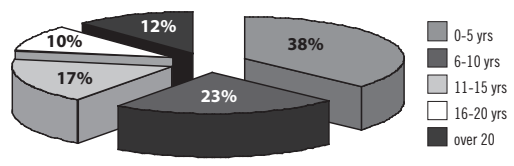
of Control Workers Belonging to Professional Orgs *2008: 1500 surveyed*



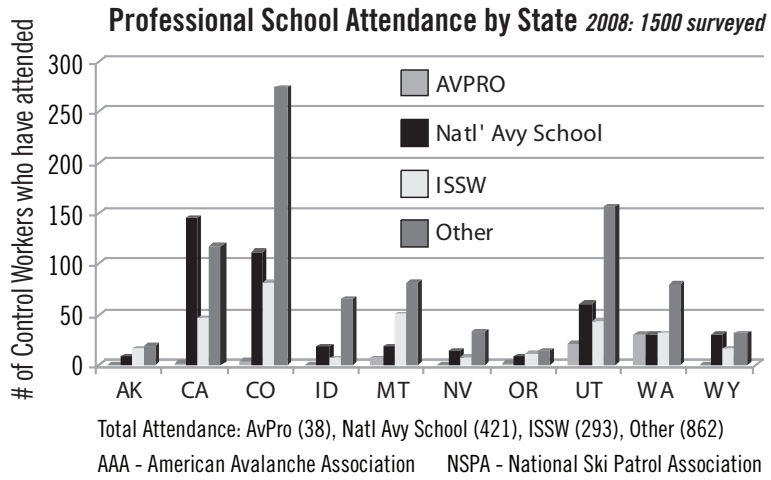
Avy Worker Citizenship *2008: 1500 surveyed*



Avy Worker Years of Experience *2008: 1500 surveyed*



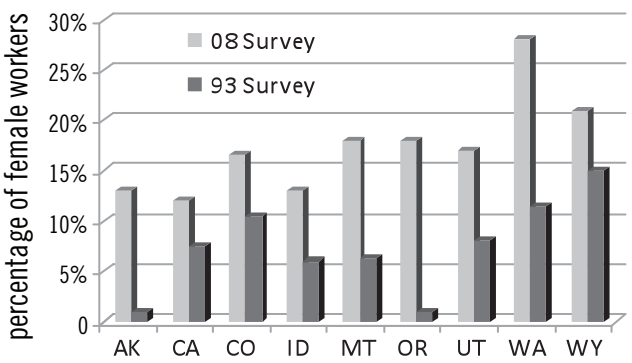
Professional School Attendance by State *2008: 1500 surveyed*



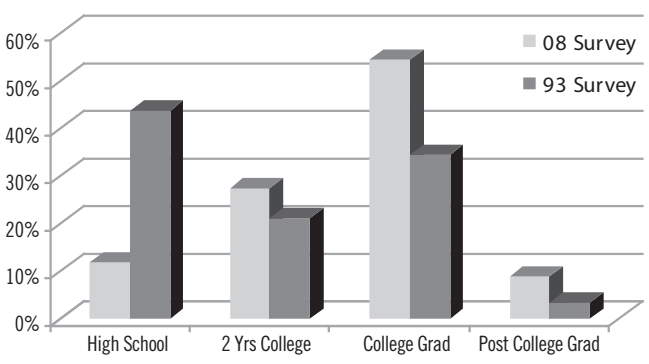
Total Attendance: AvPro (38), Natl Avy School (421), ISSW (293), Other (862)

AAA - American Avalanche Association NSPA - National Ski Patrol Association

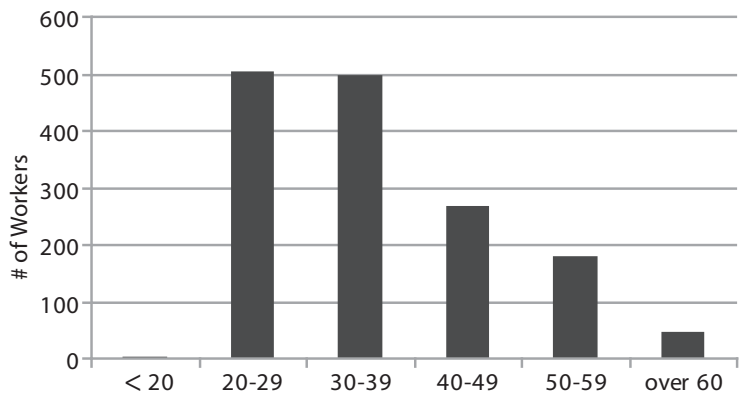
% of Female Avy Workers by State *15 yr comparison*



Avalanche Worker Education Level *15 yr comparison*



Avalanche Worker Ages *2008: 1500 surveyed*



A Convergence of Nerds: Avalanche Forum in Ketchum, Idaho

Story by Blase Reardon

For several days this past January, the biggest snow-related hazard around Ketchum, Idaho, was encountering a knot of people jabbering about mixed mode anti-cracks, spatial variability scale length, near-infrared photography, layer geometry, and the dielectric properties of snow. Even in town there was no escaping this knot of nerds; one night the researchers spoke at a public panel discussion addressing the question, "How does avalanche research help Joe Backcountry?"

The event was sponsored by the Wattis-Dumke Foundation and the Friends of the Sawtooth National Forest Avalanche Center (SNFAC). The panel discussion was held at a local theatre where 170 people watched a 10-minute presentation by each researcher and participated in a 45-minute question and answer session with all four researchers. The attendees represented a cross-section of the local backcountry community, including snowmobilers, long-time skiers, local guides and patrollers.

The researchers' short presentations outlined their ongoing studies to address significant snow science questions. While some of their work was familiar to professionals, it was fresh to this audience. Here's a summary of the presentations and discussions, along with questions fielded from the audience (in bold).

Karl Birkeland of the Forest Service National Avalanche Center began by observing that when no obvious signs of instability are present, we rely on stability tests; those are problematic, however, because of spatial variability and false stables. Thus, his research goals are to develop more accurate stability tests with less ambiguous interpretations. Karl then described the Extended Column Test (ECT), noting that it assesses propagation potential as well as strength. Studies of that test's effectiveness showed an improved false stable rate (5% versus a 10% rate for compression tests). Its binary scoring – the failure either propagates or doesn't – make it much easier to interpret. The test is a step forward, but it has a false unstable rate of about 20% and is still affected by spatial variability. He emphasized that he uses tests to identify instability, not stability. "There's no perfect way to assess stability. It's a multi-faceted thing," he concluded.

With the ECT, does Karl still use the compression test (CT)?
Yes, while they compile more data on the ECT and become more comfortable with what the ECT is telling you. The CT is also quick, although with two probes and a cord the ECT is almost as quick.

How effective is the ECT on deep slabs?
They get good results up to 75 or 100 cm deep. All tests are problematic below that depth, so he looks at structure.

Chris Pielmeier of the Swiss Federal Institute described her efforts to use the snow micropenetrometer (SMP) to provide snow stability information. The SMP allows faster sampling at a higher resolution and much finer scale than digging snowpits. Its 5mm tip measures the force needed to rupture bonds in the ice matrix, making it an excellent tool for measuring physical properties of the snowpack such as weak layer strength and slab density, which prove to be good predictors of overall stability. In a comparison of SMP profiles and 36 snowpits, these two parameters correctly classified the stability in 85% of the cases, with the accuracy increasing with more measurements. Pielmeier's next goal is to use the SMP profiles to classify stability when the weak layer is not already known, and eventually to develop a probe that could be used by backcountry travelers.

Has Chris looked at spatial variability using the SMP?
No, she's focused at the rutschblock scale.

Does it have similar accuracy as the CT?
Yes.

Can you get the same information by running a credit card down a pit wall?
Not really; you would have to move the card at the ideal speed constantly.

Hans-Peter Marshall of Boise State University offered a glimpse of tools that he hopes will someday allow practitioners to rapidly assess the layering on individual slopes. He is currently using these tools for high-resolution measurement of snow stratigraphy and mechanical properties at the "trench scale" – larger than a snowpit but smaller than a slope – where small-scale topographic features, vegetation and wind interact to produce spatial variability. HP is experimenting with near-infrared photography, which makes it easy to see layers in pit wall. He is also developing Frequency Modulated Continuous Wavelength (FMCW) radar, which can be used to make fast measurements of snow stratigraphy over larger areas, such as an avalanche starting zone. So far HP has created a portable version that can be carried between two skiers and is developing another that can be mounted on a helicopter. Combining FMCW radar and SMP measurements may allow mapping of the slab and weak layer properties over entire slopes.

Ian McCammon of Snowpit Technologies moved away from gizmos and gadgets to outline findings from research into decision-making. Ian noted that human error is easy to see from the outside or after the fact, but much less obvious within a situation because a "rogues gallery" of attitudes and cognitive habits prevent people from perceiving dangerous conditions. To avoid that, one can avoid dangerous situations entirely, educate people about the dangers, or engineer solutions that minimize the effects of these attitudes and cognitive habits. The last approach began with Bilegiri in the 1930s and has continued through Fredston and Fesler to current rule-based approaches to decision-making like the Munter 3x3 and McCammon's Alptruth. McCammon suggested that future research in this area would focus on situational awareness tools, schema tools, social dynamics tools and better predictive models. Developing these tools is critical because, as he commented, "If I get caught in an avalanche it's not going to be because I missed some very subtle weak layer. It's probably because I was in a hurry and decided to cut some corners."

Six geeks and lots of gizmos: Chris Pielmeier, Blase Reardon, Ian McCammon, H.P. Marshall, Karl Birkeland, and Chris Lundy geeking out in the backcountry near Galena Summit.
Photo by Janet Kellam

Aren't all accidents due to human error?
Generally accidents classified as human error are those in which information that might have prevented the accident was available to the victims.

How does group size affect decision-making?
McCammon's research echoes earlier studies that show in groups of three to five, conversation cycles are complete; in larger groups not everyone gets all the information.

Does Ian have any statistics related to group selection or preplanning?
Devil's advocates are very powerful. These are not necessarily the most experienced person and aren't confrontational or antagonistic.

After the presentations, the audience and researchers participated in an open question and answer session.

Does the use of new technology to assess stability distract from decision-making?
Ian: Science is very important to our understanding of our world and the mysteries of phenomena like avalanches. We need to continue to look at both the phenomena and how we interact with it.

With the recent inbounds accidents, are people getting too comfortable in steep terrain? Should people apply backcountry ideas inbounds?
Karl discussed some details of recent accidents, noting that all occurred shortly after the slopes were opened for the season or after storms, and suggested that it may be a good idea to take more precautions in these situations. Regarding avalanche hazards at ski areas he observed, "You can take that risk and you can push it towards zero, but you can never quite get it to zero no matter what you do."

How far into a slope should you go to dig a pit?
Chris: At SFR, she and other forecasters use representative test slopes.
Karl: It's a huge question. The biggest mistake is to dig too close to a ridge, where thick slabs crush weak layers. The information you want is in the middle of the slope, where you'd trigger it. He gets information from test slopes and big picture evidence, then from the edges of a slope on the way up. "It's an ongoing process."

Is there any research into new methods for controlling deep slabs?
Karl: Boot-packing has been highly effective at Highlands Bowl. It creates spatial variability that limits propagation. People have experimented with road salt, chemicals, bigger explosives and different delivery systems.

How useful are snowpits for the average skier if human error is the cause of accidents?
Ian: The question is when does the decision-making process begin. Formulating questions is a very important part of the process. What question do you want the snowpit to answer? There are lots of ways to collect information on the way to your destination; that's a longer process but you want some idea what you are going to find.

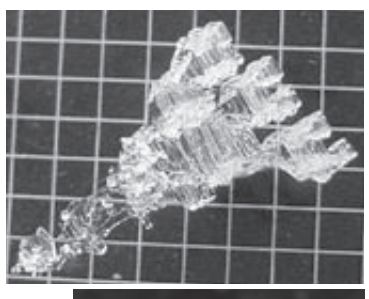
Have you ever been caught? If so, how much does knowledge protect you?
Karl: Two situations in which he'd been caught in small avalanches; both resulted from excessive curiosity, an overconfidence in his ability to manage the terrain, and underestimating the power of the phenomena.
Ian: Knowing more about snow allows you to answer questions in subtle ways and avoid the awful situation of playing with a loaded gun.

Blase Reardon is concurrently an avalanche forecaster at the Sawtooth National Forest Avalanche Center and a graduate student at the University of Montana. You'd imagine that his years as editor of The Avalanche Review would have taught him to submit articles in a timely fashion, but this one dribbled in like a deflated basketball. Blase is also the publications chair on the AAA board, so readers can contact him with complaints about The Avalanche Review.

snow science

Washington Snow Crystals

These photos are from a nice period of surface hoar that grew during the winter of 2004/05. If you recall, that was a very poor winter for us; we had about 50 cm of snow on the ground at the time of the photos (February). The weather was clear and fairly mild to begin the month with temperatures above freezing each day. The photos from February 8 followed 33cm of new snow and then a couple of clear days/nights with lows to about -7°C. By February 25, we had seen temperatures as low as -12°C, though highs still managed to sneak above freezing each day. These photos were taken in a shaded location near the bottom of a valley. RH was a bit higher in this area leading to the good surface hoar growth and preservation.



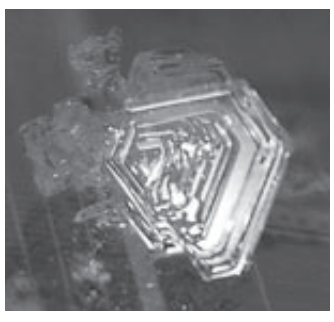
right: These were facets from within the shallow snowpack.

below: We get weird surface hoar here. Sometimes it can be feathery, but other times it is squat and stout, or needle shaped.

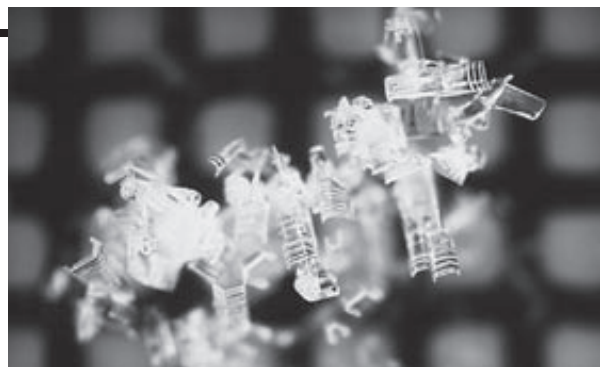
Charlie Rubin and I were teaching a snow science class during that winter – an upper level Geology course at Central Washington University, so it lasted all quarter. We had to be very creative to keep the students motivated. Imagine looking at a 30-50cm snowpack week after week, without any skiing available! Fortunately this great surface hoar formed and persisted for several weeks. It allowed the students to track the initial conditions that lead to its formation, and then they could monitor the evolution of the surface hoar each week. Our study plot reported surface hoar on 22 of 28 days in February, while the other days reported new snow. Here in the Pacific Northwest at 3400', surface hoar usually doesn't last that long.

photos by John Stimberis

They Grow Em Big in Alaska



This picture was taken by Alan Gordon, avalanche forecaster for Coeur Alaska. Alan writes, "This photo was taken in mid-January in my valley bottom study pit. It was getting dark out one evening – imagine that, dark in Alaska? – so I set up some bright halogen lights, and I had my headlamp also. I was digging down and found a very interesting layer that had a lot of air pockets in it and wasn't very dense. We had several streaks of weather that brought extremely cold temperatures, which in turn formed these very large faceted crystals. The one in the picture is about 8-10mm across. I could not resist going to get my camera and taking photographs of them!" Coeur Alaska is a mining company that owns Kensington Gold Mine about 60 miles north of Juneau in the Kakuhan Range. The mine is located in a valley that has several large avalanche paths right above it.



Picturing Unforeseen Weak Layers & Crystals

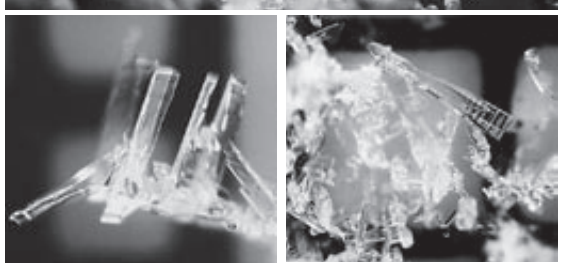
Story and photos by Doug McCabe

Last winter I worked on a season-long research project investigating near-surface faceting on Pioneer Mountain in Big Sky, Montana. The project was a collaboration between the Yellowstone Club ski patrol and Montana State University researchers. As ski patrollers, our task was to assist the MSU scientists by recording daily snow crystal observations and taking photographs of them within the top 5cm of the snowpack at north- and south-facing study plots. We made sure to pay special attention to the location, frequency, timing, and intensity of the near-surface faceting events. The MSU team set up weather stations at the two study plots to gather detailed meteorological and radiation data that would later be used to successfully recreate near-surface faceting events in their cold lab.

To our surprise, near-surface facets grew more significantly than expected on south aspects. All told we were able to document six distinct radiation recrystallization events that occurred at our south study plot between February 14 and April 9, 2008. The assumption about this particular weak layer was that Montana was too far north, and its mountains were generally too low in elevation to achieve the delicate radiation balance needed to produce radiation recrystallization more often than once in a great while.

Perhaps the reason radiation recrystallization has gone undetected for so long in this region is the nature of its creation and destruction. This weak layer formed in only a matter of a few hours, usually around noon, in the top 1cm of the snowpack, which resulted in advanced facets that were typically no larger than 1mm. Unlike surface hoar, radiation recrystallization is extremely difficult to identify with the naked eye. If buried, these forms can become a dangerous persistent weak layer, often on top of a melt-freeze crust as well, which can present an avalanche hazard. However, the same conditions that produce these facets will just as readily destroy them if high pressure persists.

Although all of this was very interesting, and arguably radiation recrystallization should be on everyone's radar while forecasting for mid and higher latitude regions, the most exciting part of our project was the 2000+ pictures of snow crystals that we captured. The ongoing joke that motivated us to take pictures was that we speculated no one would believe what we were seeing unless we had photographic proof. Thus began our journey of taking field photographs to document the snow strata.



These photos are of radiation recrystallized near-surface facets on a 1mm grid. Where the grid cannot be made out, the facets are roughly 0.75mm.

photo bottom right by Henry Munter

Our photography setup – although not exactly ideal – was affordable, easy to use, and took some decent photos with a bit of practice. All we used was a basic point-and-shoot digital camera (Olympus SP-510 UZ) with a 10x magnifying loupe (Brunel macroscope) attached via several threaded rings. We'd pick out whatever layer of snow we wanted to get a look at on a crystal card, place that on a flat surface (i.e., the hard camera case), and shoot away. Capturing snow crystals in this manner allowed us to examine the same set of images and revisit these images as a group. This proved extremely helpful with identification and at times challenged our individual assumptions about what we were seeing. Usually these debates were educational and settled amicably; however, the jury is still out on the 12-armed stellar.

To view the full article, see *Near-Surface Faceting on South Aspects in Southwest Montana* from the 2008 ISSW proceedings. This project was made possible with the support of my fellow Yellowstone Club patrollers (Henry Munter, Irene Henninger, Doug Catharine, Mike Cooperstein, Tom Leonard), MSU researchers (Ed Adams, Andrew Slaughter, Pat Staron), and Karl Birkeland.

If you'd like more info about our research involving radiation recrystallization, have ideas about taking snow photos, or want some snow photos, email dougiefresh@riseup.net.

Doug McCabe is a ski patroller for the Yellowstone Club in Big Sky, MT and Broken River in Canterbury, New Zealand.

Jason Kohlhase in a mid-January average Alaska snowpit.

Juneau Avalanche Forecast Back Online

In October 2008, the city and borough of Juneau, Alaska, hired Tom Mattice in a full-time, year-round position as their avalanche forecaster to head the Juneau Avalanche Program. Tom will create Urban Avalanche Forecasts for the borough, provide avalanche education, develop partnerships with other avalanche experts, and seek funding sources for the forecast program and other avalanche-related projects. The primary goal of the Juneau Avalanche Program is to provide daily urban avalanche forecasts. Find them online at juneau.org/avalanche/.

Tom was previously the operations manager and lead guide for Cascade Powder Cats, a snowcat skiing business which operated on Washington's famous Windy Mountain (site of the historic Wellington avalanche disaster).

Avalanches are of special concern to Juneau because they threaten two sections of the only north-south roadway, over 60 residences, a hotel, a boat harbor, and popular hiking trails. All of these are located directly beneath avalanche paths. National experts consider Juneau one of the largest municipal avalanche-hazard areas in the country because of the combined threat from the Behrends and White paths, as well as the many other paths that threaten to empty onto the Thane Road southeast of the downtown area. Avalanches have hit, damaged, or destroyed at least 72 buildings within a 10-mile radius of downtown Juneau in the past century.

Tom was recently appointed as the executive director of the Southeast Alaska Avalanche Center (SAAC). The SAAC is in the process of reviewing its mission and determining the future direction of the center. With new additions to the Center's Board of Directors such as Tom Ainsworth of the National Weather Service, Greg Patz from the State of Alaska Department of Transportation and Public Facilities, and Mike Janes of Alaska Avalanche Specialists, the center's future looks bright.

Avalanche Forecaster Tom Mattice (right) with field assistants Jason Kohlhase and Tammy Hoem.

In the region, Eaglecrest Ski Area, Kensington Mine, and Alaska Electric Light & Power all have full-time forecasters on staff. Through communication and data-sharing cooperation, one of the SAAC's future goals is to create a regional avalanche discussion posted on the SAAC Web site www.avalanche.org/~seaac/.

Bruce Edgerly of BCA reviews essentials of the beacon search in a TGR workshop classroom session. *Photo by Jill Garreffi*

Teton Gravity Research Holds Backcountry Safety Workshop at Grand Targhee

Story by Todd and Jeremy Jones

The idea to start TGR came in the long nights holed up in tents at the heli pad on Thompson Pass and was later funded by long summers spent commercial fishing off the coast of Alaska. From the beginning the goal has been to take riding to new levels in unexplored mountains and document it on film. Giving the riders all the tools necessary to excel in this environment and to do it quickly has been an ongoing evolution.

Ten years ago TGR brought on Jim Conway to be the head guide. Since that time we have tweaked, re-tweaked, and evolved our protocol to safely go into the mountains and do things that have never been done before. To take things to the next level, TGR started doing its own version of an avalanche class. The focus is on everyday situations we as riders and filmers find ourselves in. The guts of it are: "Can I ride it," and "What happens if something goes wrong?"

This year our International Pro Rider Workshop ran December 15 to17, 2008, at Grand Targhee Resort. The three-day course is a comprehensive avalanche and film safety course lead by Jim Conway. Guest speakers Bruce Edgerly from Backcountry Access, Dale Atkins from RECCO, and Kevin Brazell from Jackson Hole Mountain Resort ski patrol were on hand to work with our team on better preparing us for the hazards we face in the backcountry.

This is a unique course in that it is geared towards the situations we put ourselves in as pro riders and filmers. Over the last 13 years we have learned a lot about film protocols and riding in wild terrain. Attendees include a wide range of TGR skiers and riders, photographers, cinematographers, and staff.

The course is a mix of classroom discussion and real-life field drills. Topics covered include:

- Beacon drills; single and multiple scenarios
- Leading your team through a rescue
- Advanced shoveling techniques for victim recovery
- RECCO demonstration
- Advanced rescue techniques
- Protocol for backcountry filming in sled access, heli access, foot access and resort access filming
- Snowpack-evalution techniques, including cornice dropping and snowpits
- Film operations and daily safety plans before you go
- Insurance for high risk professionals
- CPR and basic first aid protocols
- Line selection and onslope safety plans

The course culminates in a comprehensive exam.

One of the more exciting parts of the course is called "Defend My Line". Led by Jeremy Jones, Sage Cattabriga-Alosa, Jeremy Nobis, and Eric Roner, the riders pull up lines on the video screen where things went right or wrong. They explain the scenario and then dive into a Q and A with riders, guides, and filmers. This is a great opportunity to take real-life scenarios that we have been in and learn from them.

decision·making

Drew triggered this slide unintentionally in George's Bowl in the Wasatch, spring 2008. The likelihood of triggering was high, as were the potential consequences. The sensitivity and distribution that day warranted a Considerable rating.

The UAC archives contain many examples of days that may have been better described as Moderate X. In particular, have a look at two accidents that occurred just hours apart on December 13, 2007, both just outside the Brighton boundaries. The hazard that day was rated as moderate, but the consequences of both slides were high. To view the reports, go to http://utahavalanchecenter.org/accidents.

X: *death or serious injury may occur*

Story and photo by Drew Hardesty

What's the danger? Moderate? Considerable? Scary Moderate? How best to convey this information to the Tier 1 user? I've never felt comfortable with this, particularly when deep slab instability persists for weeks, even months. For Tier 2 information (the actual avalanche advisory), I like our current method in Utah of separating out the individual "threats" (wind slab, persistent slab, wet avalanche, loose snow, etc) and rating them on probability, size, trend, and distribution (see TAR 24/4). But boiling it down into one word for a danger rating? Not so easy, especially with Moderate. For many users, it's the new Low!

Let's look more closely at Moderate danger, where the devil's in the details. You and I will choose our terrain and manage our clients differently when presented with different types of avalanche problems. It comes down to what Roger Atkins and others term "avalanche character." Implicit in its character is its "manageability." Loose snow, shallower soft slabs, and storm-snow avalanches can often be "manageable" hazards; that is to say they respond to ski cuts and cornice drops and propagate from your skis, board, or sled. Hard slabs, deep-slab instability, remotely triggered slides – these are arguably "unmanageable" hazards. Yet, there are times when these hazards are rated as Moderate simply because they lack the previous (day's/week's/month's) sensitivity and spatial distribution. Maintaining the Considerable hazard for the public risks the perception of crying wolf.

In the climbing world, a clean, well-protected 5.9 is rated 5.9 due to its difficulty. What about that same route when it's a tower of loose and friable rock with few options for protection? It's a 5.9X. The X universally denotes that "serious injury or death may occur." Here, consequences pair with difficulty to give the climber the complete picture. When one sees the X, one is required to pause and give it some thought. If a mistake is made, consequences are significant.

When the Tier 1 user sees Moderate, they understand that potentially "dangerous avalanche conditions exist on some terrain features." Or "human-triggered avalanches are possible. Natural avalanches are unlikely." And that they should "evaluate the snow and terrain carefully and use good travel habits."

When they've been trained to see Moderate X, they get a different picture. When the sensitivity and distribution doesn't warrant a Considerable rating, a Moderate X conveys the potential consequence in no uncertain terms. Again, X is wholly a function of the avalanche character, size/consequence, and manageability. And this makes all the difference – that not all Moderates are created equal – a lesson that some have learned with tragic consequences.

Spatial distribution of the danger also has interesting parallels in the climbing world. By most accounts, a single pitch route that is mostly 5.7 with one move of 5.9 is rated as a 5.9. How do you rate the overall danger if it's Moderate with "one move of" Considerable? Do you follow the climbing paradigm? Perhaps.

The X may be most useful as a modifier for Moderate, but I can see many uses for it in the higher danger ratings as well. Thus far, I've gotten a lot of good feedback from many Tier 1, 2, and 3 users in the Wasatch on this model. And I feel strongly that it's not whether we like it or not, but whether the public at large likes it. If it's a simple, intuitive, and useful tool for the public to make good choices in the mountains, then, particularly at this time of evolution with the North American danger scale, we officially utilize the subscript or modifier X to wholly convey the bottom line when only one word counts.

Drew's been at the Utah Avalanche Center for about 10 years. In the summer you'll find him working the salt mines at Grand Teton National Park in Wyoming as a Jenny Lake climbing ranger.

Thoughts on Self-Rescue

Story and photo by Don Carpenter

The day was unfolding like so many before. A foot of fresh snow in the last 24 hours made for excellent skiing. It was snowing hard with moderate visibility. We had skied two runs and a third sounded good.

The shot in mind was similar to the last two. But what looked like a well-filled-in slope was actually new snow over an old slide that had run to the ground. As I made a ski cut across the upper slope the bare rock stopped me dead. I was launched headfirst and landed hard upon more rocks downslope. After an initial assessment from my partner, we determined that my back was OK. The pain in my leg was below boot level, and I was able to ski out on my own. We covered a mile and descended 1800'. The broken fibula now has a plate and six screws holding it together. I will heal up and be just fine.

It is amazing how things can go from an ordinary day to "we have a problem" in the blink of an eye. I am lucky that my injury was relatively minor. My back was OK and I did not break my tibia. If I was unable to ski out on my own, things would have gotten serious in a hurry. Storm conditions and less then two hours of daylight might have meant a forced bivy.

The likelihood of a traumatic injury on a backcountry ski day is low. But the consequences of a winter bivy with a patient going into shock are quite high. We can rely on good judgment, strong bodies, and a little luck to get us home safely most of the time. This experience makes me think harder about not making it home.

I have always carried a repair kit, bivy sack, first aid kit, fire starter, cell phone, and a few extra clothes in addition to standard gear one would carry in the mountains.

I don't know what is "enough" in terms of rescue gear for a winter tour. For me it is unreasonable to carry a stove, shelter, and sleeping bag on every trip. But I think it is important for all of us mountain enthusiasts to ponder the question, "What will I do when my injured partner is going into shock, we are a few miles from the road, and a cold winter night is approaching?"

Injuries could result from a ski accident or an avalanche. In dealing with trauma in this setting, a first aid kit may help, but emergency gear to prevent hypothermia will make the difference. A rescue sled is part of my guiding kit. It may become part of my kit for longer personal tours. Getting the patient out of the mountains is the best option if the conditions and injuries allow. If you can't get them out, having enough gear to stabilize and keep them warm will help keep them alive.

The gear needed to "self rescue" will vary depending on terrain, season, and the group. Knowing that an accident can change circumstances very quickly, being aware of escape options, and having some extra gear on hand will go a long way if things go bad. It's something I'll be thinking about as next winter rolls around.

Don Carpenter is a Teton Valley skier who guides on Denali and Mt Rainier in the summer and teaches avalanche courses in the winter. He fills in the gaps by banging a few nails and searching for the wily wapiti. He and his wife Sarah are to be the new owners of the American Avalanche Institute in the spring of 2009.

The Hazard Evaluator:
The Interplay between Consequence & Likelihood

Story and photo by Martin Volken

Christian Santelices mitigates his likelihood factor in a high-consequence situation in Slot Couloir, Snoqualmie Pass, Washington.

Decision-making in hazardous terrain can be difficult. When it is not difficult, the decision-making process happens intuitively and very fluidly because the terrain, snow stability, and/or weather give you clear indicators. For example, if you stand on top of a 1000' cliff with your skis, it becomes very apparent that the skiable terrain has come to an end.

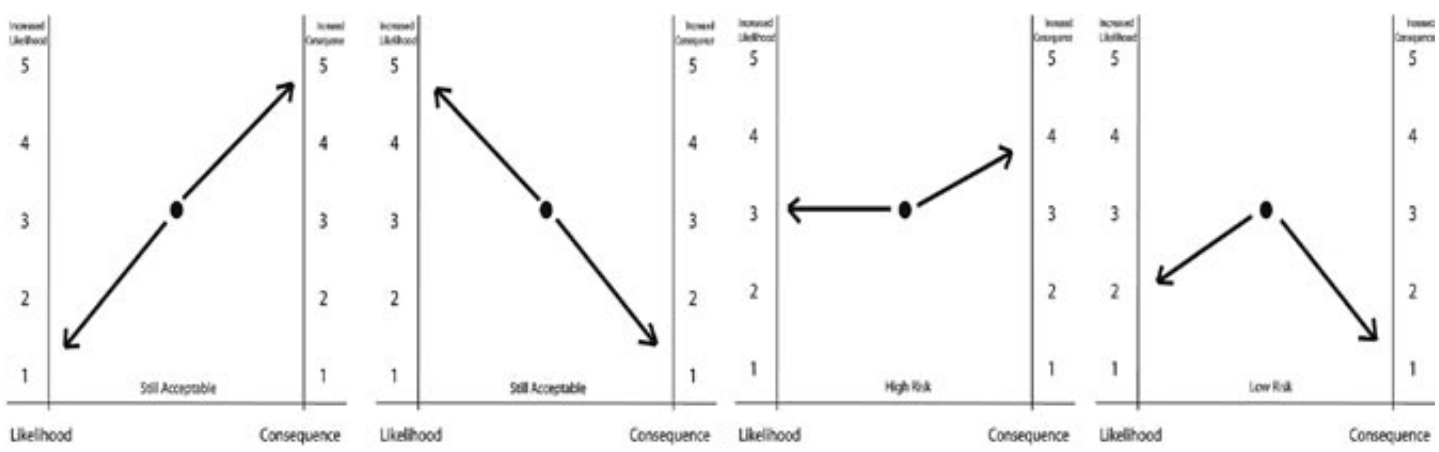
Regrettably, the decision-making process in standard mountain terrain, avalanche terrain, or any other high-hazard terrain tends to be much more dubious. Many factors can and should be considered. And so it happens that a simple ski outing can turn into a stressful ordeal where uncertainty is your companion or you do not complete your objective.

How can one simplify complex decisions and not make terrible mistakes? The trick is to not oversimplify complicated matters, but base your decisions on a simple framework. Any decision-making in a potentially high-hazard field can quickly seem overwhelming, but hazard evaluations all have one thing in common. They are based on the relationship between ***likelihood*** and ***consequence***:

- What is the ***likelihood*** that this hazard will play out?
- What will the ***consequences*** be if the hazard plays out?

The elements of consequence and likelihood are always linked in the hazard-evaluation process, and if you fail to recognize this, you are running on faith.

It is important that we have some mechanism to translate all the considerations which ultimately help in the decision-making process. All of us have played this game many times in real life, ranging from crossing a busy street to handing in a report after



When evaluating risk, add the level of likelihood of a hazard occuring with the level of consequence if it does. This sum should never exceed six.

deadline. As basic as this relationship seems, it has helped me tremendously in organizing my hazard evaluation and decision-making process.

The diagrams *(above)* are simple – so simple that you should have a mental picture of them when the time comes. I find this imperative. Complicated decision-making matrixes and time-sensitive, high-hazard situations lead to elevated stress levels and confusion. Here are the simple guidelines:

- If one of the likelihood or consequence indicators is at the very top (5) of the scale, the other indicator should be at the bottom of the scale, so the cumulative number of the two indicators should not exceed six. A five on the likelihood scale means that the hazardous event will play out with great certainty. At one, the likelihood is as remote as it can get. Five on the consequence scale means that a hazardous event will lead to certain death or an extreme consequence. A one would mean that the consequence is as benign as it possibly can get.
- When the sum total of both indicators starts to exceed six, you are coming to the limit of acceptable risk. The maximum total is set at six and not five, because there is always a minimal risk (the so-called rest-risk) that cannot be eliminated.

Keep in mind that the interpretation of this scale will be different for many people in the same situation. The likelihood of an event can be greatly influenced by personal skill, equipment, etc. To a certain extent the consequence of an event can also be influenced by personal skill, equipment, age, etc.

For instance, when an expert skier with superb equipment stands on top of a frozen 40-degree slope that doglegs above a cliff, the risk calculation will be different than for an intermediate skier with low-end equipment. The consequence is the same for both, but the likelihood is different. If the superb skier feels absolutely confident that he or she can ski the slope, it might be an acceptable decision to simply ski it. Let's say Likelihood 1 and Consequence 5. For the intermediate, skiing this slope might mean Likelihood 3 and Consequence 5. With a total of eight, this situation presents an unacceptable risk.

Now say that the intermediate skier is a very smart person who is aware of his or her limitations, so he or she brought along crampons and an ice axe. The slope now turns into a cakewalk with Likelihood 1 and Consequence 4 (there is still the chance of a self arrest in the unlikely event of a slip).

The trick in hazard evaluation and hazard management is to keep the relationship between likelihood and consequence intact.

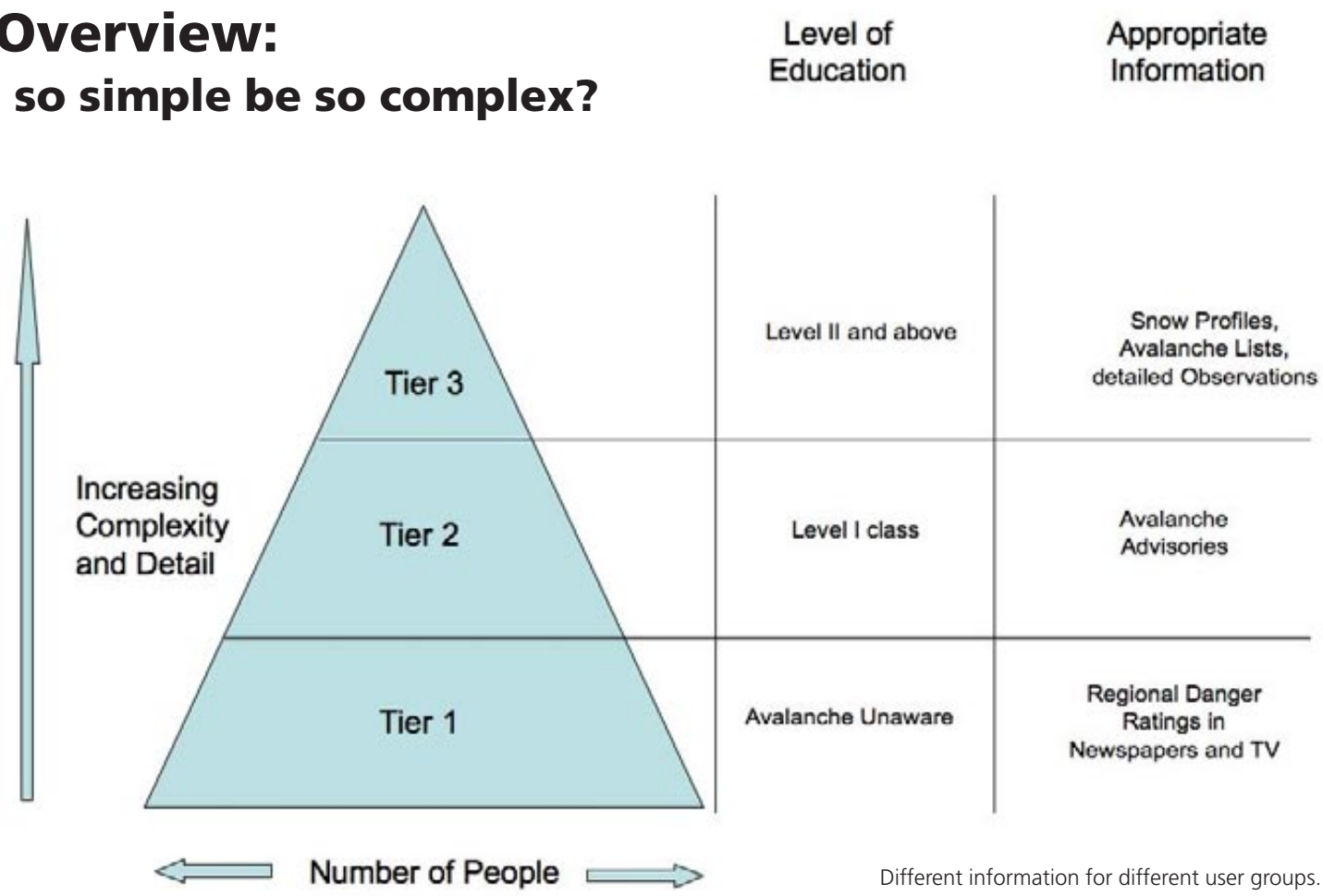
This matrix should also work for novices who lack confidence in their judgment. The bottom end of their likelihood scale may be higher to start out with, so with the golden rule of Max 6, they simply need to operate in lower consequence terrain.

No matter your level of experience and skill, when your cumulative number adds up to six or greater, let this serve as a serious red flag. Bring the relationship between likelihood and consequence back into a healthy proportion by using alternate gear, technique, terrain, etc. The bottom line is to have faith in your decision-making process, but do not let faith make your decisions for you.

Martin Volken is a Swiss Mountain Guide who lives with his wife and two daughters in North Bend, WA. He is the founder and owner of Pro Guiding Service (www.proguiding.com) and co-author of "Skills for Backcountry Skiing and Ski Mountaineering."

Danger Ratings Overview:
How can something so simple be so complex?

Story by Bruce Tremper



Different information for different user groups.

Yes, I'm guilty as charged.

I am an admitted member of the Committee – the Avalanche Danger Scale Project (ADSP). In fact, I think it's fair to say that I was one of those pushing most strongly for changes in the avalanche danger ratings, their definitions, and how they are determined. Guilty. But what I have to say here does not represent the official positions of the ADSP. I'm just trying to summarize some of my thoughts on this difficult issue as well as many of the ideas that came out of the ADSP.

As one of the original ringleaders, I attacked with problem with the usual zeal of ignorance that seems to occur all too many times when naïveté runs headlong into the morass of huge, complex problems. I have since lost much of my gumption for the thing, and mostly it just makes my head hurt. I think I can speak for others on the Committee in this matter.

We started out innocently enough several years ago – to merely "tweak" the danger descriptors to make them more accurately reflect avalanche conditions. The problem was that the old, public danger descriptors were written only in terms of probability and did not address consequences. It was the "Scary Moderate" problem, as I called it. Many of the avalanche centers, ours included, started using terms like "Scary Moderate" or "Scary Considerable" to describe a condition we see all too often in intermountain and continental climates: when avalanches are difficult to trigger, but if you do trigger one, it will be unusually large and dangerous. The old definitions just didn't work.

The Scary Moderate problem had become quite a point of contention among our staff because one forecaster's Considerable was the other forecaster's Moderate. One would say, "Well, look at the definitions. Avalanches are not 'probable' they are only 'possible.' So I'm going to stick with the official definitions." And the other forecasters would reply, "Oh, come on. For years we have always bumped the danger up for large, un-survivable avalanches." And we would sometimes settle the arguments by calling it a Scary Moderate. It seemed to work fine, but it was really only a band-aid solution to a more complex problem. So we did the unthinkable: we formed a committee – to solve the problem once and for all, by God.

But we quickly discovered several things:

1. We did not even know what factors avalanche forecasters used to determine danger ratings.
2. We had no idea whether we were forecasting hazard, danger, or risk – nor did we know the differences.
3. We had no idea whether the danger ratings were even perceived correctly by the public.
4. We did not know if better systems existed in other disciplines.

I think we all felt like first-year congressmen who were elected because they ran on a single issue and suddenly discovered that this new job was not nearly as easy as it looked. Hmmm. I never thought about THAT.

Undaunted, we decided that we could quickly knock out the first two questions above. That took us over two years. Grant Statham from Parks Canada did a wonderful job of tackling the theories and previous research, herding the cats into a couple multi-day meetings in Canmore, and he published a portion of our work in the most recent ISSW paper and in both Avalanche.ca and *The Avalanche Review*. Grant deserves a medal for this – or perhaps to be canonized.

But the rest of the work remains – to answer the last two questions. Do the danger ratings even work, and is there a better way? We can't answer these questions until we do some intensive focus-group testing and also consult other communication experts to see what has worked in other disciplines. The Canadians have some funding for this, and they are proceeding as I write this. Without this basic research, we are all just blowing hot air. But this has never stopped me before and it won't stop me now.

Drew Hardesty has proposed that we borrow from the climbing community and use the term "X" after the danger rating to indicate a *Scary Moderate* situation. It got me thinking again, which is always dangerous, and it finally got me motivated to type out some of my thoughts on the subject. If nothing else, it gives us all a great excuse to start a discussion on the subject, at least among us avalanche professionals.

My first debate among my cohorts about danger ratings started back in 1985 when, after several years doing avalanche control for ski areas, I began my career as a backcountry avalanche forecaster in Alaska. My boss, Jill Fredston, being much smarter than all the rest of us combined, had come to the conclusion that danger ratings were not particularly effective because people tended to overly focus on them without listening to the more important details. So we never used them, and the public never seemed to complain about it.

When I took over as the director of the Utah Avalanche Center, most of the other avalanche centers called me privately and urged that I abandon this silly idea and use danger ratings like everyone else in the lower 48. Which I did, and we have been arguing about them ever since. So love em or hate em, ratings are here to stay, not only in our field, but in movies, restaurants, climbing routes, mutual funds, and pretty much everything else. Excuse me while I get an Advil.

The Crux of the Problem

As I see it, the crux of the problem is this: the avalanche phenomenon is complex and uncertain, yet human beings crave simplicity and certainty. The public wants to know exactly where they can go today and not trigger an avalanche. The forecaster, of course, can't know this. So their only choice is to describe the avalanche dragon de jour as accurately as they can, talk in terms of probability and consequences, thereby shifting the burden of decision back onto the customer. One person wants to know what time it is, and the other wants to explain how the watch works.

This Venus and Mars problem plays itself out on a daily basis on all of our avalanche advisories. Many years ago, I mistakenly thought that people make logical decisions, and that if I could just teach someone how avalanches worked and gave them critical information about current conditions, they would automatically make the right decision.

I eventually had to admit to myself that this just doesn't work. In the face of complexity, people tend to resort to the usual mental shortcuts (heuristics) that serve us well in the grocery store or driving the car. These heuristics have been exhaustively described in many fine articles by Doug Fesler and Jill Fredston and more recently by Dale Atkins, Laura Adams, Ian McCammon, and others. (Note: every avalanche professional should read the books *Sway*, and *How We Decide*.) So the solution, it would appear, is to make everything simpler.

But simplicity is just another name for a half-truth, which is the flip side of a half-lie. It's what I call the Czech mother-in-law problem: My adorable little 92-year-old mother-in-law from the Czech Republic lives with us, and we go through this daily routine. Her only source of weather information is the icon on the back page of the newspaper. Every day when I get home from work, she says, "Look, ze sky is blue. Da veder forecast said cloudy. Dey are always wrong."

And I always reply, "Well, it was cloudy this morning, and it's clear this afternoon, so the weather forecast was right."

She shrugs her shoulders and says, "Vell, you never know." And it starts all over the next day. It's just our little thing – one of the few things we can talk about.

Without basic research we are all just blowing hot air. But this has never stopped me before and it won't stop me now.

Jirina Hauser, still going strong on her 90th birthday, skiing at Snowbird, Utah. As an ex-bronze medalist in Olympiad gymnastics, she has good genes.

The tradeoff: a weather icon or an avalanche danger rating work well for Tier 1 users, who just want to know the basics. Can I walk my dog in Mill Creek Canyon, or should I take an umbrella to work today? But they are nearly worthless for more advanced users who need more details. Thus, we provide several levels of avalanche information. And this is the same tiered system used by weather forecasters, financial information Web sites, and many other disciplines that deal with complex information.

It seems that the decision of whether to take your umbrella to work with you in the morning is, perhaps, the most similar analogy to what we deal with in distributing avalanche information. Most of the time, we just need one icon (Tier 1 information). Sunny. End of decision. Then when we see a see an icon for showers, we suddenly need more information (bring on the Tier 2 information). We need to know whether it's rain or snow, and we need to know where the rain will fall, the probability of rain, the amount of rain, and the timing of the rain. Different people will have different criteria. With my mostly bald, crew-cut head, I don't particularly care about light rain; I just don't want to get soaked and cold. But the woman on the sidewalk ahead of me who just spent an hour on her hair and makeup probably has much stricter criteria. Finally, if I'm working outside all day, I need to gather all the details I can about the expected weather (Tier 3 information). Thus, we all graze at the information smorgasbord.

Tier 1 information

Let me digress a bit and start my ranting with the fundamentals of the much-maligned avalanche danger scale, which most of us agree, is a Tier 1 product. The first problem is one particular term, and you know which one I'm talking about. Ever since the adoption (cramming down our throats, some would say) of the term Considerable, the arguments and confusion never seem to end. Again, this has never been scientifically focus-tested, as far as I know. But I have a friend who stood at the backcountry gate at Brighton a couple months ago and quizzed 85 snowboarders and skiers leaving the ski-area boundary. He asked each one what Considerable Danger meant to them, and he said that 85-out-of-85 responded something to the effect, "You consider it before you go. No problem." He claimed that many thought that Considerable ranked below Moderate.

I did not quite believe him, so recently I spent an hour in the Brighton cafeteria and lift line. I wrote the danger ratings on five index cards and asked people to sort them into the proper order. I only had time to survey 41 people, but what I found shocked me:

- **25 (61%)** were confused by the Considerable rating and had trouble figuring out where it fit.
- **7 (17%)** sorted it incorrectly, almost always below Moderate.
- **3 (7%)** were hopelessly confused and could not figure out where Considerable fit.

In other words, 10 (24%) could not sort it into the proper order. Clearly, Considerable is considerably confusing and needs considerably more focus testing.

Since I'm still on my soapbox here, I would like to propose the term "Serious" as an alternative to Considerable. It conveys the proper respect and meaning and people can properly place it in the list of other terms. The Canadians adopted the term for their middle rating for their Backcountry Avalanche Advisory – a three-level scale of Good, Serious, and Not Recommended. In addition, there is the Variable rating for springtime conditions. It's about as simple as you can get.

The word Considerable should just be lined up against the wall and shot. Put the damn thing out of its misery.

Excuse me while I go get another Advil.

And furthermore…dare I say it? We need yet ANOTHER danger rating. We need a danger rating that means there is no danger rating. There are times, and I know that all of you know what I'm talking about, when danger ratings just don't work. It would be called "It Depends," or "Hell if I Know," or "Not Enough Information," or "Not Applicable."

For instance, this happened to me twice in the past week. We had a large, complex, and uncertain storm arriving in Utah, and the avalanche danger for the day completely depended on what the storm did and where it did it, which was extremely uncertain. Sure enough, as the storm played itself out, avalanche conditions varied dramatically by location and time, not only within the same forecast region but within the same drainage. So my advisory resembled the if-then statements we use in computer programming. "IF the winds pick up and start drifting snow, or IF more than two feet of snow falls in your area, or IF a density inversion occurs within the new snow, THEN the avalanche danger will quickly rise to HIGH. IF none of those occur, the avalanche danger will remain LOW. Be sure to continuously test conditions as you travel." Try picking one of our one-word ratings to represent that.

The Europeans are moving increasingly towards just using numbers 1-5, which everyone can certainly sort into the proper order. But the problem is that avalanche activity tends to increase geometrically while the 1-5 scale increases arithmetically, which tends to under-communicate the seriousness of the hazard. In other words, Considerable is probably 8 times more dangerous than Moderate.

The inevitable Czech mother-in-law phenomenon applies with a special vengeance to avalanche danger ratings because our committee determined that most forecasters determine avalanche danger ratings by considering both probability and consequences – or, in our case, likelihood of triggering and size. In other words, we all decide whether to bring our umbrella based not only on the probability of rain but the amount as well. So a single term or icon is doomed to failure from the get-go. Which brings us conveniently to the next point.

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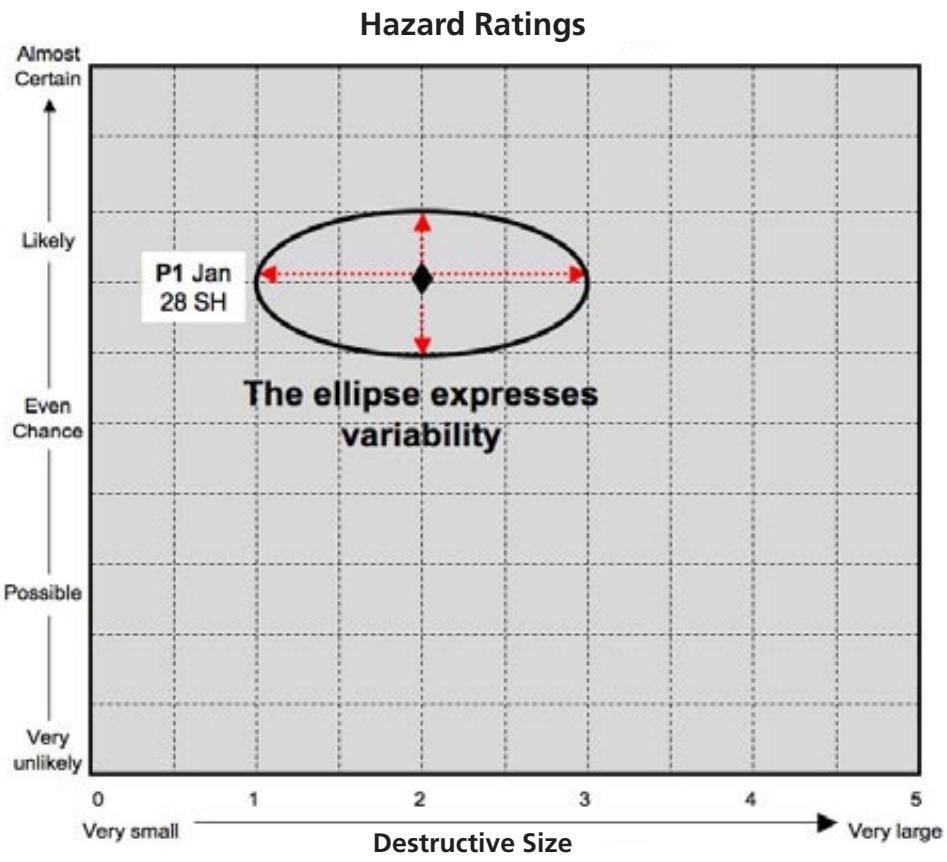
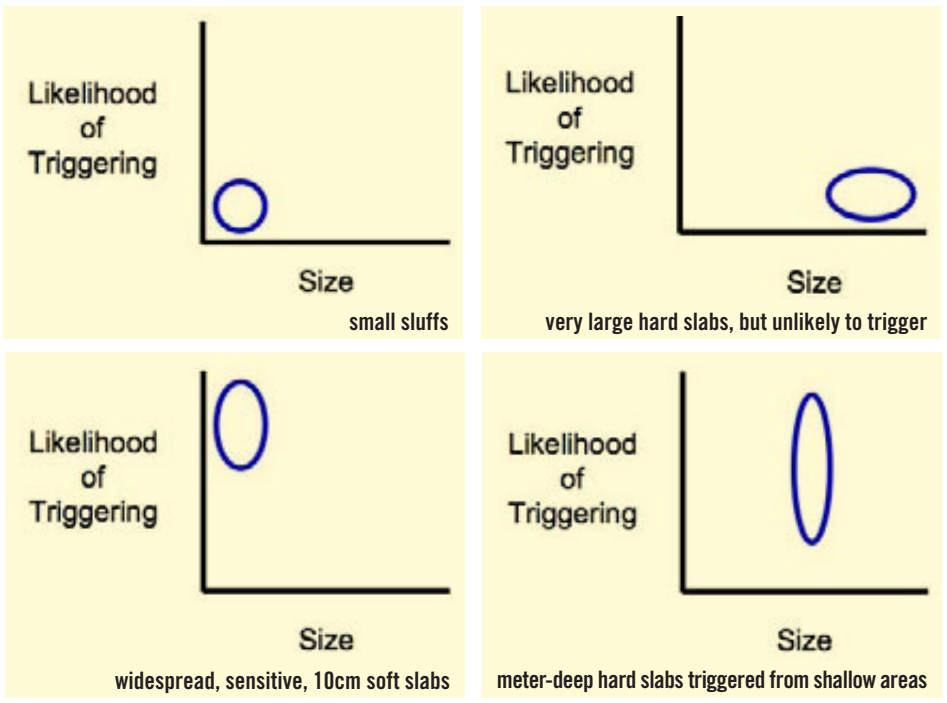


From the Avalanche Danger Scale Project, this is a conceptual diagram describing the relationship between Likelihood of Triggering, Size, Hazard Rating and the uncertainty. There are no specific danger ratings associated with the combination of factors.

Examples of Likelihood - Size Combinations



Destructive Size

Destructive Size	Avalanche destructive potential (definition)	Typical mass	Typical impact pressure	Typical path length
D1	Relatively harmless to people.	<10 t	1 kPa	10 m
D2	Could bury, injure, or kill a person.	10^2 t	10 kPa	100 m
D3	Could bury and destroy a car, damage a truck, destroy a wood frame house, or break a few trees.	10^3 t	100 kPa	1000 m
D4	Could destroy a railway car, large truck, several buildings, or a forest area of approximately 4 hectares.	10^4 t	500 kPa	2000 m
D5	Largest snow avalanche known. Could destroy a village or a forest area of approximately 40 hectares.	10^5 t	1000 kPa	3000 m

Determine the destructive potention of the avalanche(s) resulting from a specific Avalanche Character within a defined Location.

Likelihood of Triggering	
	Almost Certain
	Likely
	Even Chance
	Possible
	Very Unlikely

Determine the likelihood of Triggering for a specific Avalanche Character within the defined Location. This is a judgmental combining of both Sensitivity to Triggers and Spatial Distribution.

DANGER RATINGS

continued from previous page

The X Factor

I think Drew Hardesty's idea of an X after the danger rating is an idea worthy of discussion. The simplicity alone makes it very compelling. After all, it's the same solution we gravitated towards several years ago but by a different name – Scary Moderate. But I see several problems with it.

First, you obviously need to explain what it means. No one is going to know what the heck X means after the word Moderate, which automatically kicks it out of the Tier 1 category: Tier 1.5, let's call it. Climbing-route guidebooks are definitely not Tier 1 products; they are for the more hard-core users who can read climbing topo drawings. The climbing guidebook audience is similar to our customers who are used to reading the avalanche advisory, which we all think of as Tier 2 users.

Second, if we are going to use a modifier, I'm not sure why we can't just stick to the terms many of us have been using for years – Scary Moderate or Scary Considerable – which require much less explanation.

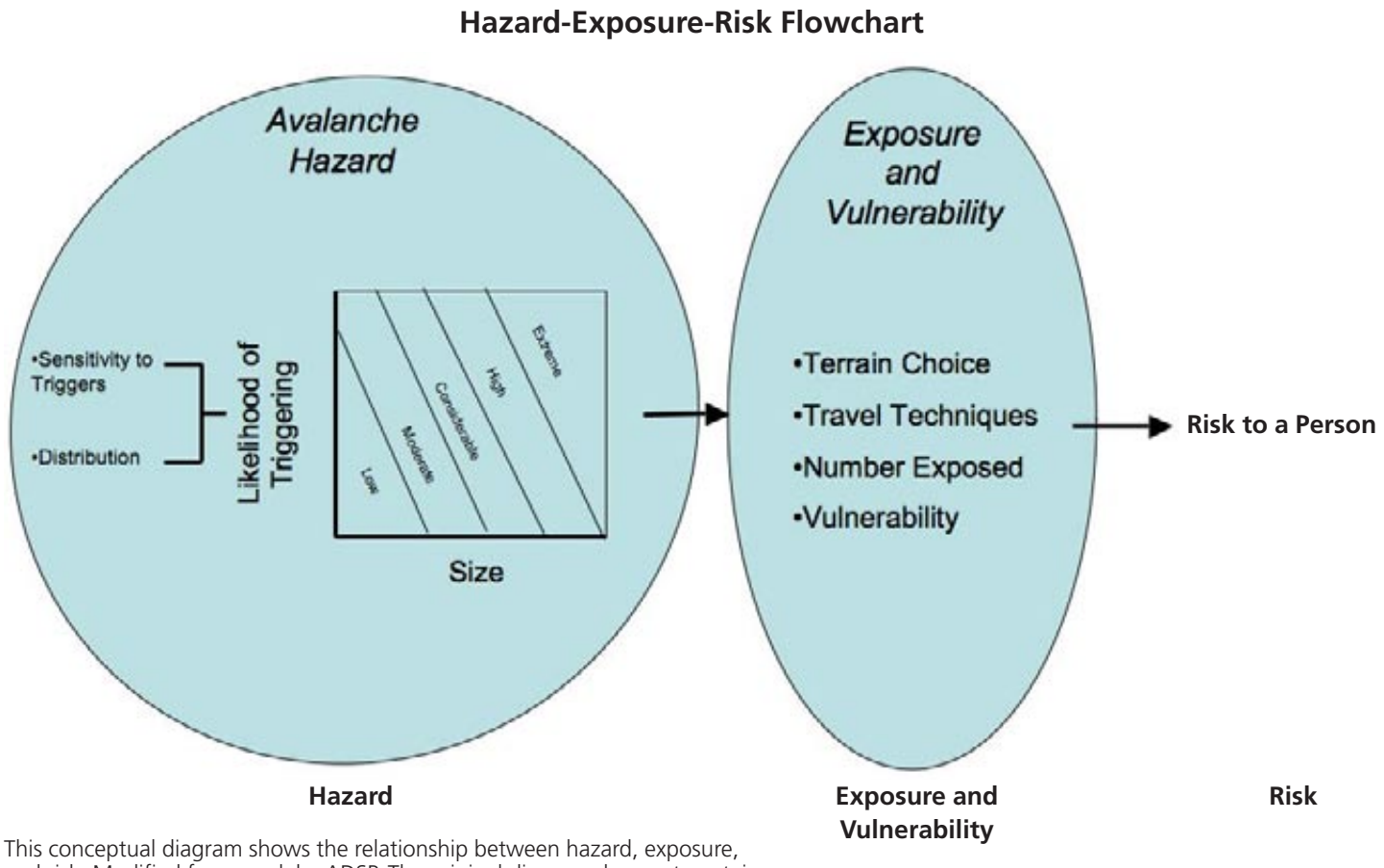
The third problem with the X idea is that, perhaps, it does not go far enough. Since we all use two factors to determine avalanche danger ratings – likelihood of triggering and size – perhaps we should just go ahead and list both terms. For instance, in the weather forecasting world it would be, "80% chance of light rain throughout the day."

The Committee agreed on two scales for likelihood and size *(see figure on previous page)*. In our case, we would say, "Possible chance of a class 3 avalanche," or "Likely chance of a class 2 avalanche." Again, the terms class 1-5 would need a short tutorial unless we just included the definitions: "Even chance of an avalanche large enough to destroy a house or break trees." But is that still Tier 1 information? Or have we just graduated to Tier 1.5 or Tier 2?

What Drew is trying to convey to the public is that some avalanches are "manageable," while others are not, which is certainly a very useful piece of information. With manageable avalanches, we can utilize test slopes and ski cuts (slope cuts, as I call them to be less sport-bigoted), and we have a higher chance of escape or surviving a ride. The X means unsurvivable; don't tease the cat.

But it's really more complicated than this, because there is a continuum between manageable and unmanageable. In addition, a "manageable avalanche" for a high-end skier or snowmobiler may be an "unmanageable avalanche" for a snowshoer, hiker, or a lower end user. So once again, the one-term solution falls short, which was one of the original problems with Scary Moderate. This is the same reason that the porn industry uses X, XX ,and XXX, not that I have much experience in this particular application.

The fourth, most serious, problem with the X term is that our new definitions of danger ratings are supposed to take the X factor into account. The old Scary Moderate is the new Considerable according to our new definitions of the danger ratings. This introduces a huge potential for confusion.



This conceptual diagram shows the relationship between hazard, exposure, and risk. Modified from work by ADSP. The original diagram does not contain danger ratings in the Hazard box, but they have been added here for clarity.

We discussed all of this in the Committee, and because of these problems we decided it was better to just stick with the scales for likelihood and size to determine danger ratings and try to communicate these details in the discussion.

But will the public even understand it? We have no idea. We need some intensive focus-group testing to see what works and what doesn't, and that should determine which direction we take. I personally don't care what we adopt as long we can clearly show that it best serves our core mission statement: saving lives.

How to Determine Danger Ratings

Because of their complexity, it seem that likelihood and size are best presented at a Tier 2 level in the avalanche advisory. I personally prefer a graphic presentation. Just one glance can tell the whole story. I especially like the graphic when combined with a timing graphic. At the Utah Avalanche Center we use an icon bar with much of the information presented in graphic form, so you can get the picture with just one glance. We provide the kind of avalanche threat you are dealing with, the danger rose – which indicates the danger for that particular problem by aspect and elevation – then we provide likelihood of triggering, size, and future trend. Some people absorb information best in graphic form while others prefer text, so we provide both.

The Committee has not yet tackled the thorny issue of exactly which conditions should be called which danger rating. Since it is subjective and complex, we purposely left the middle of the hazard box blank. But at least at the Utah Avalanche Center, we still argue about which danger rating to assign to each specific condition. So I don't think there is any way to avoid assigning some specific danger ratings to specific conditions, at least within your own operation.

The Europeans attempted to do this several years ago in their "Bavarian Matrix," when they locked experts in a room and tried to come to consensus

North American Public Avalanche Danger Scale

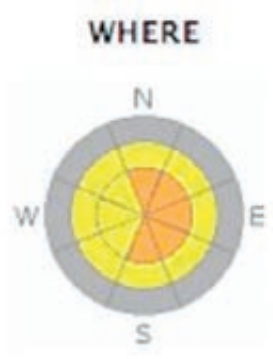
Avalanche danger is determined by the likelihood of triggering and the expected size of the avalanche(s).

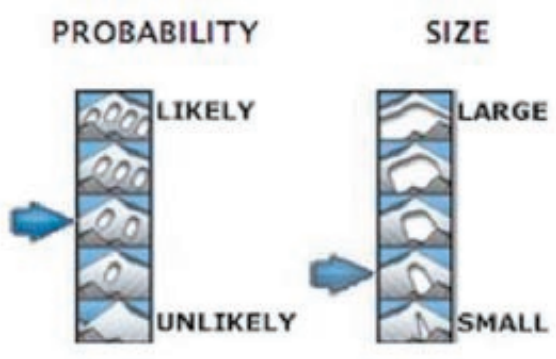
Danger Rating	Advice for Public Recreation
Low	Generally safe avalanche conditions. Watch for unstable snow on isolated terrain features.
Moderate	Dangerous avalanche conditions on some terrain features. Evaluate the snow and terrain carefully and use good travel habits.
Considerable	Dangerous avalanche conditions. Use conservative decision making, careful route finding, and good travel habits. Training and experience are essential
High	Very dangerous avalanche conditions. Travel in avalanche terrain is not recommended. Extensive skill, experience, and local knowledge are essential.
Extreme	Avoid all avalanche terrain. Travel only on gentle slopes well away from areas affected by avalanches.

The avalanche danger rating is only a starting point. ***YOU CONTROL YOUR OWN RISK*** *by choosing where, when, and how you travel.*

DRAFT. November 18, 2008 This version will be tested over the winter of 2008/09, leading to a final revision in the spring 2009.
To add your comments on the new Danger Ratings, go take an online survey at http://surveys.globalepanel.com/wix/p319164581.aspx

THREAT #1

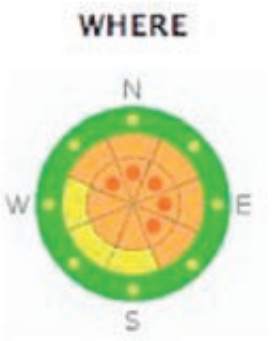


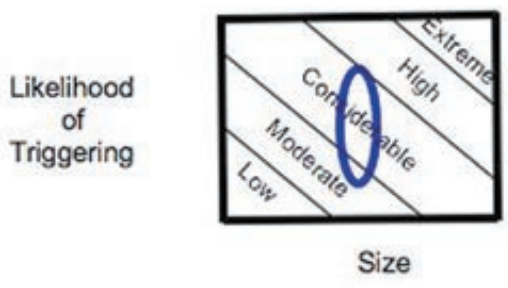


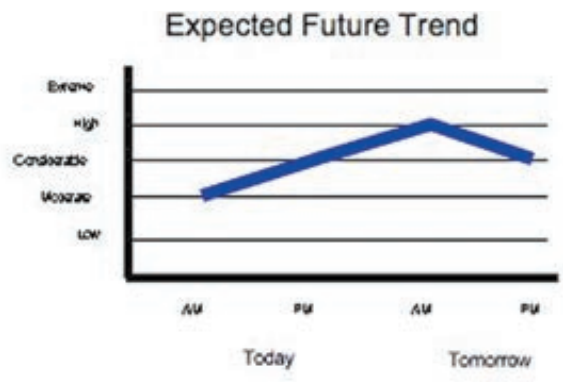
The top icon bar is the one we presently use in our avalanche advisories. There is a different one for each avalanche threat.

The bottom icon bar is one I want to focus-group test to see if it is too complicated.

THREAT #1







on some of the low-hanging fruit. They were able to fill in many of the boxes with danger ratings, but in the end they had to leave many boxes blank because they could not reach a consensus. So I'm not sure we can be any more successful.

But I still think it's worth the effort to assemble a group of experienced forecasters and see if we can all reach an agreement on what rating we would give certain conditions. For instance, what would you call widespread areas of 10cm, very soft slabs caused by a density inversion in the storm snow? What danger rating would you give to localized areas of meter-thick, pencil-hard slabs with a persistent weak layer triggered primarily from shallow snowpack areas? In this way, you can slowly assemble an expert system database. This is really just an extension of what we already do in our own operations.

A less inexperienced forecaster, for instance, could go to a Web site and twiddle the knobs on the input variables to see the agreed upon danger rating for each combination of conditions. I can imagine there would be separate sliders for avalanche type, slab depth, slab hardness, sensitivity to triggers, and distribution. You set the sliders and out spits out the danger rating. It could also be a good learning tool for the public to see which factors go into determining avalanche danger. Hopefully, they will come to the conclusion that, hey, this isn't as easy as it looks. And they will give us more money.

Clearly, Considerable is considerably confusing and needs considerable more focus testing. The word should just be lined up against the wall and shot.

OK, I can hear the howls already. First, you say, the avalanche phenomenon is too complex and subjective, so there is no way you can get a room full of forecasters to agree. Second, after they vote, it means that even if we don't agree with the vote, we have to change what we call something. Third, are the lawyers going to use this as a nail in our coffin and shut down our avalanche program? All valid concerns, I agree.

As long as I'm on the subject, one tool that helps us at the Utah Avalanche Center is to consult something I came up with many years ago that I call the "Pucker Factor Scale." The scale goes something like this:

PUCKER FACTOR SCALE

LOW—
Willing to jump into most everything

MODERATE—
Would cross most slopes but would avoid some slopes and terrain features

CONSIDERABLE—
Would avoid most slopes but would cross some slopes with careful evaluation

HIGH—
Would avoid all starting zones but willing to cross some runouts if done quickly

EXTREME—
Hide under the bed

It seems like whenever there is a disagreement on a danger rating among our staff, we often come back to the Pucker Factor. The dialogue might go something like: "So you think it's Moderate Danger? Would you walk under the Room of Doom today? No? Well then it's not a Moderate Danger."

Among our staff at the Utah Avalanche Center, even though we sometimes disagree about danger ratings, we can all agree on the details that go into an advisory. So what does that tell you? It tells me that we need to de-emphasize danger ratings and do whatever we can to steer people towards the advisory where they can see a more complete picture, which is something I think we have all been doing anyway.

Those Pesky Danger Descriptors

Finally, what about the new Danger Rating Descriptors? That's how all this started out several years ago. We thought we could just get together on a conference call and tweak them to come up with something better, and here I am, three years later, typing this on a sunny, powder day on my day off. How sick is that?

The old descriptors simply did not work because they were based on only half of what goes into a danger rating – probability – and they did not address avalanche size. Since a danger rating is the combination of likelihood of triggering and size, there is no way to cram two dimensions into one – summarize the various combinations of two factors in a static, two-sentence summary – which not only violates the laws of physics, but it violates rules of communication. The only thing we could agree on was the travel advice for each danger rating, which kind of gets back to the good-old Pucker Factor.

No, these new definitions are not perfect, but they are better than the old ones. And yes, we have much work left to do. More studies are needed, as they say.

Summary

1. Love em or hate em, danger ratings are here to stay. They have a place and a purpose.

2. At the same time, simplicity is another name for a half-truth, which is the flip side of a lie. Trying to cram complex information into a one-word descriptor and a two-sentence travel recommendation is doomed to failure, and it will always be an endless source of arguments among both forecasters and the public. So we're kind of stuck.

3. The International 5-Level Danger Scale is not perfect, but it is probably the best Tier 1 product we have right now. Besides, it is accepted worldwide, and we have little choice but to continue using it. I personally favor changing the word "Considerable" to "Serious" for North America.

4. I think it's worth the effort to assemble a team of "experts" to reach some sort of agreement on which conditions should be called which danger rating. This will be a long and difficult process with many arguments, but I think we will be the better for it. Please do this AFTER I retire.

5. We should continue to de-emphasize danger ratings and steer our users to the avalanche advisory where they get a more complete and accurate picture of avalanche conditions.

6. Tier 2 information (avalanche advisories) works best when it contains:
   a) the type of avalanche threat (wind slab, wet avalanches, etc)
   b) the location of the threat on an aspect-elevation rose
   c) scales for Likelihood and Size
   d) future trend
   Sometimes you do not have enough information to include all this, but it's an ideal we shoot for. I personally prefer the graphic presentation of this information in addition to a paragraph describing the details.

7. We can't proceed any farther nor make any changes to our programs until we do extensive focus-group testing and consult communication experts to see what has worked in other applications. Our core mission is to save lives. Whatever method best accomplishes that is what we should adopt.

In his youth, rumored to be in the late Pleistocene, Bruce Tremper was a three-year member of the Junior National Ski Team, a US Ski Team Talent Squad member, and an NCAA Division Downhill Champion before he somehow took an unfortunate turn and descended into the bowels of the avalanche business, where he still ekes out a living as the director of the Utah Avalanche Center.

LUCK:
Is it Just Another Granular Visco-Elastic Solid Close to its Melting Point?

Story by Kevin Devine

I have been thinking about *The Ascending Spiral*, an article by Ed LaChapelle, since the day I read it in the October 2005 issue of TAR. No one wrote about snow quite like Ed LaChapelle. There is something about the way he saw and wrote about snow and avalanches that was entirely unique. Only he could move seamlessly back and forth from the perspective of arcane academic science to the essence of common sense. One paragraph has you squirming in your seat in large lecture hall because of vocab inadequacy, and the next has you trudging across granitic sastrugi, trying to get to the soft stuff that looks north. Who else could use words like "rheology" and "a granular visco-elastic solid" in the same piece, while calling for a greater look into the role of luck in avalanche safety?

Perhaps we should be taking a greater look at luck; sharing stories about luck will bring both knowledge and luck to those with whom they are shared. Perhaps when enough stories have been collected, it will inspire one of those ski bums among us who validate their bummery with advanced degrees in the investigation of that which requires skis to investigate. You know who you are…yeah, you, the guy with the pocket protector in the Arc'teryx soft shell – yeah you. Maybe you can acquire grant money to investigate luck. (If you do get money, well, AAA knows how to find me.) Perhaps one of you snow geeks will find a specific "luck gene" that keeps a person on the fracture without failure side of the slope.

Here, then, is a story about luck offered with the sincere hope that it inspires others to share their own stories of luck.

Disclaimer: This tale relies on memory. To put that in perspective, not long ago in a conversation with a snowboarder on a recent snowcat trip, I referred to some intellectual pursuit as a way of preventing the early onset of Alzheimer's. He looked at me quizzically and asked, "How would you know?" Pretty insightful for a snowboarder.

Among the various TAR articles about decisions, only Stewart-Patterson mentioned luck, where he named it one of the three main factors in decision-making, though only in passing. This topic needs wider recognition. ...so the obvious conclusion must be that luck along with undocumented skills is right in there as a major player.

—Ed LaChapelle
The Ascending Spiral

A couple of photos from Kevin Devine record the era "BPB" (Before Plastic Boots), when we got by with a heaping helping of luck, coupled with nerve and timing.

This story comes from a time when I knew next to nothing about the science of snow and avalanche; from a time long before I became a dilettante about those things; from a time when we ventured into the backcountry in search of off-piste soft turns on Nordic skis, three-pin bindings, and cross-country wax. (Extra Blue, I am certain, was born in a friend's kitchen when he mixed purple and blue wax in a double boiler.) It comes from the "BPB" era of free-heel skiing (Before Plastic Boots).

There was, once, what may arguably have been the greatest ski bum job ever. (This is, after all, about luck.) Every morning before the lifts at Breckenridge began running, Dougo Sheldon or I would drive a small Thiokol snowcat up to the Peak Nine restaurant with various grocery items. Having parked the cat and unloaded the groceries, we were left to our own devices until sometime after four in the afternoon when one of us would drive the cat back to the base with the day's trash.

This was also a time when, in many ways, ski areas were more user-friendly. One particularly beautiful winter day, I left the restaurant and climbed up to the patrol shack at the top of Peak 9. I was planning to meet friends who were climbing up from the base to ski what we called "The Dark Rider" on Peak 10. This area is now part of Breck's lift-served terrain. I told Patrol my plans. They told me to be careful. I crossed Upper Lehman Gulch and cut a high traverse across what is still called The Burn.

As mentioned, this was BPB, and it was also before avalanche transceivers, shovels, and probes were part of the "don't leave home without them" backcountry operating procedure – probably before fully developed central nervous systems, too. Well, we were young. We carried extra bails for the three-pin bindings and those skiing on wood skis, Bonna 2400s or Trysil-knuts, carried aluminum ski tips. Most of us had avalanche cords – mine had numbered brass tabs crimped to the bright red nylon every three meters.

I arrived at the top of The Dark Rider under a blue-of-blues sky and found a smooth snow surface waiting for another "best run ever." My skinny Fisher Europa 77s were getting a 45cm ski penetration, and my friends had not arrived.

The Breckenridge ski patrol often tossed hand charges on The Dark Rider, either for evaluation of proposed expansion or for mitigation so they could ski it themselves. It was not uncommon to find bomb craters on this face, but there were none that day. Knowing that Patrol found this face worthy of explosives would indicate, even to young immortals, that this face had the potential to ruin a day. With this knowledge in mind, it seemed wiser to wait for my friends rather than ski it alone, but…there was a stand of trees that bordered the open face almost top to bottom on skiers' left. I remember trying to wait, but skiing a line that hugged the trees seemed like sound judgment, and the unselfishness of this line would leave the rest of the face for my friends. We'll let the academics decide if this was heuristics or impatience. Deploying the avy cord did not occur to me, since I was alone.

It was indeed another "best run ever." At the bottom, I had not but a few seconds to dig myself – hadn't even looked at the track – before my friends popped out of the trees.

My friend, Paul, looked over my shoulder, pointed up the hill Navajo style with pursed lips, and asked, "You do that?"

I turned and saw a fracture that initiated from the apogee of the arc of the second turn – a right-hand turn out toward the open face. The fracture crossed the face some 30 to 50 meters to where the failure occurred. Memory makes the metrics a little fuzzy, and I would not have known a crown profile from a bastard file, but the image is of what I would now call an SS-ASr-R3-D3-G. A bit of a memory guess, but I remember the crown being somewhere between one and two meters, making the destructive potential of D2 or D3 or D4 irrelevant because the destructive potential was undeniably D me. My bacon was saved by a phrase I would not hear for years to come – spatial variability.

Thinking back on this, the decision to ski this turned out to be sounder and luckier than I used to think. If I had waited, and we had gang skied this face, it is a certainty that this would have been an avalanche accident pre-dating *The Snowy Torrents: Avalanche Accidents in the United States 1980-86*.

Was this all luck? Was it intuition and a speck of knowledge? Why am I here and my friend Dougo Sheldon, with whom I shared that ski bum job, is not? (Dougo was killed by an avalanche on Christmas Day, 1982 near Montezuma, Colorado. An accident that raised the awareness of many friends and acquaintances, and by doing so may have saved more than a few lives.)

One of the main themes of Ed LaChapelle's *The Ascending Spiral* is, "Do nothing in haste." Was that small amount of deliberation regarding whether and how to ski The Dark Rider enough or was it all luck?

I'll leave you with those questions and two more perspectives. The first is from Hemingway's *The Old Man and the Sea*. It is Santiago's rumination about luck: "It is better to be lucky. But I would rather be exact. Then when luck comes you are ready."

The second is from Forrest Gump, the real Gump, not the faux Tom Hanks Gump: "Let me say this: Being an idiot is no box of chocolates."

Unless you are a lucky idiot.

Kevin Devine works as a guide for The San Juan Ski Company, a snowcat skiing operation based out of Purgatory at Durango Mountain Resort. He likes hero snow, jasmine tea, Miles Davis, quiet alpenglow walks across breakable crust, and arguing with SJSC owner, Bob Rule.

Avalanche on Sunburst Ridge: A Trigger's Point of View

Story by Ian Wilson

Photo by Mark McKinney

Chronology of the Day
February 23, 2008

We woke Saturday to blue skies and an inviting sun. It was the second bluebird day in a row, a bit of a gift as far as Alaskan winters are concerned. The mood was high, and everyone had those bluebird jitters. After breakfast we (eight of us) headed for Turnagain Pass, about a half hour away.

Being a blue-sky Saturday, by local standards the pass was flooded with ski parties. This meant perhaps 10 cars in the Sunburst parking lot. We had planned to ski another area called Tincan, but the 20 or so tracks that had already been put down Sunburst Mountain looked absolutely irresistible, so we altered our plan.

The morning was cool and crystal clear, and the approach was breathtaking. We started off in the shadows snaking our way over beautiful pillowy foothills, cruising past willow and alder along the low-angle drainage. The skin up was about 2000-vertical feet, and somewhere in the middle we broke out of the shade into the powerful sunshine as we gained the ridge.

The ridge was steep and exhilarating. With each zig-zag we could see more and more of the raw vastness of the Chugach Range stretching out in every direction. Everywhere, massive peaks with infinite variation sprang up from near sea level and appeared as an endless playground perfectly sculpted and arranged. As we continued up the ridge, we looked down on many sets of tracks continuing just far enough to a place where that softest canvas was blank. Not a track for a half mile up canyon. Sean dug a pit about five feet down, and we all examined the snowpack, all of which had fallen in the last 10 days. The snow looked great. Very consistent and well-bonded and passed all of our compression tests. We came to the conclusion that it was pretty darn solid and safe to ski.

Sunburst is a long and beautiful ridge which stretches for about a mile back to the east. It is fairly uninterrupted, so that one could pick nearly any place along the ridge and have a 1500' ski descent on a 30-40º pitch.

I had a very natural and pronounced reluctance about where we were skiing. It was sort of a mix of attraction and revulsion to what seemed like a very big and open and powerful space up in these massive alpine peaks. Although I was nervous about my first big Alaskan line, the feeling abated as each of the first five members of our party took their turn plunging downward into what looked like the fluffiest and most inviting of snows.

Sam went fifth, and I took a little video of him as he hooted and hollered in each and every turn. I liked his line a lot and decided I wanted to play off of his route down. I packed my camera and buckled my boots. I took a good long look out onto that mystical horizon and took a few deep breaths to try to quell the butterflies which were fluttering in my stomach.

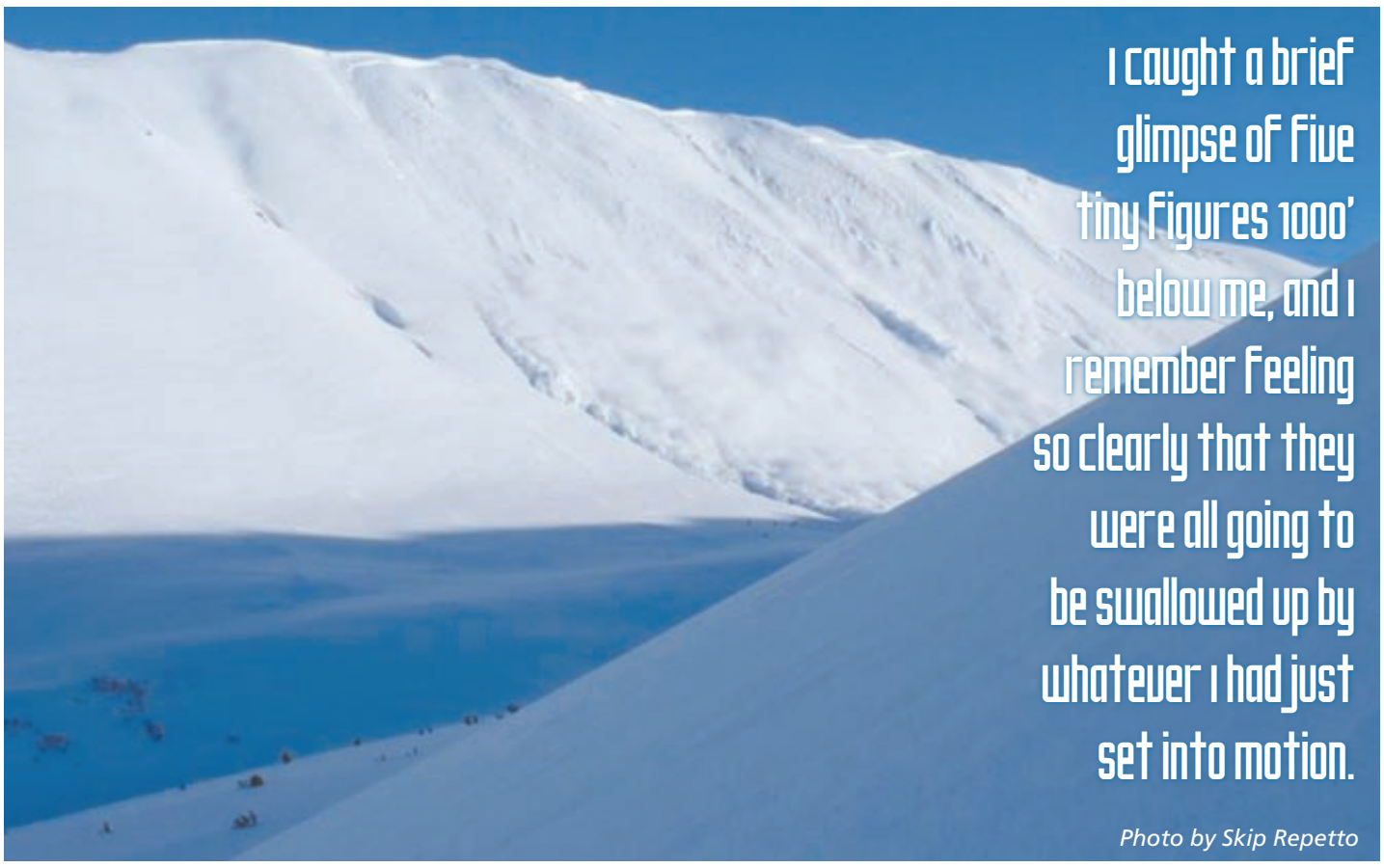


Photo by Skip Repetto

"Okay," I said, and dropped in. The snow was good. Really good. My first couple of turns were tentative, but then I began to settle into the ecstasy of that run and open up my line, picking up some speed and angling toward the small rock outcrop where Sam had taken a nice little air. I crossed his track and unweighted into that blue sky for just a moment. I landed softly in the snow which cradled me like a big fluffy sponge. I made a turn to the right and initiated a turn back to the left. As I finished this turn I had the strange sensation of getting a little bogged down, as though the snow had gotten deeper and heavier. Almost simultaneous with this sensation was the sudden image of all the snow to my right and in front of me fracturing into a thousand small pieces like an arid desert whose mud has dried and spiderwebbed. These shapes separated from each other and danced on the surface of the now downward-moving slope.

I heard some faint voice from below yell, "Avalanche!" This sound was concurrent with my own realization that indeed I was in an avalanche.

When the slope broke, and even throughout my experience, I never realized how big that slide was, even as far as avalanches are concerned. My instinct in that moment was to go, and to go fast, downhill. It was a flight instinct, I think partly rooted in images which flashed through my mind of so many skiers narrowly outrunning avalanches that broke above them. I leaned back and felt my tips climb toward the surface and pointed skis down the fall line. I caught a brief glimpse of five tiny figures 1000' below me. I remember feeling so clearly that they were all going to be swallowed up by whatever I had just set into motion.

What followed is a difficult thing to articulate and I am still unsure of exactly what my relation was to the moving snowpack. I can only gather that my trip to the other side of the valley was

Continued on next page ➡

SUNBURST TRIGGER

continued from previous page

something inbetween riding on top of the slide and being carried with it. The analogy to an ocean wave continues to feel very accurate in qualifying the experience I had riding down the mountain. And the comparison is very literal as it is just water in the end, frozen or liquid.

As I rode downhill, I managed to stay above the snow to a large degree. This quickly became my only intuitive goal. My initial flight instinct that I might escape was quickly transformed into that of fight, as I realized that the slide was not behind me but also in front of me, to the sides of me, all around me, and that we were moving together, the slope and I. Strangely I don't remember any sound after that muffled sound of "Avalanche!" – although others have said that the sound was intense, like a jet engine or a freight train.

As I moved downward I got more and more bogged down, covered now to the waist. I had a thought that by keeping my pole raised high in the air, I might be able to give a visual clue to my whereabouts, even if I were fully buried. My ride, which had thus far been remarkably consistent and balanced with my head out of the snow and my feet oriented below me was changed in an instant when I felt the violent impact of some feature of the land and I was cast down into the snowpack. When the wave of snow hit that feature, all of that balance and buoyancy was lost in an instant, slammed by the wave.

I had no control any longer, tumbling and cartwheeling, ragdolling below the surface. This seemed to end as quickly as it began as I felt the whole slide begin to slow down and grind to the slowest stop, molding and stretching my body and four limbs into awkward and – as I quickly realized – immoveable positions.

When I came to a stop, I had the very strange and also very rational and simple realization that I was buried in an avalanche. At first it struck me as odd. Yes, very much like a dream in its strangeness. This moment passed quickly, and a sharper awareness brought me back to my situation and my needs. When I began to tumble in the slide's turbulent finish, I had been concentrated on staying above the snow and had forgotten the importance of making myself an air pocket. As I came to a stop I found my arms and legs spread away from my core, stretched and bent into awkward and puppet-like positions at the whim of the snow, which had settled like concrete all around me. I struggled for a moment, trying to move my hands toward my face. The sheer impossibility of movement was so absolutely clear that I became fully aware in a moment of how helpless I was.

It was beyond my control now. This moment was incredibly potent in my mind. Even in that struggle to move my arms toward my face, I was still fighting for a chance. My struggle must have lasted all of five seconds. When my utter inability to move hit me, it triggered something powerful deep within me. I had several distinct thoughts, one after another:

this is out of my control.
I may die today.
I need to calm down.

These thoughts came easily and with total clarity. In a way, they were the first thoughts. Everything before had been pure reaction, a place with no room for thinking. The surrender of control was liberating and led me quickly to several deep breaths. They came effortlessly. I was unafraid. I remember taking no more than three or four slow breaths, each one seeming to take me deeper into a profoundly relaxed (un)conscious state. I hesitate here because although I remember nothing of the next 25-30 minutes, a certain sense of peace and serenity permeated that time. It was quite present when I opened my eyes and saw 10 or 12 strangers leaning over me with the most intense looks on their faces.

My "mild hypothermia" was far away from me when I began to piece together where I was and what had happened. I began to answer questions about who I was and my lack of allergies, medications, and persistent health problems.

"Do you know where you are?"

"Avalanche," I forced through a rigid jaw. I was pretty dazed, quite separated from it all. Answering the questions was good. It was easy and it brought me back slowly to myself. Now I was cold – violently shivering and answering questions in one and two word spurts. My head was stabilized and someone was checking CSMs on my extremities, asking me to wiggle fingers and toes and push with hands and feet. I was enthusiastic about moving, affirming my capabilities to myself. My legs had been in very awkward positions for a half hour or so and moving them at first was the strangest feeling and a bit alarming, as though they weren't properly connected. But they moved, and I didn't feel any pain.

Then I wanted to move everything: hands and feet and arms and legs. I wanted to wiggle and squirm and just move my bones.

Within minutes of consciousness I realized I had only seen a couple of people from our party of eight. I feared the worst and inquired about my friends. Someone told me I was the only one, but I was confused and unconvinced. Were they just saying that? I was too out of sorts to pursue it, and before I knew it, they were loading me onto a helicopter and I was shuttled to an ambulance at the parking lot below. I saw Caitlin poke her face into the ambulance and saw a look of relief come over her; she confirmed that everyone was okay.

Unbelievable.

So all the way to Anchorage these two great guys from the fire department warmed me up with blankets and hot packs and did all of these things to make me as comfortable as they could. The idea of my comfort at the time struck me as such a ridiculous and funny notion, given that my life had just been saved. I wondered if they saw the irony in their generosity. But they did make me very comfortable and gave me water through a straw. I was about as thirsty as I had ever been.

I met Mitch and Sam and Gregg an hour or two later at the hospital. I checked out normal. I was pretty short on emotion and energy and most everything that day. I let the family know before the media storm and caught a few hours of sleep. I woke up in the morning without any more adrenaline, as sore as I have been, and began slowly to sort out the enormity of what had taken place.

Ian Wilson is based in Portland, Oregon, and works for SUWS in the Idaho high desert. He tells TAR that his decision-making process has changed after his accident.

Photo by Lisa Portune

Sunburst Reflections: *Decision-making & Lessons Learned*

Story by Ian Wilson

Thinking back on that day, I realize how many different decisions (both positive and negative) were made along the way leading to that singular moment when I triggered such a snow event. Despite this incredible matrix of cause and effect, there are a few basic decisions that were made and not made, both individually and at a group level, which put us in a much higher risk category.

First was our decision to ski at all on that beautiful day. The massive week-long storm had pounded the Chugach with over 10' of classic coastal snow. It had only just subsided, giving way to blue skies and heavily laden, pristine terrain. Less than 48 hours had passed since precipitation had ceased and the mountains had not had much time to recover; it was still relatively early to go out and give them a real test. The CAIC daily avy forecast *(next page)* reported considerable avalanche danger at all aspects, also warning that deep instability was still a possibility.

Another factor in my own decision-making process was my utter inexperience in Alaska. Although I have logged countless days in the backcountry in Colorado, Utah, and Wyoming, the Chugach was totally new to me. I was skiing with a group of people, many of whom had logged close to 50 days in this backcountry already that season. I knew nothing about local snow patterns, snowpack behaviors, etc. So I surrendered some of my autonomy in the matter to friends and friends of friends. Regardless of what the avy forecast had said or what our stability tests would indicate, there was a certain part of me that was very tentative about skiing 1500' of such utterly treeless and exposed terrain. The notion of a "safe zone" on Sunburst is laughable. The top of the ridge is the only real safe zone for thousands of feet. It was obvious enough that any slide on Sunburst would go massive if it went at all.

We set out that morning from the cabin with an entirely different plan, which involved skiing the protected and more low-angle trees at Tin Can, honoring the avalanche center warnings. As we drove along the highway in the sunshine and looked up at so many other familiar areas of Turnagain Pass, we realized that a lot of people were skiing the backcountry that Saturday. Sunburst, especially, had dozens of tracks pouring off the ridge. We all salivated over the thought of making turns. There was a brief discussion about whether we should modify our original plan and skin up Sunburst instead. The consensus was an overwhelming yes. Our previous plan, which had ruled out Sunburst because of its exposure, was out the window after seeing so many other happy and avalanche-free skiers enjoying the bounty. We didn't know any of these people; we didn't know why they were skiing where we had planned to avoid. What did these people know that we

didn't? We brushed these thoughts aside quickly as we took each perfect set of tracks to indicate stability.

We were a group of eight. This is the only time I have skied in a party of more than three or four in the backcountry. But eight friends all wanted to go skiing, so why not? Even so, the size of our group continues to plague my memory of that day. It was never clear who was leading. I surely wasn't, but there was a range within our party as far as experience, comfort, desire, and intention. I felt I was the most conservative in my ambitions and intentions for the day. I just wanted to go skiing. I was already impressed – fulfilled, in a sense. One member was perhaps the most liberal in his agenda. His confidence in the snowpack and his desire to ski the steep and deep was tangible. As we gained the ridge and began to traverse higher above many sets of tracks, each independent of the next, there was much banter about where to drop in. I would have skied anywhere, as there were ample freshies to be had even among the tracks we were crossing. Others wanted to go farther, toward the place where all the tracks ended and a perfect white curtain extended for a half mile up canyon, where wilderness began. As you traverse the ridge, the slope angle increases very slightly over the course of a quarter mile, starting close to 30 degrees and increasing to a maximum angle of close to 40 degrees. When we finally reached the place where the last tracks plunged downward, we had reached some of the steeper terrain on the ridge. Not scary steep, but just "perfect." That angle which is, in my opinion, most enjoyable to ski, and most prone to slide.

I confessed to Mitch and Sean that I would be so happy to ski back down the ridge a ways and drop in where so much other ski traffic had already been. I was reassured by both that we were in the clear. I definitely didn't want to burden the group with a new plan. Besides, we were one group. I was committed.

Sean and some others excavated a pit 5-6' deep and isolated a column of snow. We all crowded around and took a peek at the snowpack. A swipe of the credit card showed incredible consistency all the way to the bottom (6' down, that is). It was very reassuring, and a shovel shear test showed the same. Despite my persistent anxiety, I was more and more confident, especially considering the high spirits of everyone in the party. I watched one, two, three, four, five others drop in and put together incredible lines, plowing through deep and beautiful powder, skiing tight, skiing wide, crossing each others lines as each person had their turn, top to bottom, a blank canvas.

I watched Sam ski off a small rock outcrop, maybe 6' tall at most, a little blip on the uninterrupted terrain. I have always gravitated towards these features and planned my whole line around the little air I wanted to take. I skied off that rock, and two turns later I was in the middle of an avalanche.

That landing still seems the moment that unleashed the slide. Matt Murphy and Lisa Portune at CNFAC have speculated that I tapped into some instability around that feature which stepped down to deeper layers and then ran underneath all the way up to the crown, where it all came loose. Land features have very different snowpacks / snow histories than surrounding terrain. So it could have been that 10' of snowfall was represented there in a much shallower way, so it was easier to disturb a weak layer near the rock than anywhere else on the slope.

As far as locating and unburying me in the wake of the slide, I am obviously not a good resource as far as what could have been done differently. Most everything went right; here I am. It is hard to find fault or even ask those questions after such an incredible rescue. There were a couple of things that came up as great lessons within the success.

First, if you arrive at an avy scene from afar, switch your %$@ing beacon to search mode before you arrive. The false hopes that were ignited, and the ensuing confusion and frustration that happened when people showed up still "sending" were absolutely maddening for people who were searching.

Second, as should have been the case, the search was initiated from the "point last seen." As it turned out, this was a full quarter mile or so from where I ended up, at the place where the slide terminated. It wasn't until Matt came in from the bottom and happened to catch my signal that the other end of the slide was explored, 20 or so minutes after the slide broke. With limited resources, a systematic and thorough search from top to bottom is necessary; however, with such a large number of rescuers and in such a large-scale slide, covering the whole range of the potential burial area within those first 15 minutes could have led to an even quicker extraction.

SO…in short, some major lessons we learned from Sunburst:

Ski and Snowboard tracks are POOR indicators of stability.
Make your own decisions, trust your instincts. Just because someone else has skied somewhere doesn't mean that the slope is safe. It doesn't mean they know what they are doing.

Make a plan and stick with it.
Don't let other circumstantial factors make your decisions for you. Make good informed decisions and have faith in the decisions you make.

Ski in small groups.
Big groups lead to poor communication, lack of communication, miscommunication, divergent agendas, and more stress on a slope.

Snow events/storms take time to settle.
Respect the mountains. Respect yourself. Give the snowpack time to tell the story.

Stability tests have serious limits in indicating stability.
Unless you are digging to the bed surface, and even then, snowpits and compression tests are inadequate stability indicators, especially considering variability in snowpack from place to place.

Avoid unnecessary terrain features and stresses on the snowpack.
Rocks, trees, ridges, gullies, dips, pillows… every inconsistency in the terrain can indicate inconsistency in the snowpack.

In searching for a buried victim:

Make sure you are receiving, not transmitting.
Please.

Explore the whole fall line.
Don't get hung up on point last seen as it is not always where the victim is buried.

February 23, 2008

Good morning backcountry travelers this is Carl Skustad with the Chugach National Forest Avalanche Information Center on Saturday, February 23, at 6:30am. This notice will serve as a general backcountry avalanche advisory 5 days a week (Wednesday-Sunday) for the Turnagain Arm area, local variations always occur.

Due to recent warm temps and rain at sea-level, 20-Mile and Placer Rivers will be closed to motorized use.

Weather Observations

In past 24 hours:The Center Ridge weather station at 1800' in Turnagain Pass recorded 0" of new snow. Total snowpack depth this morning is 133" after 7" of settlement yesterday. The temperature this morning is 22°F (5° colder than yesterday).

Sunburst weather station at 3800' in Turnagain Pass recorded decreasing winds averaging 6mph out of the NE with average gusts in the low 20s. Temperature this morning is 19°F (3° colder than yesterday). The storm subsided yesterday with the following alpine storm totals: Turnagain Pass 83" or 7' and Alyeska 11'.

Bottom Line (Primary Avalanche Concerns)

The avalanche hazard has decreased since yesterday. Today, human-triggered avalanches are probable and natural-triggered avalanches are possible on snow-loaded, alpine slopes steeper than 30 degrees.

1. Large slab avalanches possible. 7-11' of storm snow is sitting on older cold snow.

2. Patience! We need to give the mountains a chance to adapt to the new snow load.

Avalanche and Snowpack Discussion (more detailed info…)

In the last week we have received nearly 7' of snow in Turnagain Pass and nearly 11' at Alyeska. Very strong winds have been present in most locations for the duration of the week. We have seen large natural avalanches occur in many areas, in some cases running more than once. With this much wind and snow many starting zones are reloaded again.

Lisa found favorable stability within the new storm snow yesterday in Turnagain Pass. This will be the case in most areas. The big question and area of concern following this storm is what deep instabilities are left, if any. Most areas went through a very large natural avalanche cycle and Mother Nature pushed the reset button on many starting zone weak layers. I don't yet have a sense if our previous weak layers are still present or not. Large avalanches could very likely be triggered were the snowpack is thinner due to wind and topography. If an avalanche is triggered, the likelihood of it propagating into a monster are very real. Approach all steep alpine terrain as you would a loaded gun. You can't tell if the safety is on or not until you investigate the snow stability of the snow you are traveling on or under. Chugach Powder Guides reported three deep, post-control avalanches measuring 6-8' deep in upper Winner Creek drainage yesterday. Another great example of what possible weak layers still exist.

Travel smart in the backcountry this weekend. We don't need any more accidents!

Photo by Lisa Portune

From Lisa Portune of the Chugach National Forest Avalanche Center:

Luck played such a huge role in this avalanche, it's almost unbelievable. I can't help but think of what could have happened…something on par with the '99 slide in Turnagain Pass that killed six snowmachiners. Six skiers from that party could have easily been buried (if the fracture line propagated further down valley) in addition to the separate party of two in the valley bottom who decided to turn around at the last minute because they felt like they were in a death trap. The initial report Carl and I got in the parking lot that day was that seven people were buried. I felt nauseous as chances were we most likely knew some of those folks.

As far as the immediate rescue response: How do you better control a situation like that when 20+ people with unknown levels of training show up at different times from different directions, spread out over an avalanche ¼ to ½-mile wide with an unknown number of burials? Ski patrols and SAR groups train for this but generally not members of the public. Sounds like Sean was trying to step into the leadership role, telling everyone who showed up to switch their beacons to receive (a few folks did not, which added to the confusion), but the search area was so large that it was very difficult to get everyone under control.

I think everyone learned a lot that day, including myself, and I am so thankful it turned out the way it did.

Avalanche Rescue Tools: PROBES

Story by Manuel Genswein and Ragnhild Eide

The publication of the V-shaped snow conveyor excavation strategy triggered many questions concerning the quality and efficiency of the working tools. The following study focused on avalanche probes that can be carried in a normal-sized backpack. Screwable steel probes with very long segments used occasionally by organized rescue have not been taken into consideration. Under the conditions of this research, probes were tested while applying correct probing techniques. All failures and observations were seen during regular use of the probes in avalanche rescue, the application they are primarily designed and sold for.

In addition to testing and rating a selection of products currently available on the market, this research aims to provide a detailed overview on the many important characteristics and functions of a probe. The resulting criteria may be used as an evaluation guide for future products. The manufacturers of the tested products were asked to comment on the test result for their product, which may be read at www.bergundsteigen.at.

This project was carried out by the authors Manuel Genswein and Ragnhild Eide under the patronage of The Austrian Alpine Club.

	length	weight	probe diameter	tip diameter	connection between segments	tip replaceable	locking mechanisms	remarks
BCA Carbon 260	260cm	211g	10.2mm too small in general (bending)	11.7mm (+1.5mm)	angled on two sides	no	Easy to handle with big gloves, incl. attaching the clip at the end of the cable. Mechanically weak.	Centimeter scale printed on probe does not last long.
BCA SR3 QuickDraw Probe	300cm	334g	12.7mm	13.0mm (+0.3mm)	angled on two sides	no	Easy to handle with big gloves, incl. attaching the clip at the end of the cable. Mechanically weak.	
BCA SR3 Standard Probe	300cm	315g	12.7mm	13.0mm (+0.3mm)	all open	no	Very durable, oval. Time-consuming assembly.	
Black Diamond Carbon Quick Draw Probe 230	230cm	234g	13.3mm	14.2mm (+0.9mm)	angled on two sides	no	Easy to lock, harder to unlock with bigger gloves/mittens. Some icing problems make it difficult to unlock the mechanism. Nice grip on the top segment. Clip-on mechanism at the end of the cable works well.	Measurement imprint should go to the top and not stop at 185cm. Cable length can be manually adjusted.
Black Diamond Guide Quick Draw Probe 300	300cm	351g	12.8mm	14.4mm (+1.6mm)	angled on two sides	no	Easy to lock, harder to unlock with bigger gloves/mittens. Some icing problems make it difficult to unlock the mechanism. Nice grip on the top segment. Clip-on mechanism at the end of the cable works well.	Measurement imprint should go to the top and not stop at 263cm. Cable length can be manually adjusted. Nice color coding. Plastic coating of the metal wire is thin. The wire is too short which damages the wire in the dismounted state as the radius of the wire is very small.
G3 Tech Probe 240	240cm	270g	12.6mm	14.1mm (+1.5mm)	angled on two sides	yes	Very durable, round. More time consuming. Needs to be periodically retightened or it will unscrew itself and fall apart. Missing locking clip for the end of the cable.	Best and most functional probe bag!
Mammut Expert Probe	265cm	230g	10.8mm	12.7mm (+0.9mm)	open	no	Hard to unlock.	Measurement imprint should go to the top and not stop at 225cm. Cable length can NOT be manually adjusted. Weak probe in general.
Mammut Standard Probe	280cm	218g	9.4mm	11.7mm (+2.3mm)	open	no	Knot in the top, proper locking mechanism totally missing	No measurement imprint, but simple color coding. Cord is made from rope, far too much elasticity. Probe seriously deformed (destroyed) in test. Very weak probe in general.
Ortovox 320	320cm	440g	13.3mm	13.9mm (+0.6mm)	angled on two sides	yes	Locking and unlocking easy to handle even with gloves. Should be more rigid. Locking mechanism for the end of the cable does not work.	No coating on wire. Cable length can be manually adjusted. Additional grip material gets slippery in wet snow conditions.
Pieps Standard Probe	260cm	286g	13mm	14.5mm (+1.5mm)	angled on two sides	no	Not easy to handle with big gloves, in particular the unlocking mechanism. Needs a lot of force to extend it so that there is no slop. This is only possible if extended to the very last segment of the locking rings where the segment is not straight, stable line to the probe any more Mechanically rather weak.	
Voilé Tourlight Probe	250cm	266g	11.1mm	12.7mm (+1.6mm)	all open	no	Hard to unlock, mechanism failed during test.	Measurement imprint should go to the top and not stop at 195cm. Nice color coding. Wire too short. Cable length can be manually adjusted.

The Ortovox Pro Steel 320 and Ortovox Carbon Pro 240 Plus both exhibit nice features, but neither were fully tested as their locking mechanisms exhibited poor long-term durability. The steel cable kept breaking just above the metal spanning bolt.

1. Probe Selection Criteria

From all major manufacturers, only one or two of the most promising (i.e., mechanically strong, ergonomic, light weight) versions were selected for the test. One of each of these was purchased in a regular mountain sports shop. Not all G3 probes we would have liked to have in the test were available.

2. General Description of Important Characteristics and Features

LENGTHS

A companion-rescue probe should not be shorter than 240cm, whereas an organized rescue probe should not be shorter than 320cm.

DIAMETER

The smaller the diameter of the probe, the more often deformations and strong bending will occur in the debris. In particular, carbon probes need a sufficient diameter to withstand the forces applied in avalanche rescue.

MATERIAL

High-quality carbon probes are not only lightweight, they also withstand the stress they are subjected to in companion rescue. This implies that probing will not be performed over several hours, i.e., in a probe-line search. However, for organized rescue, metal probes are definitely preferable.

SPANNING MECHANISMS

The spanning mechanism should not allow any or, at most, very marginal play. This play leads to faster mechanical destruction of the probe and the overlapping sections in particular. Textile-based spanning cords, including Kevlar, are not sufficient. The most static spanning mechanism is a screwable probe, where the individual elements are screwed together. However, the necessity to frequently retighten the elements makes this option less attractive.

Spanning cables need to be long enough in their total lengths that the probes may be easily folded into the collapsed state without damaging the cable or probe segments.

CONNECTION BETWEEN SEGMENTS

The connection between the segments influences how smoothly the probe can be assembled and how durable it will be. Sharp, open edges are inferior to segments with a smooth finish on both sides.

PROBE DESIGN

Probes should have a centimeter scale in order to determine burial depth, which also makes them a versatile tool for snowpack investigation.

LOCKING MECHANISMS

Many locking mechanisms are available. It is important to find a good balance between user-friendliness while wearing gloves, reliability, durability, and proper functionality under icing conditions.

Probes with threaded locking mechanism are more time-consuming to deploy and required most testers to remove their gloves in order to spin the locking nut.

TIP DESIGN

The tip of the probe should be replaceable with a maximum diameter larger than the probe shaft. Probes with rounded tips were harder to push through hard layers in the debris than those with pointed tips.

PROPER USE OF THE PROBE

Always deploy the probe downwards, perpendicular to the slope. Wear gloves to prevent freezing on the probe. Always probe with two hands in order to penetrate the debris quickly and in control.

3. Recommendations

Personal probe for touring: high-quality carbon probe, approx. 240cm, sufficient diameter. Probe for frequent use in courses and organized rescue: high-quality metal probe of at least 300cm length.

Declaration of neutrality: *All equipment rated in this study was purchased and paid for by the authors, and none of the involved parties are in any way involved in the manufacturing, sales, or promotion of any of the tested equipment.*

This research project also includes a section on avalanche shovels, which was published in TAR 27/3.

Manuel Genswein is an independent avalanche instructor. He can be reached at manuel@genswein.com. Ragnhild Eide has been working as a NF mountain guide in Norway since 1997. Since 2005 she and Manuel have been part of the development of the V-shaped snow conveyor technique for excavating avalanche victims.

THE EXTENDED COLUMN TEST:
A Way to Assess the Snowpack Fracture Propagation Propensity

Story by Ron Simenhois

Slab avalanches result on steep slopes when a weak layer underlying a stronger slab fractures. This fracture must first be initiated in the weak layer to a critical size and then propagate *(Gauthier and Jamieson, 2006)*. Hence, stability evaluation can be broken into two basic questions:

1. Is fracture initiation on the weak layer likely?
2. Is the slab/weak layer combination conducive to fracture propagation?

Signs like whumphing, cracking, and – most of all – avalanche activity unambiguously inform us that both fracture initiation and propagation are likely. However, in many cases the state of the snowpack is not as clear, and we rely on less obvious data like snowpit tests to assess snowpack stability. Snowpit tests that aim to assess fracture initiation like compression tests, rutschblocks, or stuffblock tests *(Greene et al., 2004)* have long been used by people traveling in avalanche terrain. People also use indirect methods like shear quality *(Johnson and Birkeland, 2002)* and the closely related fracture type *(van Herwijnen and Jamieson, 2004)* in addition to test results to evaluate fracture propagation. The Swiss have long noted the type of release and what portion of the block releases with rutschblocks tests *(Schweizer and Wiesinger, 2001)*. However, only recently have we witnessed the development of two tests directly targeting fracture propagation: the Extended Column Test (ECT) and the Propagation Saw Test (PST).

Procedure Presents New Recording Standards

The ECT is done by dynamically loading one end of a vertical column 90cm across the slope by 30cm downslope in the same manner as in the compression test *(Greene et al., 2004)*. The tester notes the number of taps required to initiate a fracture and whether or not the fracture propagates across the entire column.

The recording standards are designed to emphasize what the test results are telling the user, i.e., whether or not a fracture propagates across the entire column:

ECTPV – Fracture propagates across the entire column during isolation.
ECTP## – Fracture initiates and propagates across the entire column on the ## tap or the fracture initiates on the ## tap and propagates across the column on the ## + 1 tap.
ECTN – Fracture initiates but does not propagate across the entire column in a single loading step.
ECTX – No fracture occurs during the test.

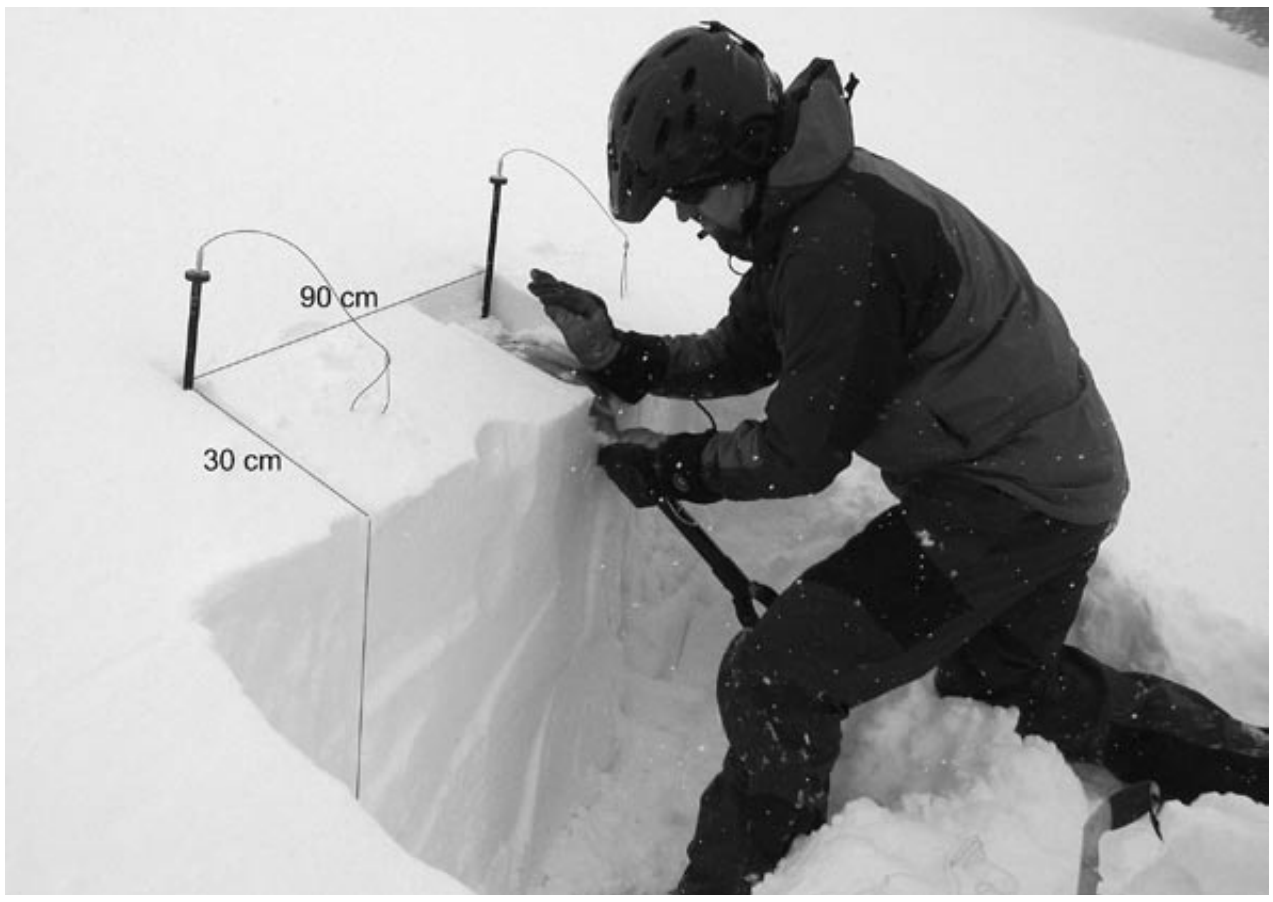
An advantage of the ECT is that the test's interpretation is straightforward. ECTPV and ECTP## results suggest unstable conditions, while ECTN is generally indicative of stable conditions. With ECTX there is no fracture initiation, so we know nothing of the fracture propagation for that layer. Thus, while ECTXs also generally indicates stable conditions, we recommend using a different test on the snowpack when a user gets an ECTX result.

Advantages and limitations of the ECT

Results from two different datasets of over 300 snowpits each indicate that the ECT is an effective stability test, with a false stability ratio generally less than other standard snow stability tests *(Birkeland and Simenhois 2008; Birkeland and Chabot, 2006)*. Also, the ECT gives us a good indication if an initiated fracture under a person traveling on the snow surface is capable of reaching 90cm in length. Data so far suggests that this fracture length is more than the critical fracture length needed for self propagation under unstable conditions. Another advantage is the effectiveness of the ECT on flat terrain. Reports from the last couple of years reveal that the ECT works well on flat terrain as well as on inclined slopes; therefore it can be a good tool to detect remote triggers from flat areas.

No test is perfect and it is important to be aware of the test's limitations. First the ECT may overestimate snowpack instability in some cases where a weak layer sits under a thick hard slab. Second, the ECT has a reasonably high false-instability rate (up to 18%). Third, the ECT is not a good tool to assess soft (F+ or less) upper layers of the snowpack or in mid-storm shear layers. In these cases the shovel edge tends to cut those soft layers and sink through. Fourth, as many other stability tests, the ECT relies on surface loading to initiate a fracture in the weak layer, hence, the deeper the weak layer, the harder it is to initiate a fracture on this layer.

Finally, as with any other stability test and regardless of snowpack conditions, site selection is critically important in order to sample an area that is representative of the slope of concern.



The preparation of the ECT is done by isolating a column 90cm across the slope by 30cm upslope. The column is then loaded from one side using the same technique as in the compression test. *Photo by Karl Birkeland*

Sore Hands and Weak Layer Depth

As the ECT gains popularity and more folks are using it on daily basis, I often discuss the all-important question of how deep in the snowpack should the column be isolated. Further, some people have been getting sore hands from tapping too hard for too long.

As mentioned above, fractures are hard to initiate on deeper weak layers. Experience from the Colorado Rockies and New Zealand shows that testing weak layers deeper than 100cm can be challenging. Cameron Ross and Bruce Jamieson *(2008)* found that the soft snow of the Colombia Mountains tends to absorb surface loading better than hard snow, hence in the Colombia's snowpack, initiating fractures deeper than 70cm deep can be difficult. Therefore I rarely use the ECT to test layers deeper than 120cm. If the weak layer depth is pushing 100cm, I usually use compression test (CT) results as a guide. If the CT score is >25 I would probably save my hands and use other tests like deep tap test, PST, or look for shallower snowpack areas to dig my pit.

Conclusion

The ECT offers a new way of testing the snow stability, with a focus on examining the fracture propagation propensity of the slab/weak layer combination. Data from two different datasets with over 300 snowpits each and the positive feedback from a worldwide network of observers indicate that it is a valuable addition to other tests. Further, the ECT appears to have a lower false-stability ratio than any of the other snowpack stability tests, which enhances its practical usefulness for slope stability evaluation. Also, the rapid acceptance of this test by practitioners around the world in only two seasons confirms its practical usefulness for field testing.

Besides the practical application of the test, the ECT offers scientists a tool to investigate changes in fracture propagation over space and time. In other papers the ECT was utilized to detect changes in fracture propagation propensity as a result of changes in slab depth *(Simenhois and Birkeland, 2008a)*, with surface warming *(Simenhois and Birkeland, 2008b)*, and over space and time *(Hendrikx and Birkeland, 2008; Hendrikx et al., under review)*.

Finally, no test is perfect and all tests must be used in conjunction with additional data.

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Ron splits his time between Colorado and New Zealand. About every other year he fills the lack of summer with a two warm weeks in his homeland Israel. Ron is always on the lookout for easy, simple ways to do his job. Please send him your thoughts and ideas on the ECT at ron_si@yahoo.com.

On Varying Slab Thickness And Fracture Propagation

Story by Ron Simenhois and Karl Birkeland

On January 4, 2008, a Copper Mountain ski patroller found himself riding for his life, trying to dodge a class 4, hard-slab avalanche. This avalanche was triggered by the patroller himself from the lower part of the slope where the slab was thin. This slope was previously tested with explosives where the slab was thicker, including two sizable charges that left dents in the bed surface. Further, there was no additional loading between the time this slope was tested with explosives and the time it slid. This incident left everyone involved unharmed. However it also left us with the obvious question: why the slope did not avalanche when tested with big explosives but avalanched the next day with a person's load, especially since the dents those explosives left in the bed surface indicate that fractures were initiated in the weak layer but did not propagate far enough for the slope to avalanche?

Research and field observations show that people are more likely to initiate fractures in thin snowpack areas. However, our knowledge of how thinner and thicker areas of the slab affect the propagation of fractures is limited. This information is important because slab depths commonly vary widely across avalanche start zones (figure 1). This article reports on a recent research (Simenhois and Birkeland, 2008) aiming to measure the snowpack's fracture propagation propensity across areas with varying slab thickness. We used the Extended Column Test (ECT) with column widths of 200 and 300cm and the Propagation Saw Test (PST) to assess fracture propagation propensity. In this research we look at side-by-side test results in areas with naturally varying slab thickness and in areas where we reshaped the slab to create varying slab thickness. Our results suggest that fractures are more likely to propagate from under thin to thick slabs than from the other direction.

Figure 1: How would a fracture propagate across this slope?

DATA AND METHOD

Our study was conducted in and around Copper Mountain, Colorado, and Mt Hutt, New Zealand. During the 2006, 2007, and 2008 seasons we collected ECT, modified ECT, and PST results from 52 pits. All of our pits were on slopes with high fracture propagation propensity, as evidenced by recent avalanche activity or by fracture propagation results using a standard ECT or PST. In 20 pits the slab thickness above the weak layer changed naturally within a column length, and in the other 32 we reshaped the slab above the weak layer with a snow saw.

Data collected in each pit included results from side-by-side ECTs (figure 2), modified ECTs with column widths of 200cm in 15 pits, 300cm in eight pits and PSTs in 18 pits (figure 3). In each set, a fracture was initiated from where the slab was thick in one test and where the slab was thin in the other test. We also collected grain size and type, layer hardness, layer thickness, and slab density *(Greene et al. 2004)*.

RESULTS

In our dataset (consisting of 116 side-by-side tests from 52 pits), fractures that initiated under the thin part of the slab always propagated across the entire column and toward the thicker part of the slab. However, when we initiated the fracture under the thick slab in the same pits, it consistently failed to propagate toward the thinner slab, with slabs cracking before the fracture along the shear plane reached the end of the column. Those results were consistent on slopes with highly variable slab thickness as well as in those 32 pits where we reshaped the slab. Further in our dataset, there were no conflicting results between the different tests.

CASE STUDIES

Our test results are supported by case studies from the 2007/08 northern hemisphere winter around Copper Mountain, Colorado. This article only presents two of the four cases reported in the original research *(Simenhois and Birkeland, 2008)*. In all cases fractures initiated in areas where the weak layer was under a thicker slab but did not fully propagate across the slopes. However, those same slopes slid in their entirety a day or two later when tested with much smaller loads on areas where the slab above the weak layer was thinner.

The first case was on January 1, 2008, on a 37° east-facing slope at an elevation of 3680m. On December 31, 2007, this slope was tested with both one and two kg charges on the upper part of the slope where the weak layer depth was about one meter. Those explosives produced cracks down to the weak layer and about four meters along it. However, the majority of the slope remained intact. On January 1, 2008, this slope avalanched with a one kg charge placed in the compression zone where the weak layer depth was about 30cm. There was no additional load on this slope between the time it was initially tested and the time it slid, and the perimeter of this slide included the two explosive placements from the day before (figure 4).

The second incident occurred on January 4, 2008, on Tucker Mountain, Colorado, on a 35° northeast-facing slope at an elevation of 3800m. This slope was tested numerous times on January 2 and 3 with no visible results. On January 2, a 14kg charge was placed in area where the slab above the weak layer was a meter to a meter-and-a-half thick. On January 3, an 8kg charge was placed where the slab was one meter thick. On January 4, a patroller triggered a hard-slab avalanche (HS-Ab-D4/R5-O) by snowboarding across the lower part of the same slope where the slab was less than 10cm thick. Explosive work from the previous two days was visible on the bed surface with two dents of seven and 10m in diameter (figure 5), demonstrating that the applied charges were effective in initiating the fracture. However, those fractures did not propagate sufficiently to result in an avalanche. There was

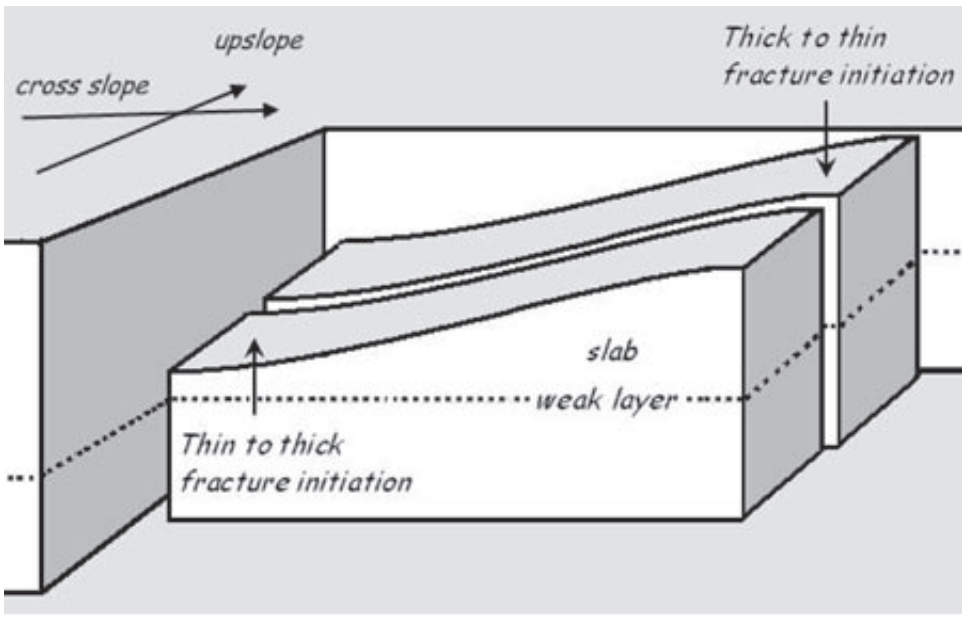

Figure 2: Schematic illustration of side-by-side extended column tests. Fractures are initiated under thin and thick parts of the slab by placing and tapping on a shovel on the thin side in one test and on the thick side in the second test.

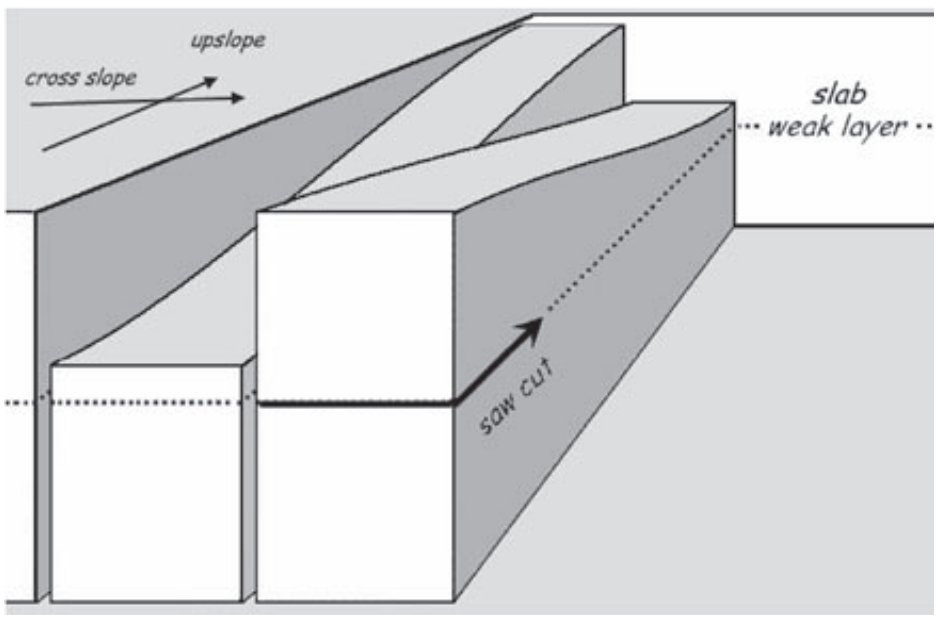

Figure 3: Schematic illustration of side-by-side propagation saw tests.

no additional load added to the slope between January 2 and 4.

DISCUSSION

Both theory and practice support the idea that fractures are more likely to be initiated in thinner areas of the snowpack. However, our limited data and field observations show that fractures are also more likely to propagate from areas with thinner slabs toward areas where the slab above the weak layer is thick than in the other direction. Hence, our results suggest that these two mechanisms reinforce each other. We are not sure what the reasons for the asymmetric fracture propagation propensity underneath a highly variable slab thickness may be. We are hoping to answer this question with future research.

PRACTICAL IMPLICATIONS

Our findings of asymmetric fracture propagation propensity over slopes with spatially variable slab thickness have practical implications on a variety of subjects.

1 Avalanche Mitigation

Explosive placement is likely most effective when placed in an area of thinner slab than at its thickest spot. Still, to support fracture propagation on the weak layer, a slab needs to be strong enough and therefore thick enough to withstand the energy transfer at the point of initiation *(Gauthier, 2007)*.

2 Ski Cutting

Moving in direction from thick to thin slab when ski cutting across a loaded slope more likely places the skier/snowboarder closer to the edge of the slide parameters in case of slab release. Further, it also will have you skiing through areas with a smaller volume of moving snow.

3 Avalanche Prevention

Structures for snowpack anchoring may be more effective if their design takes into account the prevailing winds and creates highly variable slab thickness across start zones. This highly variable slab thickness may help to minimize avalanche size.

4 Escape Route

Aiming toward a thin slab area will increase the chance of getting off the slide perimeter and into areas where the propagating fracture is less likely to reach. This strategy also puts you in areas with a smaller volume of moving snow.

5 Snowpit Location

When digging snowpits in areas of variable slab thickness, fractures in ECT and PST should be initiated where the slab is thinner since such tests are less likely to produce false-stable results. Further, care should be taken in snowpits where the slab is too thin. Some of these tests may indicate lower fracture propagation propensity than in areas of the slope with a thicker slab.

Figure 4: Case study from 1 January 2008, in this photo the disturbance in the bed surface is from the explosive work on the day before this slope avalanched.

FINAL WORDS OF CAUTION

Our dataset does not contain cases where, in the same pit, a fracture propagated from under thick slab toward a thinner slab and did not propagate in the other direction. However, it would be wrong to assume that fractures initiating under thicker slabs will not propagate toward areas of thinner slabs. We and many others have frequently observed fractures propagating from thicker slab areas toward thinner slab areas under some conditions.

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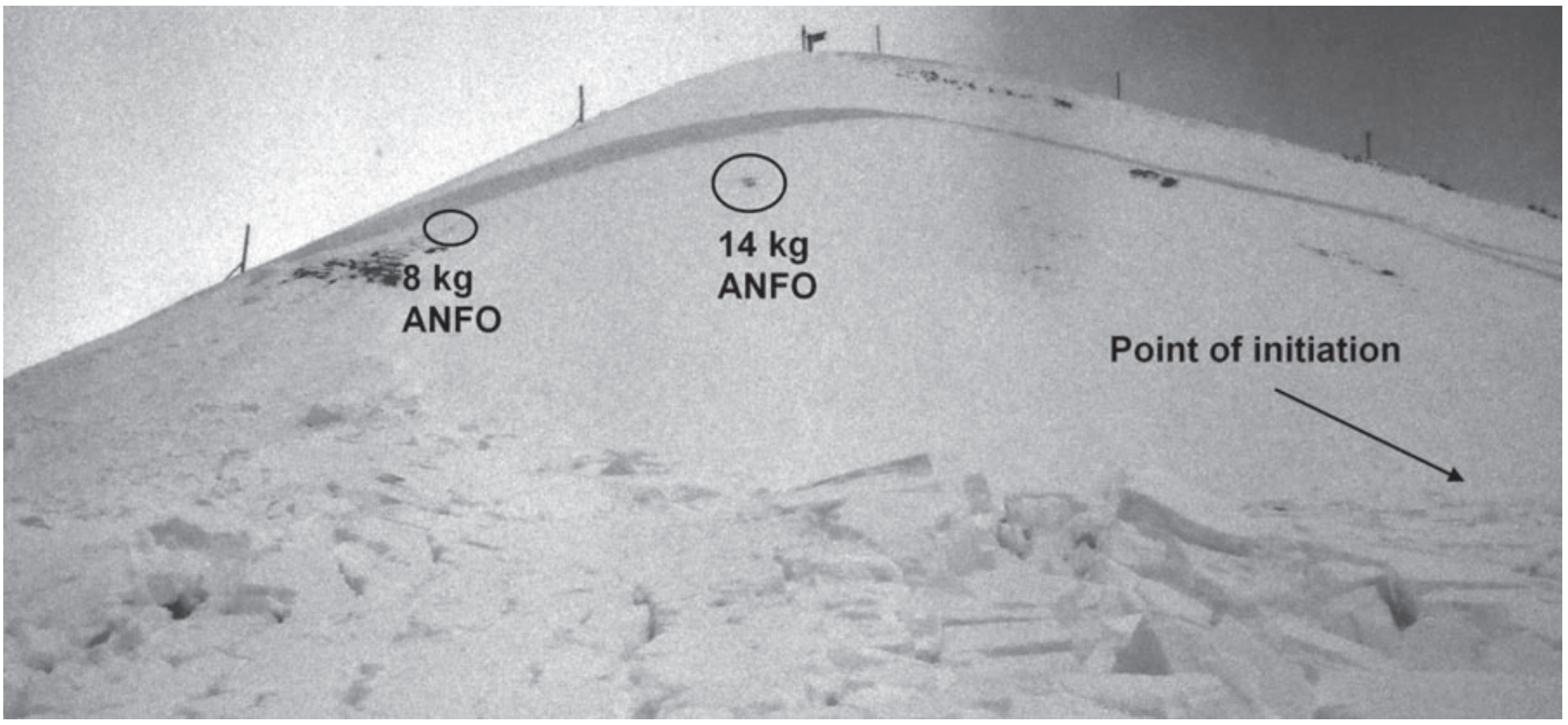

Figure 5: Case study from January 4, 2008 locations where explosives were placed and left marks on the bed surface.

38° Revisited: A Closer Look at Avalanche Types & Slope Angles

Story by Ian McCammon

Differentiating between avalanche types is an idea that has been with us for a long time. In his 1909 classic *The Ski-Runner*, E.C. Richardson described three kinds of avalanches that today form the basis of the avalanche classification system.

But there's more to avalanche classification than mere taxonomy. As experienced avalanche folks know, the type of avalanche expected on a particular day tells us a lot about which terrain choices are prudent and which are foolish. Route selection when the danger is isolated wind slabs, for example, is a very different game than when the danger is a deeply buried surface hoar layer. Bruce Tremper sums up the link between avalanche type and terrain nicely:

> Each different avalanche condition has its own characteristic patterns, routefinding considerations, forecasting considerations. Knowledge of the snowpack is an extremely powerful tool in the battle against the White Death, and I personally would feel very naked without knowing what kind of avalanche dragon I'm dealing with. *(2008, p. 113-114)*

The dialog about avalanche type and terrain management has recently become more precise with the avalanche character typology introduced by Roger Atkins *(2004)* and more pervasive with the use of avalanche character icons in regional forecasts. Most folks seem to agree that knowing about avalanche types improves our decisions in avalanche terrain, and the trend to be more specific when talking about avalanche types and terrain choices is likely to continue.

So it's a bit of a mystery that we don't have a better quantitative handle on how avalanche types relate to terrain, and more specifically to slope angle. Do different avalanche types happen on different slope angles? Do start zone angles vary by weak layer type or avalanche climate? And how can we best apply this information in our travel decisions in avalanche terrain?

BACKGROUND

Let's start with what we know about avalanches and slope angle. Numerous studies have examined start zone angles and have found that slab avalanches are very rare below 25° and that the majority occurs on slopes of 30° to 45°. Another consistent finding is that avalanche activity peaks around 38° steepness. Examples of such studies include Perla *(1977)*, Logan and Atkins *(1996)*, and Schweizer and Jamieson *(2000)*.

Two things are striking about past research on slope angle. First, results are very consistent across most studies, with less than a degree or two of difference between findings. This consistency suggests that we have a pretty good handle on how the avalanche phenomenon as a whole relates to slope angle. That's good news, since it supports these findings as reliable rules of thumb for avalanche terrain.

Secondly, virtually all past work has focused on dry slab avalanches as a class. As far as I can tell, little quantitative work has been done on the relationship between slope angle and different types of dry slabs. Likewise, there seems to be relatively little literature on how slope angle relates to wet slabs, wet point releases or dry point releases. In *The Avalanche Handbook*, McClung and Schaerer give rough guidelines for starting zone inclines by avalanche type, but lament the lack of detailed studies. That's bad news, since folks without broad field experience don't have much to go on when it comes to incorporating avalanche types into their routefinding decisions.

METHODS

In order to get a rough idea of how avalanche types relate to slope angle, I analyzed start zones angles from recreational avalanche accident reports in the US from 1972–2008. Where a range of angles was given for a particular start zone, I used the arithmetic average. For each incident, I looked at the avalanche climate where it occurred *(Mock and Birkeland, 2000)*, the avalanche type, and the grain type of the weak layer. To assess the spread of the data, I calculated the range of the central 50% of start zone values (interquartile range or IQR) for each avalanche type based on a simple numerical percentage of data points.

Measuring start zones with an inclinometer can be a rather inexact business, and reported data has a tendency to cluster around certain values (e.g., 30°, 35°, 38°). This clustering renders simple measures of spread like the interquartile range somewhat misleading as rules of thumb for choosing slope angles in actual practice. For this reason, I also calculated the proportions of each avalanche type that occurred between 30° to 45° – a useful rule-of-thumb range of slope angles that captures avalanche hazard on most of the slopes where we like to travel.

RESULTS

Start zones for the 496 avalanches in this study show close agreement with prior studies (figure 1). Avalanche activity peaked at the familiar median of 38° (mean = 38.7°), with 50% of the data points lying within a 5° range around the median (IQR = 5°). About 91% of these avalanches involved start zones between 30° and 45° (table 1). No surprises so far.

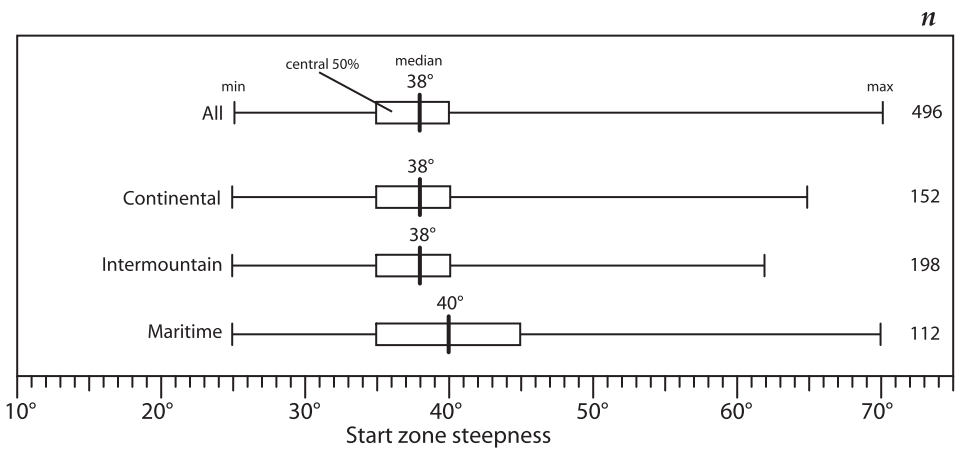

Figure 1: Start zone steepness for all avalanches in this study, and broken out by avalanche climate. The variable *n* indicates sample size.

Avalanche Climate

Avalanches in continental and intermountain climates mirrored the familiar pattern of releasing in start zones around 38° (figure 1), with over 90% of avalanches releasing in start zones between 30° and 45° (table 1). But maritime avalanches occurred in steeper start zones (mean = 40.5°), a trend that was statistically significant (PANOVA = 0.0019) and distinct from both intermountain and continental avalanches (Tukey test). Maritime avalanches also occurred over a broader range of start zone angles (IQR = 10°) than intermountain and continental avalanches. The statement sometimes heard in avalanche courses that "over 90% of accidents involve slopes between 30° and 45°" appears to be true only for intermountain and continental climates (table 1).

Avalanche Type	Mean	30°- 45°
All	38.7°	91%
Continental	38.3°	91%
Intermountain	37.9°	94%
Maritime	40.5°	84%
SS	38.5°	91%
HS	37.6°	95%
WS	40.5°	87%
WL	44.0°	58%
L*	50.8°	25%
DH or FC	37.8°	93%
SD*	42.1°	88%
DF	44.3°	76%
WG	45.4°	57%
SH	35.8°	98%

Table 1: Mean start zone angle and the proportion of avalanche types that released in start zones 30°–45°. An asterisk (*) indicates results that should be viewed with caution due to small sample sizes.

Avalanche Type

Hard slabs and soft slabs were by far the most common avalanche type in reported accidents (figure 2). While there was no statistical difference between start zone steepness for hard slabs and soft slabs (Pt-test = 0.103), significantly more hard slabs than soft slabs released in start zones 30°–45° (PBartlett = 0.0004). In other words, hard slabs in this sample released over a narrower range of slope angles than soft slabs.

Fewer accidents involved wet snow, but these avalanches generally released in steeper start zones and over a greater range of angles than dry slabs. Loose avalanches (wet or dry) appeared to favor even steeper start zones, a trend that has been qualitatively noted in the literature *(see Tremper, 2008, p68 or McClung and Schaerer, 2006, p112)*. Due to the small number of cases, particularly for dry loose avalanches, these results should be viewed with caution. Nevertheless, it is worth noting that for avalanches that are not dry slabs, the interval of 30–45° represents considerably less than 90% of start zones in these accidents (table 1).

Weak Layer

Over 70% of weak layers in reported avalanches were comprised of depth hoar (92 cases), faceted grains (86 cases) or facet-crust combinations (38 cases). There was no statistical difference between these distributions (PANOVA = 0.713) and hence all three were combined. About 93% of these avalanches released in start zones between 30°and 45° (table 1), with activity peaking around the familiar 38° (figure 3).

Other weak layer types showed a distinct tendency to release on steeper slopes. Stellar dendrites (SD), decomposing forms (DF), and wet grains (WG) generally released on slopes steeper than 38°, with wet grains showing a broader range of start zone angles (IQR = 11.5°) that is consistent with wet avalanche types in figure 2. It is worth noting that stellar dendrites were the only precipitation particle reported as a weak layer; graupel and other precipitation types were notably absent from avalanche reports where start zone steepness was known.

Surface hoar (SH) was less common than facets or depth hoar as a weak layer, but it showed a marked tendency to release on lower angle slopes (median 36°) than other crystal types. The variability of start zones for surface hoar avalanches was remarkably low (IQR = 3°), with 98% of start zones residing in the 30°–45° range (table 1).

DISCUSSION

This brief analysis tells us much that we already know: that most avalanche activity peaks around 38° and that most accidents involve start zones between 30° and 45°. This "Rule of 30–45°" applies especially well to past accidents in intermountain and continental climates that involve dry slabs running on depth hoar or facets.

But we also see some interesting patterns:

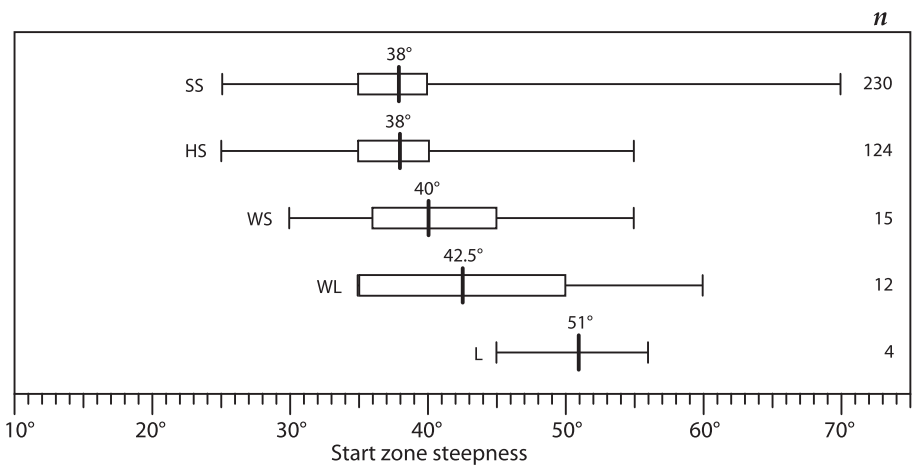

Figure 2: Start zone steepness by avalanche type (SS – soft slab; HS – hard slab; WS – wet slab; WL – wet loose; L – dry loose).

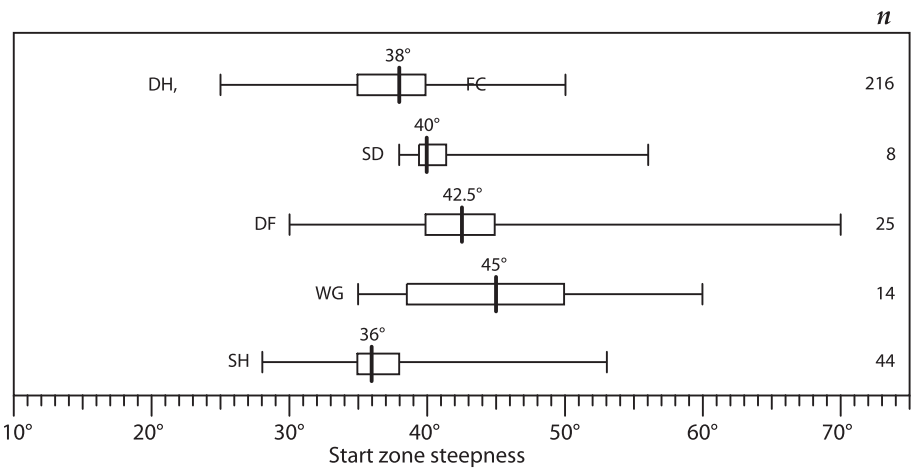

Figure 3: Start zone steepness by weak layer grain type (DH, FC – depth hoar or faceted grains; SD – stellar dendrites; DF – decomposing forms; WG – wet grains; SH – surface hoar).

1) In maritime accidents and in accidents involving wet snow, avalanches typically released in steeper start zones.
2) Accidents involving non-persistent grain types such as decomposing forms and stellars also broke the traditional 38° pattern, with a smaller percentage releasing in the range of 30°–45°.
3) Accidents involving surface hoar generally released in shallower start zones than the standard 38° pattern would have suggested. But 98% of these avalanches released in start zones of 30°–45°.

Predicting avalanche likelihood is a complex problem that goes far beyond simply measuring slope angle. But these results support the idea that avalanche type is an important factor when determining which slopes might be dangerous on a given day.

It is encouraging that these findings mirror field experience, but these results should be viewed and applied with caution. The data on which this study was based are likely biased due to patterns of recreation and the limitations of avalanche investigations. But my hope is that these results encourage further work on this important topic.

CONCLUSIONS

Under most mid-winter conditions, the "Rule of 30–45°" seems to be a reasonable (but by no means absolute) terrain selection guideline, especially for slopes in continental and intermountain climates where the weak layer is a persistent grain type. This traditional concept may prove to be more conservative in maritime climates, when the snow is wet or when the weak layer is a non-persistent grain type. But when the weak layer is composed of surface hoar, it may be prudent to dial back the slope angles you'd otherwise consider safe. While much work remains to be done on slope angle and avalanche type, these early results show promise for improving our decisions in avalanche terrain.

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Ian McCammon is a reliable contributor to TAR and to our overall understanding of translating theory into better practices and decision-making in avalanche terrain. He lives in Salt Lake City where he is learning to say, "No, I cannot take on another project."

A Practitioner's View of Fracture Propagation Propensity

Story by Sarah Carpenter

I don't have a PhD in snow science. In fact, I have an undergrad degree in French. But…what I do have is a lot of time with my head in the snow.

Reading Karl Birkeland's article out loud to Don Sharaf prompted a good discussion on how we incorporate all of this new research into our stability analysis. We're no Ed LaChapelle, but one thing that we both agreed on is that you often get a really good sense of the snow (slab properties and potential weak layers) just by digging. As LaChapelle writes in *The Ascending Spiral*, "By the time I have finished digging a snow pit, I usually know about 90% of what I am going to find from it about snow stability."

As I mentioned, I'm no Ed LaChapelle, so usually I need more information. I still rely heavily on some of the information-gathering techniques taught in my Level 1 class. I poke and prod the snowpack with my ski pole in search of the recipe for a slab avalanche on my ascent. I jump on switchbacks and watch the results. If that little area of snow fails under my skis and propagates another 10', I've got yet another great insight into the properties of a particular slab and weak layer combination. I seek out test slopes and test slope stability on a small scale. And if I still need more information, I stick my head into the snow.

What do I use in my snowpack and stability analysis? I incorporate strength, structure, and energy. This view of the snowpack, as described in TAR 23/3 by McCammon and Sharaf, is a more holistic picture of stability. As much of the research has shown, strength can be incredibly spatially variable, so just looking at CT scores or RB scores paints a very incomplete picture. In all of my reading, my many email queries to Karl Birkeland this fall, and my personal observations, it is my understanding that both energy (shear quality or fracture character) and structure are more spatially uniform. So, when I get a Q1 score in my pit, I tune in. And if I'm getting consistent Q1 scores in my pit, I really tune in. High energy to me means that if I am able to affect the weak layer, I'm going to see a significant avalanche.

And what about those days when I'm getting consistent moderate compression test scores with Q2 results? I have found the Extended Column Test (ECT) to be invaluable at narrowing the gray zone. I use the ECT to clarify the propagation propensity of particular slab/weak layer combinations. Yes, I can initiate a fracture, as demonstrated in my compression test, but will that fracture propagate? The ECT and the PST are invaluable at demonstrating this piece of the puzzle. They are particularly valuable in conjunction with other tests…as are all of the formal stability tests.

And if I'm still confused after poking, prodding, and digging…I'll stand above my snow pit and jump on it. That piece of visual data – how the slab and weak layer combo reacts to my jumps – can fill in quite a few information gaps with minimal effort.

A ski cut is another great assessment tool that I use on a regular basis, especially on layers that are too shallow or soft to be effectively assessed with formal stability tests.

What about the slab properties that Birkeland, Schweitzer, and Jamieson commented on in their article? I would agree that paying attention to slab properties is essential. On the SW Montana AVPro course, Scott Savage gave a great talk on the deep-slab avalanche problem that exists at Big Sky. The effects of slab properties on fracture propagation seem to be at play here, potentially explaining why, at the crown, there appears to be no weak layer in his avalanche, but only an interface between a hard layer and a REALLY hard layer.

Don Sharaf and I hypothesize that a weak layer existed and was affected lower down on the slope. Due to the stiff nature of the slab, that failure propagated up into an area where that weak layer no longer existed. Don has also seen failures that have propagated around a wind-blown ridge through an adjacent slope. Propagation of these failures through the slab, rather than through the weak layer, seems to be the likely explanation.

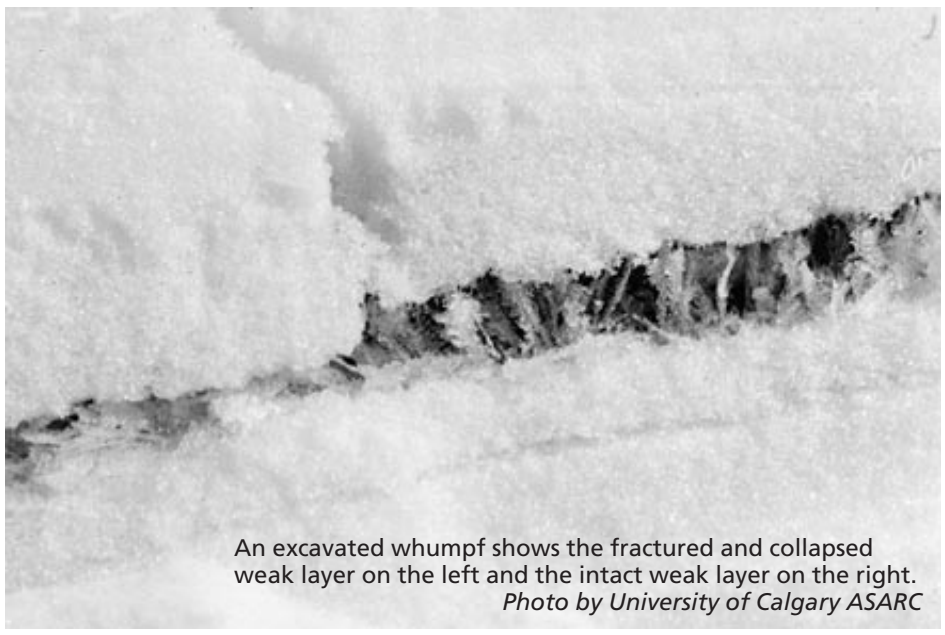
The bottom line: I am grateful for our researchers. In the field, I find that incorporating recent research alluded to by Birkeland, et. al., *(see next page)* has improved the accuracy and efficacy of my stability analysis. Class-one data, such as avalanche activity, still trumps all other observations. Informal stability tests help paint a picture of snow stability on the fly. And when I get into a snowpit and gather data, I try to gain a holistic picture of the snowpack, looking at strength, structure, and energy. In other words, I look at not only fracture initiation but also fracture propagation. And of course, with all of these tools in my toolbox, I am always in search of safe, fun powder skiing.

Much credit for this article goes to Don Sharaf; I've been riding in a car with him for many hours now, plus have worked with him almost constantly for the last month or so.

Sarah Carpenter is finally home after many days in the field and classroom on both AvPro courses, ski guiding, and other avalanche classes too numerous to list. Now she can turn her attention to her husband Don Carpenter, whose broken fibula prompted his meditation on self-rescue on page 12 of this issue of TAR.

FRACTURE PROPAGATION: Recent Research and Implications

Story by Karl Birkeland, Jürg Schweizer, and Bruce Jamieson



An excavated whumpf shows the fractured and collapsed weak layer on the left and the intact weak layer on the right. *Photo by University of Calgary ASARC*

A quick perusal through some recent ISSW Proceedings demonstrates a greater emphasis on fracture propagation. The Whistler ISSW boasted 16 papers and posters on fracture propagation and associated field tests, and the evening's beer-fueled discussions often came around to talk of fracture propagation. In her usual nice way, TAR editor Lynne Wolfe cornered us at that conference and encouraged us to write a quick article summarizing some of this work; out of her encouragement came this article. We attempt to synthesize some of the recent research and ideas, and discuss some of the implications for avalanche practitioners.

Propagation versus Initiation

While several new tests are available, many of the ideas about fracture propagation are not new. We have known implicitly that avalanches require both fracture initiation and propagation, though this has only been emphasized in our writing and teaching for about the last five or 10 years *(e.g., Schweizer, et al., 2003)*. Until quite recently, our field tests and much of the research have predominantly emphasized initiation over propagation. Likewise, some of the recent new models of fracture propagation simply provide an improved explanation for phenomena that practitioners have known and observed for many decades, such as avalanches remotely triggered from flat terrain.

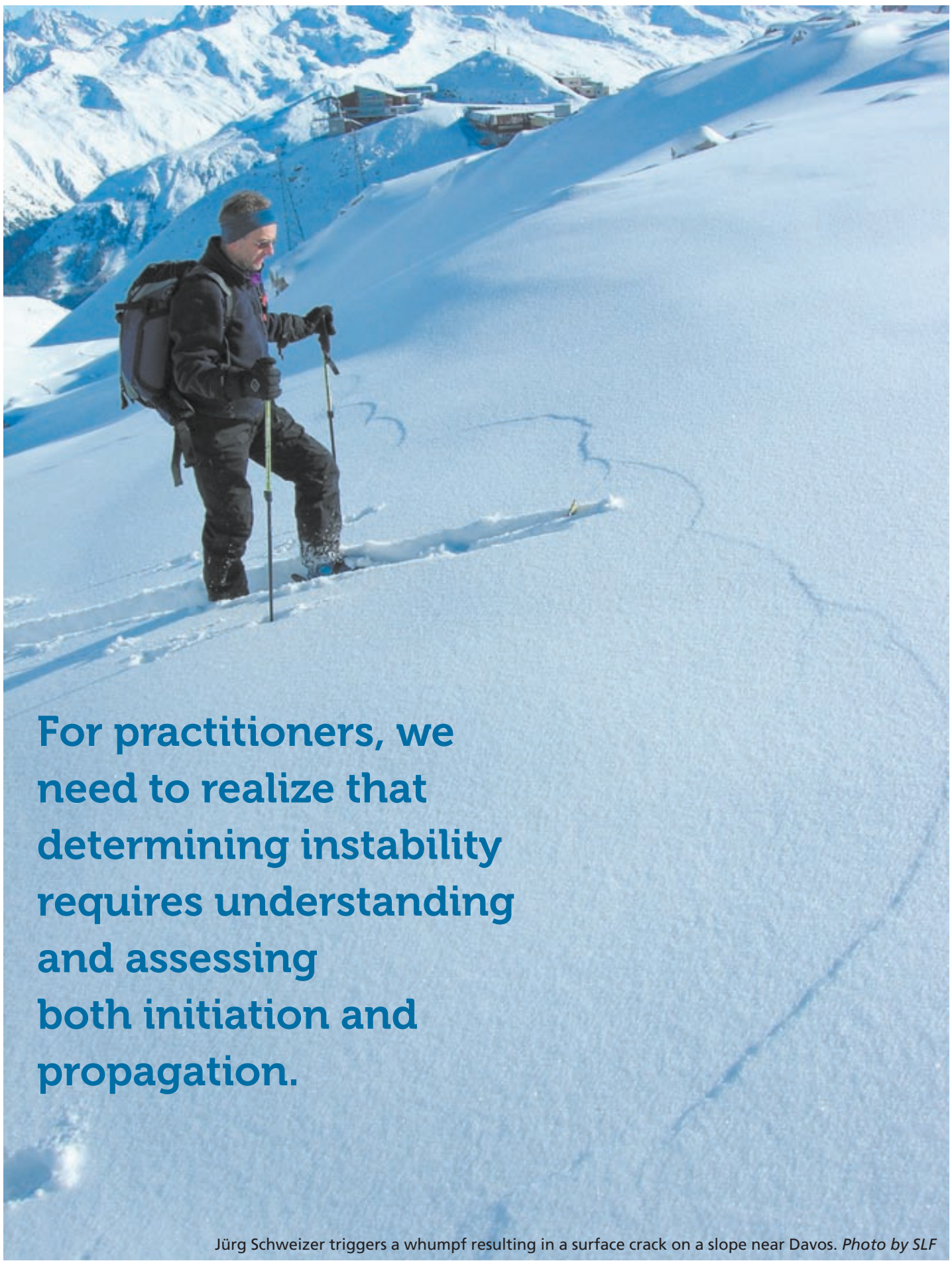
This most recent emphasis on fracture propagation began when researchers formalized what many practitioners had long observed about stability tests – that it is important to not only observe how much dynamic force (or load) it takes to fracture a weak layer, but also to look at how that fracture occurs. With rutschblocks this meant observing the type of release (whole block, part of the block, or the edge), as noted by Schweizer, et al., *(1995a)*.

A later survey of avalanche forecasters indicated they were typically more interested in the way a rutschblock fractured than in the actual rutschblock score *(Schweizer and Wiesinger, 2001)*. With compression tests and stuffblock tests, researchers began to look at shear quality *(Birkeland and Johnson, 1999; Johnson and Birkeland, 2002)* and fracture character *(van Herwijnen and Jamieson, 2002, 2004)*. Johnson and Birkeland *(2002)* hypothesized that shear quality might provide a qualitative measure (at a small scale) of how a fracture might propagate. Observing the way these tests fractured and whether fractures were "clean" or "sudden" had been done by practitioners for a long time, but research showed that taking this into account when interpreting stability tests could reduce the number of "false stables" or test results indicating stable conditions on slopes that showed other obvious signs of instability *(Johnson and Birkeland, 2002; Birkeland and Chabot, 2006; Schweizer et al., 2006)*.

New tests focusing specifically on fracture propagation expanded on observations of shear quality, fracture character, and rutschblock release type. Gauthier and Jamieson *(2006; 2008a)*, Sigrist *(2006)*, and Sigrist and Schweizer *(2007)* came up with a test that involved isolating a column parallel to the fall line of the slope, initiating a fracture with a saw, and observing whether or not the fracture then self-propagated through the rest of the column. This test was refined and eventually dubbed the Propagation Saw Test (PST). Simenhois and Birkeland *(2006)* simultaneously and independently worked on the Extended Column Test (ECT), in which a 90cm-wide cross-slope column is loaded on one side with loading steps identical to the compression test.

Both the PST and ECT quickly found their way into the toolboxes of many practitioners, with recent research showing the ECT to have a low false-stability rate and the PST to have a low false-instability rate. Since there are already several articles on both of these tests, we won't go into further details here *(in addition to the papers already cited, check out Birkeland and Simenhois, 2008; Gauthier and Jamieson, 2008b; Moner et al., 2008; Ross and Jamieson, 2008; Winkler and Schweizer, 2008)*. One advantage of the new tests is that we can now begin to investigate some of the factors affecting fracture propagation in the field, such as changes in slab depth *(Simenhois and Birkeland, 2008a)* or surface warming *(Simenhois and Birkeland, 2008b)*.

In addition to some of the new tests focused on fracture propagation, there has been renewed interest in the theory behind fracture propagation. Johnson et al., *(2004)* measured the speed of a propagating fracture across a flat meadow utilizing geophones, finding that the fracture traveled at 20 ± 2 m s-1. van Herwijnen and Jamieson *(2005)* measured fracture speeds with a high speed camera, calculating speeds between 17 and 26 m s-1. These fracture speed measurements helped to reignite a mostly dormant



For practitioners, we need to realize that determining instability requires understanding and assessing both initiation and propagation.

Jürg Schweizer triggers a whumpf resulting in a surface crack on a slope near Davos. *Photo by SLF*

debate about the relative importance of collapse in fracture propagation. The speeds are consistent with theory proposing collapse as a driving force of fracture propagation *(Johnson, 2001; van Herwijnen and Jamieson, 2005)*, though other work suggests they are also consistent with existing models of shear fracture propagation *(McClung, 2005)*. Gauthier and Jamieson *(2008a)* reported similar PST results on slopes as on adjacent flat terrain, an observation that supports the importance of collapse in driving fracture propagation.

High-speed videos show a variety of weak layers – including thin weak layers – collapsing and shearing, with none of them showing slope-parallel shear fracture without collapse *(Schweizer et al., 1995b; van Herwijnen and Jamieson, 2005; van Herwijnen et al., 2008)*.

Of course, the idea that collapse plays a role in fracture propagation is not new. After all, snow in general and weak layers in particular are highly porous, making collapse possible. Seligman *(1936)* noted that avalanches could be triggered from flat terrain, and Bader *(1951)* stated collapse as one of several methods for fracture under the slab. Bradley *(1968)* developed a field instrument and method for forecasting avalanches related to collapse in depth hoar snowpacks by calculating a bulk strength-to-load index. Lackinger *(1989)* described the bending wave due to a collapsing weak layer. Johnson *(2001)* wrote a simple equation for the bending wave and better described remote triggering from low-angle terrain. Heierli and colleagues *(Heierli, 2005; Heierli et al., 2008; Heierli and Zaiser, 2006; Heierli and Zaiser, 2008)* greatly improved the mathematical description for the collapse and bending wave and then combined this theory with shear-fracture theory.

In essence, this most recent work allows for both collapse and shear as potential driving forces behind fracture propagation *(Sigrist, 2006; Heierli et al., 2008)*. Fractures in thinner weak layers and on steeper slopes are predicted to be more dependent on shear, while fractures in thicker weak layers and on flatter terrain are more dependent on collapse.

On this part of a spring tour in the Rockies, Dave Gauthier (in background), Antonia Zeidler (foreground), and Bruce Jamieson were triggering whumpfs every few steps. *Photo by Bruce Jamieson*

What Does this Mean to Us?

While plenty of new information is available for pondering the theory behind fracture propagation, the big question is: "What are the implications for practitioners?" Before we address this question, we need to remember that the basic observations we have made for years are still valid. For example, practitioners have known of and observed avalanche triggering from flat terrain for many decades. Some of the new theory simply gives us a better mathematical description for that observation. Further, we have known – at least intuitively – that both fracture initiation and fracture propagation are necessary for avalanches.

The first implication for practitioners of some of the new work is that researchers and practitioners need to consider both the slab and the weak layer. Our emphasis in the past has been on fracture initiation, and we tended to focus primarily on the weak layer. This shifted as we came to better understand the role of the slab in initiation, and as we now start to gain knowledge of the role of the slab in propagation we are realizing that it is vitally important to look at both the slab and weak layer together to better understand avalanches. Practitioners should be sure to note the characteristics of when fractures are propagating and integrate this knowledge into stability assessments.

A second implication for practitioners is that we need to realize that determining instability requires understanding and assessing both initiation and propagation. Luckily, we now have – besides things like the rutschblock release type, fracture character, and shear quality – two tests (the PST and ECT) that give us a start at specifically indexing fracture propagation potential, thereby providing us with new methods for assessing snow stability. We also need to be better aware of how fracture-propagation propensity might vary spatially around starting zones. This is an open question, though some preliminary work has been done *(Birkeland and Simenhois, 2008; Hendrikx and Birkeland, 2008; Hendrikx et al., in press)*.

A third implication has to do with the location of our field tests. We don't know if fractures are occurring first in shear or in compression. However, it is clear that both shear and collapse are occurring in some sort of mixed mode and that collapse is an essential energy source for propagation in some cases. Thus, for collapsible weak layers, tests in flat areas or in areas with shallow slope angles might be useful for predicting conditions on nearby slopes, as long as the snow stratigraphy in those flat areas is representative of the slopes in question.

Indeed, a limited dataset shows this to be the case for the PST *(Gauthier and Jamieson, 2008a)*, and some limited and preliminary data from this season suggest that ECTs in flat terrain may provide useful information about the potential for remote triggering *(Simenhois, pers. comm., 2009)*. If these findings are confirmed, it would be extremely helpful for practitioners and recreationists since safe pit sites would be much easier to locate in the flats or at least on gentle slopes than on steep slopes during unstable conditions. Of course, some layers (such as poorly bonded crusts or weak interfaces) are much less collapsible. If they don't collapse – and so far, high-speed videos have not revealed any that don't have at least some collapse – then tests involving such weak interfaces will need to be conducted on slopes.

New Ways to Look at Snowpack

Recent research on fracture propagation and the development of tests attempting to index fracture-propagation propensity provide all of us with new tools and new ways to look at the snowpack.

It is important to remember that these new tools and insights don't replace our proven tools developed over the past several decades, but instead they simply add to our toolbox. Avalanche forecasting and stability assessment still require a holistic approach that takes into account diverse data including weather, avalanche, and snowpack observations. The key is to look into the snow, poke around, and do a variety of tests, while at the same time realizing that there is no ultimate test. Hopefully future research, combined with careful observations by practitioners, will continue to improve our understanding and our methods for evaluating slope stability.

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left: A 50lb shot released a good-sized slide just after Christmas. right: The snow shed in this photo gives a great perspective on how the West Riverside runs across Highway 550. When the snow hits that wall, it has nowhere to go except sidewise and usually fills the snow shed. After one shoot, CDOT workers had to clear 6' of debris out of the snow shed.

Photos by Jerry Roberts

RED MOUNTAIN PASS – CHIEF OURAY HIGHWAY: A History of Forecasting and Mitigation, Part 2

Story by Jerry Roberts

The East Riverside avalanche path has a long, sad history.

It is one of the larger paths on Highway 550, with approximately 80 acres of starting zone and 3250 vertical feet of drop. It consistently runs across the highway in its track and fills the narrow Uncompahgre Canyon with debris. There is no runout zone, only a vertical runup zone. It has killed seven people, miner Fritz being the first.

The next victims were a preacher and his two young daughters who were traveling from Montrose to Silverton for church on March 3, 1963. Their car became stuck in the single lane just cleared by a plow that was spotting not 30' away. The 20-ton plow was pushed backwards into another vehicle by the air blast of the East Riverside as it ran a second time, burying Reverend Hudson while he was putting on tire chains. His daughters were buried in the car. There was a 30' wall of snow where the highway had been. Hudson was found a week later 280' down the canyon. The car and one daughter were located two weeks later, 600' downstream from the main hit: the car hardly recognizable, a twisted, torn, and mangled hunk of steel. The second daughter was discovered almost three months later when she melted out of a rock crevice on the other side of the canyon in late May. (An added twist of fate: Mary Hudson, widow of the Reverend Marvin and mother of the two daughters, Amelia and Pauline, died on Monday, March 3, 2008, in Grand Junction – 45 years to the day after the tragic slide wiped out her family. She was 87-years old.)

Seven years later almost to the day, on March 1, 1970, rescuers were back in the gorge looking for Robert Miller's body. A Colorado Department of Transportation (CDOT) plow driver and father of seven, he was cleaning up 15' of debris from the Riverside hitting the road the day before. Miller was left clearing the road as the other crew members returned to Ouray for additional equipment when the path ran a second time and threw the D-7 down canyon 300', burying it beneath 7' of debris. Noel Peterson, head of the avalanche-control team, grabbed a tethered dog out of a backyard in Ouray to hopefully find Miller's scent, but without success. His body was found the next day 120' from his equipment.

Terry Kishbaugh, another CDOT employee, was buried and killed February 10, 1978, by the East Riverside. Terry was called out on his day off due to lousy road conditions during a big storm. The Riverside had run, and Terry had made a few passes through the debris. On his last pass it ran for the second time and blew his plow away, almost hitting a CDOT rig on the south side of the path that was spotting him. Blane Thomson stepped out of his truck and was hit by a second air blast that tore off his glasses and hard hat. "The snow drifted down around me, and I couldn't see a thing," he said. "It tears a guy up to lose a friend and fellow worker like that."

In the early 1980s, the Colorado state government gathered Swiss and Canadian engineers along with their own design engineers and Art Mears, local southwest Colorado avalanche consultant and civil engineer (no relation to Otto Mears), to discuss the possibility of building a snow shed below the East Riverside – a path that affects 1,100' of the road. Designs were drawn up and the shed was built in 1985. Initially the shed was a proposed 400' long, but was finished at 180'. There wasn't enough money to cover the entire length of the hazard, so it was placed to protect the area of highest impact and danger. Not everyone was happy about it, though the compromise was a big improvement over *no* protection. Many storms have occurred since the construction of the shed, and many tons of avalanche debris now hit the shed instead of the highway or passing vehicles.

Don't let the weak eat the strong

Early morning, March 4, 1992, I received a phone call from the Montrose dispatch asking me to report to the Ouray County Sheriff's office. I thought it was a joke. What had I done that night? Oh yeah, I'd gone to bed early, nothing to worry about…I finally got enough information from the dispatch informing me there were two plow drivers buried under the East Riverside!

A big storm was in progress and as the closed-low moved east of the San Juans it wrapped around on the north side of the range in its low pressure spin and had turned into a gorge storm when it stuffed the Uncompahgre Gorge with its energy. Three highway workers and one woman traveler were trapped in the snow shed for 12 hours. The storm had begun to move east; Silverton had started to get clear of the storm so CDOT supervisor Gary King and San Juan County Sheriff Greg Leithhauser were joined by several volunteers who plowed their way to almost the south end of the shed from RMP. Everyone in the shed was taken back to the safety of Silverton by mid-day.

Everyone, that is, but the two plow drivers, Eddie Imel and Danny Jaramillo. Danny had thrown a chain just on the north side of the shed under what is called East Riverside Left or North. It's not the main path, but that didn't matter when the path released, burying Danny, Eddie (who was helping replace the chain), and the plow. It was an ugly scene. The rescuers had to make a decision. There's a saying in the mountains, "Don't let the weak eat the strong." It may sound grim, but there is good reasoning behind it. Don't sacrifice the living for those that may already be dead. Not a comforting thought and made more poignant as Gary King and Eddie were childhood buddies and best friends.

Miraculously, in what the Montrose radio dispatcher thought was a cruel joke, a call was received from a man who claimed to be Danny Jarmillo asking to get picked up in the snow shed and for a pack of smokes. He had survived after 18 hours of a live burial under his truck. He had dug himself out and made it back to the shed and the emergency phone! Sadly, Eddie died of hypothermia after Danny did his best to keep him alive.

Fate, synchronicity, cruel coincidence? Three of the accidents happened in early March and on the second running of the path.

Call in the Cavalry

The citizens of Ouray and San Juan counties had seen enough. Public meetings were called with CDOT and other state officials to express outrage. The people were tired of losing their men. Ideas and emotions ran to the extremes. Some ideas were reasonable and some were not. Snowsheds from Ouray to Durango were

In this photo of the 1992 slide, the exhaust stack of one of the buried trucks is visible – still running after 24 hours. Danny and Eddie were trapped underneath it for 18 hours, but the rescue crew came in from the south, where they couldn't even see the road. Because of high-hazard conditions, the rescue focused on the live victims trapped in the snow shed, unaware that the two men were still alive under their truck. *Photo by Mike Friedman*

In 1992, three highway workers and a woman traveler were trapped by a slide on Hwy 550. Two were trapped inside the filled East Riverside snow shed, but two plow drivers were caught outside on the road After 18 hours of burial under his truck (right), Danny Jarmillo managed to dig himself out, but his partner, Eddie Imel, died of hypothermia. *Right photo by Noel Peterson*

suggested. Of course that would never happen because of the great expense.

Knox Williams of the Colorado Avalanche Information Center (CAIC) was at the Ouray meeting along with many other avalanche professionals, and a deal was proposed between CAIC and CDOT to forecast the state and federal mountain highways and passes. The following winter, 1992/93, highway avalanche forecasters were hired for a pilot program to observe and forecast the Highway 550 corridor (Red Mt Pass, Molas/Coal Bank Passes). The following season more forecasters were hired throughout the state to forecast the hazards and help mitigate the avalanche paths threatening the highways of Colorado.

The forecasters who were hired to forecast and help mitigate Hwy 550 by the CAIC for CDOT were a roguish bunch, as different from one another as yin and yang, but all pursued the same goal: the safety of the highway and its users from hostile weather and avalanches that buried the road. The following is a list of names and dates of forecasters who worked or are still on the job, all of whom are AAA professional members.

- Don Bachman ... 1992/93 through 1994/95 season
- Denny Hogan.... 1992/93 through 199/97 season
- Andy Gleason ... 1995/96 through 2003/04 season
- Doug Lewis..... 1997/98 through February, 2000 season
- Jerry Roberts..... 1999/00 and still present
- Mark Rikkers..... 2004/05 through 2005/06 season
- Susan Hale..... 2006/07 and counting

There is a great deal of work and responsibility for the highway men and woman observing and forecasting for the state and federal highways who mix it up with avalanches six months of the year and are paid to worry full time.

The use of computers brought the forecast program into the twentieth century allowing forecasters to access the internet. Weather maps, radar, and satellite photo loops (both infrared and visible) have made the job of avalanche forecasting easier and more relevant. A variety of computer-generated weather models along with real-time data have enabled them to forecast weather conditions and follow storms into the region, to make educated decisions and appropriate responses to the changes. The National Weather Service (NWS) in Grand Junction, Colorado, and CAIC forecasters in Boulder, Colorado, provide vital information. Avalanche forecasters communicate with the NWS any time, day or night, talking with a meteorologist on duty for the latest information and opinions. The experienced voice on the other end of the line is always very helpful and comforting.

Remote weather stations have also become an important part of the forecast program. Every fall, four Campbell weather instruments that record temperature, relative humidity, wind speed/direction, and in some cases depth of snow are flown out to various peaks along the Hwy 550 corridor by helicopter and set up by the RMP forecasters. The stations record real-time weather information and transmit to the office computers for monitoring. Hourly averages from the weather stations are available to the public through the CAIC Web site and the Grandnet Web site: www.avalanche.org/~wxstns/grandnet/. The Hwy 550 sites are Mt. Abrams, Eagle, Kendall Mtn, and Molas Pass.

Dodging the bullets

Since the CAIC began working with CDOT 16 years ago, forecasting weather and avalanche hazards and helping mitigate the beasts, the program has been successful by all accounts. There has not been an avalanche accident in the San Juans since the program began in 1992, but avalanches do hit the road with over 100 paths that can potentially hit Highway 550 from Coal Bank Pass north of Durango to Ouray, it seems to be a matter time until we have another incident with traffic volume (Avalanche Hazard Index) on the increase. The law of averages eventually catch up. Ducking the statistics over time, the last decimal points usually come into play. All of the deaths enlarged our knowledge of the avalanche hazard on the highway and initiated the forecasting program, yet did not guarantee a future without tragedy. Even if we understand situations as well as we sometimes think we do, and even if we choose the best response to a situation, even then, nothing is certain. It is totally unrealistic to believe you can get it right all the time. There is no magic elixir. Ask any highway forecaster.

The winter of 2007/08 we had a fair amount of snow; it was a short but intense four-month season. From December through March, RMP was closed for over 15 days due to High avalanche hazard, mitigation, and the struggle to regain the road. There were 111 natural avalanches that hit the road, were 1' to 30' deep, and covered 7401' of highway. We triggered 178 slides that put debris 1' to 16' deep covering 11,777' of road. These numbers (19,474' of road covered) point to big storms with large natural avalanche cycles that forced us to shut the road for long periods of time. The numbers also show our mitigated slides were numerous but smaller with shallower debris piles covering more than two miles of road.

Mike Friedman, former Telluride HeliTrax owner and snow safety consultant, said to me, "It's hardly a no-brainer to shut the gates when impending doom is knocking at the door." I agreed. Closing the road is the last and best option for protecting the public when conditions are unmanageable and a means of avoiding catastrophe.

Continued next page ➡

Winter 2007/08 closed Highway 550 for over 15 days, with 111 natural avalanches and 178 triggered slides that covered 19,474' of roadway. *Photos by Mark Rikkers (left) and Jerry Roberts (right).*

SAN JUAN HISTORY

continued from previous page

A world of uncertainties

Friedman asked what kept my interest in the job. Probably a few things. The winding asphalt ribbon of Highway 550 draws you in with its beauty and diversity of topography, altitudes changes, and the resulting storm conditions. The road climbs out of the sub-alpine zone of Ouray at about 7811' and crests in the alpine on the top of Red at 11,075', then drops into Silverton at 9,305', and climbs again to Molas/Coal Bank at 10,400', dropping quickly into the high desert of Durango. But more importantly, the people I work with are the biggest bonus by far. The real road warriors like Noel Peterson, Ted Vickers, Gary King, Greg Roth, and Dennis McCoy, to name just a few, have made the job very interesting and enjoyable. On each shoot, the protocol has always been safety-first followed with camaraderie and enjoyment. The history and myth of the "old-timers" are a constant source of entertainment and learning. Noel Peterson told me with a smile that the CDOT slogan was always, "Never let the truth get in the way of a good story." Some fine memories and tall tales have come from the CDOT crews.

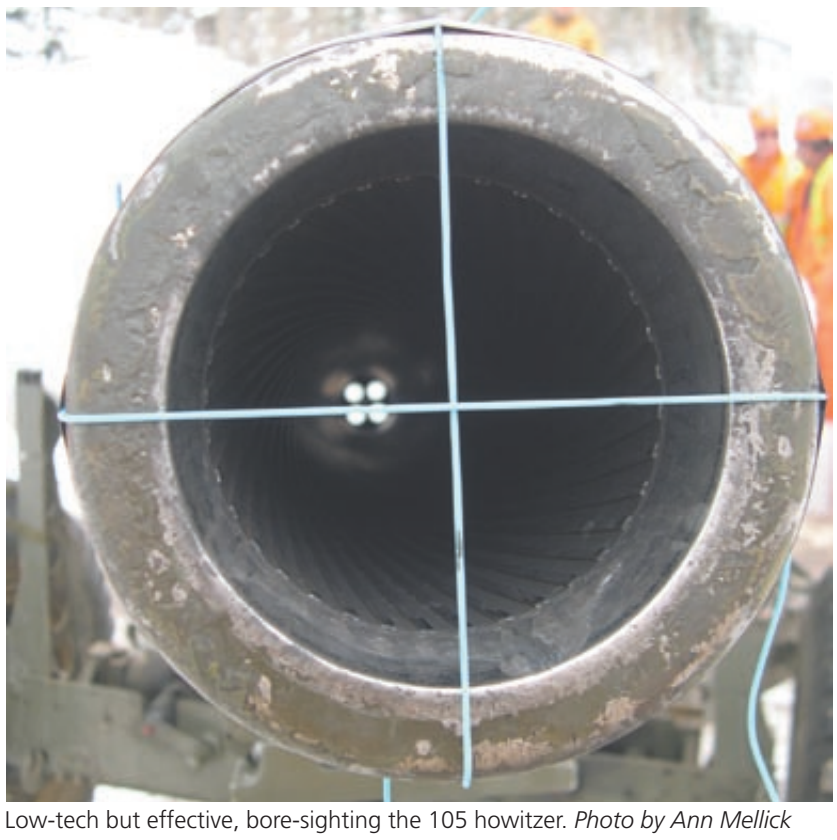
At times you can feel pretty isolated on the high wire, an elevated and risky autonomy. Pressure builds with a big storm, anticipating the paths that will probably hit the road because you've seen the movie before. It's anybody's guess why forecasters do this job. It could be the smell of powder, throwing 50 pound shots from the helicopter, watching hard slab failure release energy over several alpine basins at once, or maybe just the company you keep.

Whatever the reasons, you get hooked on the excitement and the challenges of the job. It requires a lot of field experience (series of non-fatal errors), collection of empirical evidence, listening to your inner voice (intuition), and distilling all of the variables to reduce uncertainties until you can finally make a decision that you can live with. There are many truths to be learned. It's no big mystery; you pay attention and do your work because you don't want to be a victim of your own bad planning. It helps to be comfortable in the world of uncertainties.

My involvement with the Eddie Imel/Danny Jaramillo tragedy hit me with some harsh realities. A friend of mine calls Red Mountain Pass, "The Living Highway," and I finally realized how accurate his description was. Merely driving the road in winter is a challenge. Add storms, avalanches, rock/ice fall, and night driving to the equation, and it adds up quickly to a difficult and potentially hazardous journey. On a good day there are risks and a bad day can be adventurous.

Jerry Roberts prowls Red Mountain Pass, where he tracks the cast of usual suspects above and below the snow surface. See TAR 27/3 for Part 1 of Jerry Roberts' avalanche history of the San Juan mountains.

Batman had the bat phone for crime fighting, but Jerry has the duck phone for avalanche fighting.



Low-tech but effective, bore-sighting the 105 howitzer. *Photo by Ann Mellick*

Two bikers negotiate through Telescope slide debris that ran naturally. *Photo by Andy Gleason*

A crack following a whumpf on a slope in southwest Montana. *Photo by Karl Birkeland*

FRACTURE PROPENSITY

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Karl Birkeland *(center) is an avalanche scientist with the USDA Forest Service National Avalanche Center in Bozeman, Montana. Between snowpits he is always hoping to take a few powder turns, and he especially likes chasing his daughters around Bridger Bowl in the winter.*

Jürg Schweizer *(right) is a senior research scientist and head of the Avalanche Formation group at SLF Davos, Switzerland. He continues to be a great fan of the grandfather of most snowpack tests: the rutschblock. However, he has to admit that the snow saw has become his favorite tool for playing in the snow.*

Bruce Jamieson *(left) holds the NSERC Research Chair in Snow Avalanche Risk Control at University of Calgary, and supervises the ASARC field program. He is rather fond of digging square holes in the snow and watching how snow fractures.*