A Publication of the American Avalanche Association

THE Avalanche REVIEW

US $4.95

VOLUME 23, NO.4 • APRIL 2005

Web site: www.AmericanAvalancheAssociation.org

Seven avalanches remotely triggered from the point the photo was taken, approximately 70m from the base of the slope. Fracture layer was a facet/crust layer buried 25-30cm deep. See *Conspiracy Theory* on page 17 for the full story. *Photo by Chris Lundy*

in this issue

When I reached CJ's skis, I could see him lying head first, face down, pinned by the heavy snow covering much of his body, his pack, and his skis. He said, "Hey, buddy."

Observations on Faceted Crusts pg 16

"It is rarely possible to have all the information necessary to determine whether a slope will or will not avalanche. Avalanche forecasting is not a mystery, but it is an imperfect science. The human mind has a limited capacity to comprehend the complexity of the natural world, and avalanches are certainly complex. Humility and patience are very important to understanding the avalanche phenomena. It takes years to see all the different snowpack combinations that cause avalanches, and we are presumptuous to believe we understand them even after years of observation.

It is, however, possible to determine patterns and trends that tell us when certain kinds of slopes may be likely to avalanche. It is possible to perceive clues to existing instability. Developing our senses to perceive these patterns and clues is a gradual process and one that is never complete."

—Brad Meiklejohn, UAC forecaster
Forest Service Utah Avalanche Center Avalanche Accident Report
February 12, 1992, Talking Mountain Cirque, La Sal Mountains, San Juan County, Utah

THE Avalanche REVIEW

APRIL 2005 • VOL. 23 • NUMBER 4

The Avalanche Review is published each fall through spring by the American Avalanche Association, Inc., a non-profit corporation. The Avalanche Review welcomes the submission of articles, photographs and illustrations.

Please send submissions to:
Blase Reardon — Co-Editor
636 Columbia Avenue
Whitefish, Montana 59937
tel: (406) 862-0812
work: (406) 888-7926
blase_reardon@usgs.gov
blase@cyberport.net

Lynne Wolfe — Co-Editor
PO Box 1135
Driggs, Idaho 83422
tel: (208) 709-4073
lwolfe@tetontel.com

Advertising:
Marcia LeMire
P.O. Box 1400
Jackson, WY 83001
tel: (208) 787-2223
fax: (307) 733-5916
mlemire@tetontel.com

Production:
Fall Line Design
370 N 110 E
Driggs, ID 83422
tel: (208) 354-6500
fax: (208) 354-2213
karen@FallLineDesign.com

Business and Subscription Office:
Mark Mueller — AAA Executive Director
P.O.Box 2831
Pagosa Springs, CO 81147
tel: (970) 946-0822
fax: (970) 731-2486
aaa@avalanche.org

american avalanche association

The mission of the AAA is:

A. To provide information about snow and avalanches;
B. To represent the professional interests of the United States avalanche community;
C. To contribute toward high standards of professional competence and ethics for persons engaged in avalanche activities;
D. To exchange technical information and maintain communications among persons engaged in avalanche activities;
E. To promote and act as a resource base for public awareness programs about avalanche hazards and safety measures;
F. To promote research and development in avalanche safety.

Subscription: $20 per year (4 issues). Subscription is included with membership dues to AAA. For subscription and membership information, see **www.AmericanAvalancheAssociation.org**.

Contributions: Please submit material eight weeks prior to publication date. Include address and telephone number. Please submit typed manuscripts by e-mail or disk (3.5", Zip or CD), using any popular word processing program. Submit any figures in B & W, or as a TIFF or JPG file (300 dpi resolution at 100%). We will return materials if you include a stamped, self-addressed envelope.

Articles, including editorials, appearing in ***The Avalanche Review*** reflect the individual views of the authors and not the official points of view adopted by AAA or the organizations with which the authors are affiliated unless otherwise stated.

Layout & Design: Karen Russell, Fall Line Design, (208) 354-6500, karen@FallLineDesign.com.

from the editor

ABOUT 15 YEARS AGO I skinned to the top of Days Fork from Alta with a Little Cottonwood highway forecaster and a snow ranger. It was one of my first tours. I had talked my way into tagging along despite my inexperience and was excited for the chance to learn from experts.

Somewhere on the ridgeline, one of the forecasters stepped out on a cornice hanging over the Days Fork side and jumped a few times. Nothing happened. He skied off down the ridge towards Two Dog Chute. The snow ranger slid out on the cornice a little further, jumped a few times, and again nothing happened. He skied off after the forecaster. Figuring that's what experts did, I worked out on the cornice just past the snow ranger's tracks, and jumped. My skis hit the hard snow with a solid thud. I jumped again. When I came down, I didn't stop. The cornice softly, quietly collapsed as my skis touched the snow, and I kept falling. It had a down-the-rabbit-hole-and-into-Wonderland quality.

I fell a body length or more but landed upright on my skis. The slope below the cornice fractured and slid, and I watched trees whipping and shaking as the snow hit them on its rush hundreds of feet down the slope. It was the first avalanche I'd ever seen, and it was something.

Then I heard the forecaster yelling at me, anxious and a little cross, "Where's Dave? Where's Dave?" I looked up and saw the forecaster a hundred feet or more away, at the edge of the broken cornice. The snow ranger – Dave – was actually just below him, wordlessly getting to his feet and brushing the snow off after his surprise fall – with his back to me, he'd never seen the cornice zipper towards him. It seemed like I'd done something wrong, but dropping the cornice was the idea, right? It was all very confusing – and thrilling.

There are plenty of lessons to be learned in that incident. Lately, though, it strikes me that the incident illustrates the fuzzy line that separates good learning from disaster when it comes to avalanches. I've been thinking about the tremendous value of mentors in helping learners – and I am both these days – recognize that line, as well as translate the sometimes murky lessons found there.

The editor in his day job. *Photo by Heath Korvola*

I'VE EDITED *The Avalanche Review* in some capacity – assistant editor, editor, co-editor – for the past five years. My aim has been to provide articles that, like good mentors, highlight that line and its lessons for avalanche professionals. I've looked for articles that encourage us to learn, that spark insights or challenge our existing notions. TAR can provide a regular forum for the merging of theory and practice, a venue for professionals to share their experiences, observations, and hypotheses, and to do so immediately and relatively informally. It's a place where hunches and garage science can exist side-by-side with statistics and formal research. That's a vision I inherited from my predecessors – Faerthen Felix, Steve Conger, Bruce Tremper, and Sue Ferguson – and one I hope outlasts my tenure.

TAR has grown a lot in those five years. It's now 20 pages, four times a year. We're able to group articles into themes. It comes out on time, if not early. And next season, much of it will be in color. I think it reflects the growing professionalism of our field. It's what I envisioned – dimly, at first – and have been working towards – clumsily, at times – for the past five years.

This issue is, however, my last as editor. It's time for me to focus on other goals, professional and personal. Those goals demand the time I have devoted to TAR, so it is time to move on. Contingent on the approval of the Governing Board at the Spring meeting, I will assume the duties of the Publications Committee Chair from Steve Conger, which will allow me to continue supporting the publication. Steve will step down after 11 years of dedicated service as Editor or Publication Committee Chair. Lynne Wolfe becomes the new editor, and is looking for an assistant. See the ad at the bottom of the next page (pg 3). I highly recommend applying; it's a tremendous experience.

When I was first asked to be assistant editor, I felt like the tag-along kid, just like I did on that tour to Days Fork Ridge. In the five years since, I've had a rare and wonderful opportunity to work with – and learn from – avalanche researchers and ski patrollers and forecasters all over the country and indeed from all over the world. Most of them have shown themselves to be not only accomplished professionals, but remarkable people. Many of them have become friends. That interaction is what I will miss most.

I will also miss the collaboration with Lynne Wolfe, Karen Russell, and Marcia LeMire. It's hard to move on because editing TAR now is more fun and rewarding than it's ever been. Lynne made the mistake of volunteering to be assistant editor at the Penticton ISSW – a loose tongue from the beer, I think. Yet she brings a wealth of experience and talents to the publication. Collaborating with Lynne over the past two seasons has been full of surprises and insights, and the publication will reflect that through her tenure.

I urge those of you who have contributed over the past five years to continue to do so. And I encourage those of you who haven't to give it a try. The avalanche community is rich with hard-won lessons, and sharing those things can be remarkably powerful. I suspect many of us feel like a tag-along kid when we compare ourselves to our peers. But all of us have earned knowledge that can help someone translate a confusing experience into good learning, or mark the line between learning and accident before it is crossed.

—Thanks for the support, blase reardon

The Avalanche Review: A Call for Submissions

- Seen any good avalanches lately?
- Got some gossip for the other snow nerds?
- Developing new tools or ideas?
- Learn something from an accident investigation?
- Send photos of a crown, of avalanche workers plowing roads, throwing bombs, teaching classes, or digging holes in the snow.
- Pass on some industry news.
- Tell us about a particularly tricky spot of terrain.

Write it up; send it to us. *The Avalanche Review* is accepting articles, stories, queries, papers, photos.

Submission Deadlines
Vol. 24, Issue 1 ... 07/15/05
Vol. 24, Issue 2 ... 10/15/05
Vol. 24, Issue 3 ... 12/15/05
Vol. 24, Issue 4 ... 02/15/06

The Avalanche Review
Lynne Wolfe, co-editor
PO Box 1135
Driggs, ID 83422
lwolfe@tetontel.com
(208) 709-4073

from the aaa

Sitting here at the computer, one storm's just ended and another is on the way. It's been very snowy in southwest Colorado this winter. It started about average, but a series of three storms from late December to mid-January pushed us over the top. We picked up about 40% of our seasonal average in two intense weeks. Wolf Creek Pass is known for having the most snow in Colorado, though when the flow is out of the northwest, Steamboat will take the honors. Persistent southwest flow this winter has kept the snowpack deep, if not always dry. For those of you a little snow-starved this winter, please bear with me. It was only several years ago that we experienced what some folks said was the driest winter in over 100 years. Your time will come.

As a snow person, I want to be around when the big winter hits. I think we all do. Will this be one? You'll be reading this in April, and by then we'll know. But right now, in the middle of February with six or seven weeks still to go, it's kind of hard to tell. The big winter is what we feed on. Folks say to me, "Well, you're earning your money now." I used to reply that they pay me for when it is boring and isn't snowing, but after a couple of 70-hour weeks, that doesn't ring so true. Unlike the ski area where I spent the first 16 years of my career, the highway is a 24-hour operation. Despite all the fatigue and stress, the challenge is invigorating.

How likely are we in our careers to experience those truly unique events? While paging through Art Mears' *Snow-Avalanche Hazard Analysis for Land-Use Planning and Engineering* (a little light reading), I came across a great chart on page 19 which is titled *Avalanche Encounter Probabilities*. I can look at the chart and compare my 15 years at Squaw Valley in the Sierra and my 13 years here at Wolf Creek Pass in the east San Juans of Colorado and judge my chances of seeing or having seen the 10-year, 30-year, or 100-year avalanche. For example, in 10 years I would have only a 29% chance of seeing a 30-year event. We are just about to the 50th anniversary of the extraordinary avalanche cycle of January 1957 at Wolf Creek. Nothing else we have on record even comes close to that cycle. See the June 2003 issue of *The Avalanche Review* (vol. 21, no. 4) for more on that. At Squaw, I had the good fortune to experience the big avalanche cycles of January 1982, March 1982, and February 1986. Nothing had really come close since arriving at Wolf Creek in the fall of 1992, until this past January. Anyone interested in Art's publication can pick it up through the Colorado Avalanche Information Center's Web site.

I hope that this year is the "big one." With 28 years in the business I may have more storms and winters behind me than ahead of me. There will be a lot of satisfaction sipping a Beck's on the deck someday knowing, "I was there, back in the day when it knew how to really snow." Whatever happens, that beer will still taste pretty good.

Your Association is going strong. The sales of *Snow, Weather, and Avalanche Observation Guidelines* (known as SWAG) have been very strong. We are more than halfway through our second printing and will be ordering a larger third printing this summer. Around 1,000 copies are out there in circulation. This successful project is something we can all be proud of.

Another thing I think we can all be proud of is *The Avalanche Review*. Our editors Blase Reardon and Lynne Wolfe, along with our designer Karen Russell, have done an outstanding job with TAR. But remember it takes material from contributors so that Blase, Lynne, and Karen have something to work with. Thanks to all the contributors this year.

The spring board meeting is scheduled for 8:30 a.m., Saturday, April 16, at Our Lady of the Snows in Alta, Utah. The AAA Annual Meeting and Professional Development Seminar is tentatively set for the weekend of September 17, 2005, at Bridger Bowl, Montana. Details will be provided in the AAA summer mailing that you should receive in late July or early August (that seems like a long way off right now). I hope you have all had a safe and successful winter, and I wish the same to those residing in or heading to the southern hemisphere.

—Your executive director, Mark Mueller

metamorphism

Dean Cardinale, a patroller at Snowbird Ski and Summer Resort is the latest AAA Certified Instructor.

HELP WANTED

Assistant Editor, *The Avalanche Review*

REQUIREMENTS:
- sense of humor and infinite patience
- a fine-tuned understanding and implementation of proper grammar and usage of the English language
- ability to communicate with a diversity of avalanche professionals and advertisers
- ability to edit, improve, and condense the writing of the above avalanche professionals
- computer and e-mail fluent, with a working knowledge of Word and "track changes"
- current involvement in the avalanche world that translates into ability to build issue themes, solicit articles, and guide content of articles
- ability to work remotely and independently with senior editor, AAA board, and layout artist
- to have the well-being & quality of this publication be one of your primary loyalties

COMPENSATION: $50 per page per issue of *The Avalanche Review* is divided between editors according to editing duties and other tasks.

APPLICATION SHOULD CONTAIN:
- Letter of intent
- Samples of writing and editing work
- Avalanche-related resume and two references

APPLICATION DEADLINE: May 1, 2005

SEND CORRESPONDENCE TO:
Lynne Wolfe lwolfe@tetontel.com
PO Box 1135, Driggs, ID 83422

Interviews will be conducted after May 1 via phone or in person. Selection to be completed by June 15.

what's new

BCA Opens Beacon Training Park for Snowmobilers

Practicing at Uintah Beacon Basin. *Photo by Jim Conway*

In January, Backcountry Access (BCA), in conjunction with Utah State Parks, the Utah Avalanche Center and the Utah Snowmobile Association, opened an avalanche beacon training site in Utah's Uintah Range. It is the first beacon training site in the world designed and installed specifically for snowmobilers. Backcountry Access has installed 20 similar sites across North America and ten in Europe primarily for skiers and snowboarders.

The site is located at the Nobletts Trailhead seven miles east of Woodland, Utah. It allows backcountry users to practice their avalanche beacon skills by locating simulated avalanche victims. It features 11 permanently buried transmitters connected to a central control panel and power source. The transmitters can be turned on an off remotely, eliminating the time-consuming process of burying and excavating beacons between searches.

The facility is free and open to all backcountry users. For more information, contact Craig Gordon at the Utah Avalanche Center, (801) 231-2170 or see www.utahavalanchecenter.com. ❄

Ortovox Announces New Beacon

Ortovox has introduced a new beacon, the S-1. The S-1 relies on "sensor-control and signal analysis" that can scan an avalanche area, isolate signals, and indicate the number of buried beacons and their direction and distance relative to the searcher. Ortovox claims the new beacon will indicate the depth of burial at the burial point and can identify up to five buried victims within a 60m radius. The beacon features an oversized, illuminated display, an electronic compass, temperature sensor, and inclinometer. It automatically reverts back to transmit mode from its other operating modes. For more information, contact Marcus Peterson of Ortovox USA at ortovoxusa@aol.com or 603-746-3176. ❄

The Avalanche Review Available Online

Recent issues of *The Avalanche Review* are available online at the publications page of the American Avalanche Association Web site, www.americanavalancheassociation.org/publications.html. Currently, issues 22/3 (March, 2004), 22/4 (May 2004), 23/1 (Sept. 2004) and 23/2 (Dec. 2004) are available as pdf files viewable with Adobe's Acrobat browser. Additional back issues will be posted over the summer. ❄

Second Call for Comments: International Classification for Seasonal Snow on the Ground

In 2003, the International Commission on Snow and Ice (ICSI) formed a Working Group to revise the International Classification for Seasonal Snow on the Ground (Colbeck and others, 1990). The primary goals of this Working Group are:

- to revise and adapt the 1990 classification to actual state-of-the-art, not including either perennial snow (firn) or snow in the atmosphere
- to promote an even more widely used and accepted snow classification, including efforts in translating the classification into languages that are not currently available

While keeping in mind the main objective of the former classifications, i.e., to:

"… set up a classification as the basic framework which may be expanded or contracted to suit the needs of any particular group ranging from scientists to skiers. It has also to be arranged so that many of the observations may be made either with the aid of simple instruments or, alternatively, by visual methods. Since the two methods are basically parallel, measurements and visual observations may be combined in various ways to obtain the degree of precision required in any particular class of work…"

The Working Group is soliciting comments from both the scientific and field practitioner communities. Comments regarding the classification of wet snow and crusts are of specific interest, but comments regarding all aspects of the classification are welcome. Let us know how the classification works and does not work for your particular application.

The Working Group will meet next in late April 2005 at the European Geophysical Union (EGU) annual meeting, and hopes to published a revised version of the classification in 2007. Comments can be submitted to Charles Fierz, Working Group Chair (fierz@slf.ch), Dave McClung, Co-Chair (mcclung@geog.ubc.ca), or Ethan Greene, Field Practitioner Representative (greene@cnr.colostate.edu). ❄

Explosives Update

Story by Bill Williamson

I'd like to give a short update on some of this year's developments in the avalanche-control explosive-users world. In January, the Explosives Committee of the National Ski Areas Association (NSAA) met at Snowbird and discussed several topics. However, the major event of the meeting was Larry Heywood handing the Chair position over to Corky Ward from Jackson Hole.

Larry resigned from Alpine Meadows last spring and is concentrating on his "Snow and Ski Safety" consulting business. Heywood has been chairman of the committee since it was conceived as an "information tree" for explosive users throughout the avalanche-control and ski industries. Shortly after the first meeting, the unfortunate Montana incident occurred, and the sights of the newly formed committee were set on the long and arduous task of creating guidelines for the 50+ areas that use explosives in the West. Larry diplomatically led the group to the project's successful completion a year and a half later. Since then, Larry has been the primary spokesperson for the Ski Industry Avalanche Explosive Users and has helped legitimize our work in the mainstream explosives world. He has spent tremendous amounts of time towards this goal and deserves the sincere appreciations of all those using explosives for avalanche-control work. Thank you, Larry. Larry did make it very clear on several occasions that he is available for consulting and can give advise on anything (yes, anything).

Concern over faulty product is always discussed at these meetings, but everyone attending seemed happy with their suppliers and product. Those using CIL-Orion's products had nothing but praise for the pre-made cap and fuse assemblies. The other main topic at the committee meeting was education: specifically, the year-old *Avalanche Blasting Resource Guide* distributed by NSAA. About 25 copies of the PowerPoint presentations have been sold, and those present who were using it had a variety of comments about how effective it was. The unanimous opinion was that, when adapted to the user's program, it was a strong training tool, especially for entry-level patrollers.

There was also discussion about regional issues. Colorado users are working with the state to tweak their regulations and to add a portion requiring a designated amount of training and education. In California, due to some changes and different interpretations in the CAL/OSHA Explosive Orders, control programs are either making some relatively large changes or are working on the very edge of being compliant. Cal users have had a couple of meetings and are looking at lobbying to have the orders changed. The discussion participants even went so far as to consider asking the "Govinator" to step in.

If anyone has any issues or questions, please feel free to contact me or Corky Ward at Jackson.

Bill Williamson is Chairman of the AAA Ski Area Committee and Resort Operations Director for the Sugar Bowl Corporation. Contact him at 530-426-9000, bwilliamson@sugarbowl.com Contact Corky Ward at 307-739-2621, corkyw@jacksonhole.com ❄

aaa news

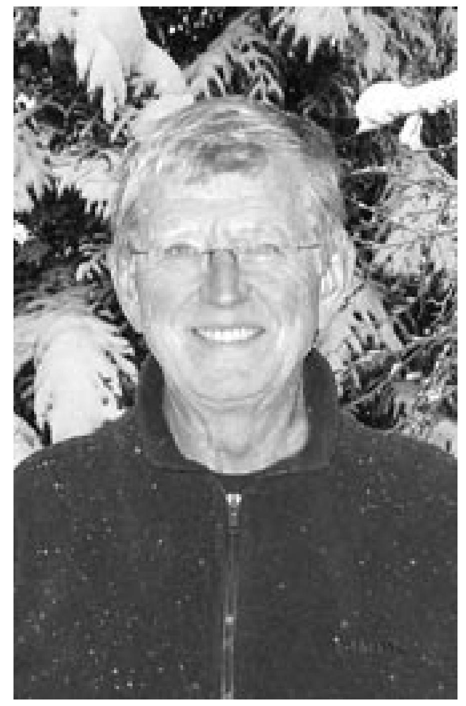
Simms Receives Special Service Award

The American Avalanche Association recently bestowed the 2004 Special Service Award to John Simms. This award is in recognition of "specific and outstanding achievement in service of North American snow avalanche activity" through the development and production of avalanche rescue and snow-research tools in the mid-1970s. These products were to revolutionize ski area and backcountry snow-safety procedures and, to this day, are utilized by snow-safety workers, backcountry skiers, and search and rescue personnel.

John Simms started his avalanche career at Arapaho Basin, Colorado, on November 24, 1961 – coincidental with a frantic, but futile, avalanche rescue effort on the infamous Palivacinni slide path. Later that winter, John, as Arapaho Basin Patrol Director, attended the U.S. Forest Service avalanche school at Berthoud Pass to learn from the masters of the time: Stillman, Atwater, and LaChapelle. In 1964, John left Arapaho for Vail and subsequently moved to Jackson in 1966 to work with the eventual legends Rod Newcomb and Juris Krissjanson. John soon became assistant Snow Ranger to Gary Poulson and spent the better part of a decade standing alongside the 75mm recoilless rifle at Tower 3 for about 2,500-rounds-worth of avalanche control that resulted in big slides and diminished hearing.

During this period, John initiated procedures and developed tools to simplify evaluation and forecasting techniques. This included a snow-sampling tube and scale which read directly in the standard density unit of grams per cubic meter. This sampling tool and procedure is now SOP for most ski areas and forecasting centers in North America. As backcountry skiing use exploded in the late '70s, so did the numbers of avalanche incidents and fatalities. John saw the need for compatible rescue tools and developed a fitting that allowed two ski poles to be linked together for use as a probe pole, thus Life-Link™ was born. Concurrently a lightweight, collapsible rescue shovel was designed and molded out of Lexan polycarbonate. John's product testing was practical and to the point. On a -30°F Jackson Hole morning, John drove his large, heavy van over the first sample shovel blade from the molder, stopping so that a front wheel of the van came to rest on top of the downward-turned blade. When the blade held, John reasoned it was strong enough to use for avalanche rescue work. The combination of probe and shovel is now essential backcountry and snow-safety equipment for tens of thousands of users throughout the world. The development of these tools and products spawned Life-Link International of Jackson, Wyoming.

John's pioneering contributions to snow avalanche rescue procedure and operational avalanche forecasting is acknowledged not only by the Special Service Award, but through the gratifying reports of lives saved through the use of equipment John designed and distributed. ❄



John Simms received the Special Service Award at the 2004 ISSW held this fall in Jackson Hole, Wyoming.

The Early Snow Rangers at the Jackson Hole Ski Area—

Special Recognition by Rod Newcomb

GARY POULSON

Avalanche Hazard Forecaster, Jackson Hole Ski Area, l97l-85

Having come from Alta, Utah, as a ski patroller and a USFS avalanche hazard forecaster to patrol at Jackson Hole in l966, Gary was familiar with avalanches in the Intermountain West. In the summer of l97l, he became the Forest Service Avalanche Hazard Forecaster at the Jackson Hole Ski Area.

During the winter of l973-74, Gary began to collect historical weather and avalanche data from the year the Tram opened (winter of 1966-67) to correlate with current weather data looking for clues to current snow stability. This had not been accomplished in the U.S. and was his idea independent of what was going on in the rest of the avalanche world. The industry currently refers to this concept as the nearest-neighbor method of forecasting, and is used as a tool for forecasting at many ski areas today.

Due to bureaucratic USFS budget restraints, his initial computer was a basic Heath Kit which he assembled himself. The cost in l973 dollars was $7000 and had a capacity of 64K and two floppy-disk drives. In order to help pay for the computer, he sacrificed his overtime pay to allow for more Forest Service funding of the computer project.

The inputs used were the standard meteorological factors: temperature, new snowfall, new snow depth and density, wind speed and direction, available snow for transport, and past avalanche activity. Since snowpit technology was in its infancy in the early l970s, he did not initially incorporate input from the snowpack but did analyze it frequently.

From January, l974, to March, l977, there were seven backcountry skier fatalities on the Bridger-Teton National Forest. These accidents inspired Gary to begin the Forest Service Avalanche Hazard Advisory for the Teton National Forest backcountry in l974, which without doubt has reduced the number of backcountry avalanche fatalities.

Krisjansons watches the blast from a tossed hand charge.

Juris Krisjansons

Avalanche Hazard Forecaster, Jackson Hole Ski Area, l966-71

Juris (Juri to his friends, family, and co-workers) came to the U.S. from Latvia with his family at the age of l2. His family eventually ended up in Cleveland, Ohio, where Juris attended Ohio State University and received a degree in aeronautical engineering. The mountains of the West eventually drew him to the Sierra where he ended up at Squaw Valley working on the patrol, lift maintenance, and snow safety with two legends of the avalanche industry: Norm Wilson and Dick Reuter.

His first view of the Tetons was from Pine Creek Pass in the early l960s while working as an assistant trip leader for a group of teenagers. His chance to move to Jackson came in l965 when he accepted the job as assistant to the Snow Ranger at Jackson Hole Ski Area. For this first year of the ski area operation, only three chair lifts were open with very limited avalanche terrain, which gave Juris ample time to explore the tram-served avalanche terrain – where every run from the top was in an avalanche path.

In l965 Juris accepted the job of USFS Avalanche Hazard Forecaster. His objective prior to the opening of the tram was to place meteorological instruments from the top to the bottom of the mountain – over 4,000 vertical feet. He had phone lines along the tram and l960s state-of-the art weather instruments at his disposal. Mountaintop wind speed and direction was achieved with both analogue (gust anemometer) and contact anemometer (records miles of wind which pass the instrument). De-riming lights were effective in all but severe riming conditions. A tipping bucket precipitation gage was wired from the midway study plot for remote mid-mountain snowfall. Temperature thermistors were placed along the tram at three elevations. All this information was hard-lined into the forecast office at the base of the mountain where recorders of various types provided continual wind, temperature and snowfall information.

Krisjanson's instrumentation program and subsequent avalanche control plan was instrumental in setting standards for major ski areas in the U.S.

Juris Krisjansons died from cancer in April, l998. ❄

Photos reprinted from *Teton*, winter/spring 1971, from the article *Avalanche Busters* by Scott Phillips.

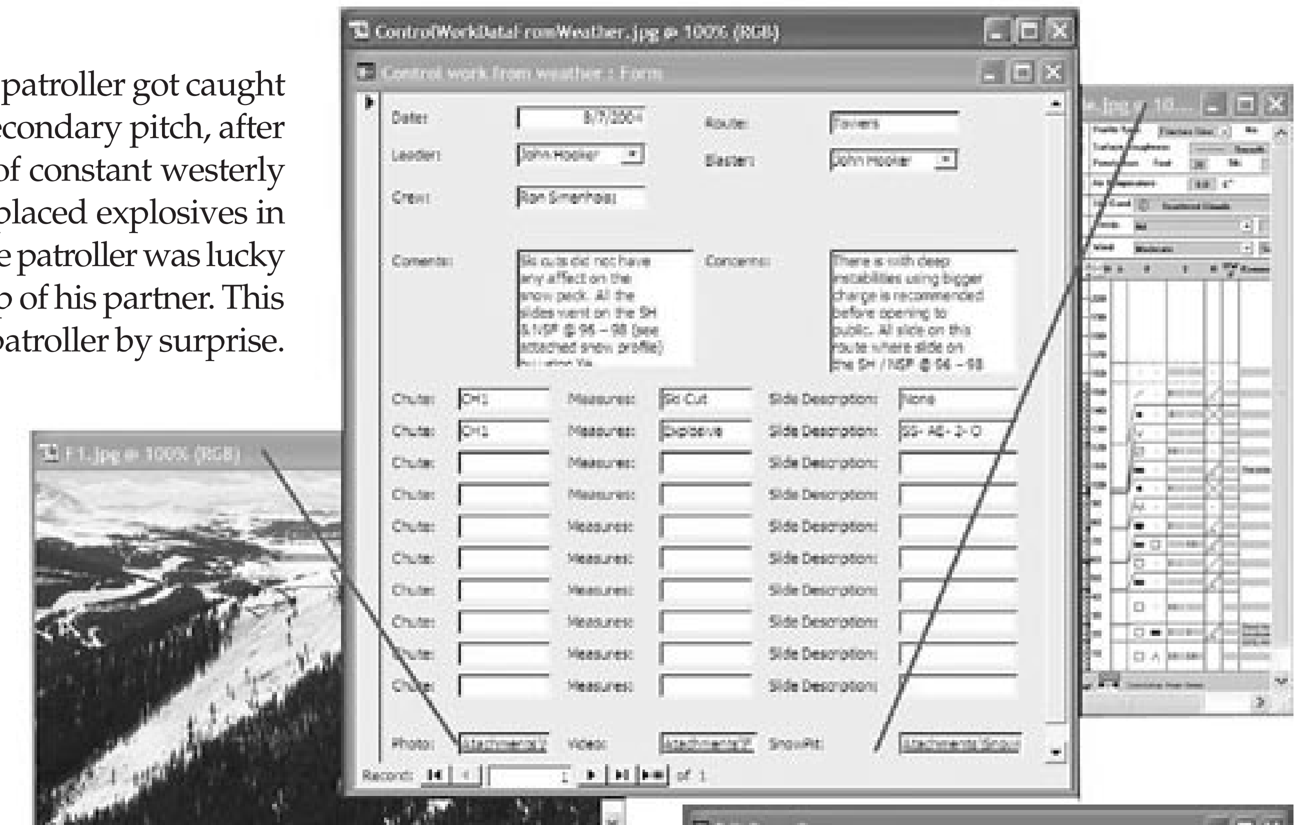
Photos by Fletcher Manley

media

Computerized Avalanche Control Database

Story by Ron Simenhois

On December 15, 2004, a Copper Mountain patroller got caught in a slide while ski cutting. This was on a secondary pitch, after more than 60 cm of new snow, three days of constant westerly wind of more than 10 m/sec, and densely placed explosives in that area with minimal results. In this case, the patroller was lucky and was able to dig himself out with the help of his partner. This was a rare snow condition that caught this patroller by surprise. Did we learn something from this incident?



Now at Copper Mountain we have a computerized snow-safety database that ensures us that we will. Objective information related to every snow-safety activity can be accessed easily according to dates, weather events, patrollers involved, and snowpack observations; this information can then give us a fair warning when similar conditions occur.

In the past, incidents like the one described above often evolved into anecdotes like the one where a patroller got buried in a slide in standing position with only one hand above the surface and dug his head out. Or when another, after being dug out, spit his tobacco and said, "It lost its flavor." These stories are usually not accompanied by the related weather events, the snowpack description at the time, or any other objective information related to the incident. Even if this information exists somewhere it is probably buried under a pile of paper in some remote storage room, and the time it takes to find it would exceed the time it would take those conditions to repeat themselves.

Today at Copper, every patroller can view the control work progress from any patrol computer on the mountain. Viewing the layers that have been drawn on the area photo and reading related comments of the patrollers on the route can help patrollers on the other side of the mountain or for those coming back from days off to fill the information gap and work effectively and safely when getting back on a different piece of terrain. Furthermore, the available information on control results can provide us important information on the conditions and can be taken into consideration when negotiating the avalanche hazard in other parts of the ski area.

When I started working at Copper Mountain ski patrol, I met Dan Moroz, one of our snow safety coordinators. It didn't take long before we started talking about a snow-safety database. Then a couple months later, while trying to battle other patrollers' handwriting on snow safety reports, I decided it was time to start building the database. I wanted it to have search capabilities, the ability to attach all types of digital data, and one reporting standard.

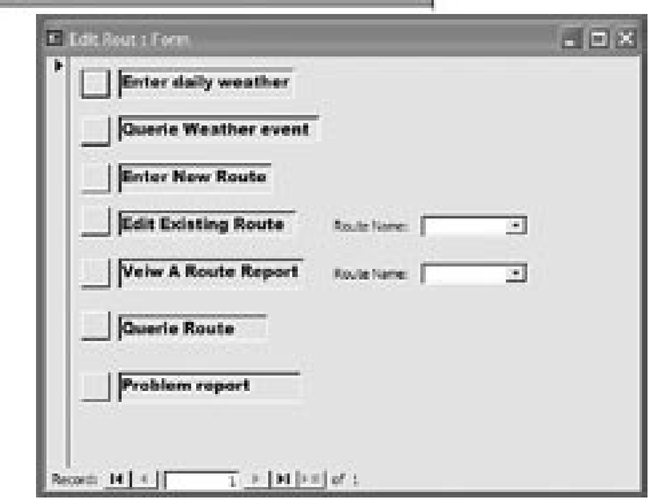
The decision to use Microsoft Access for our snow-safety database was easy. The patrol computers already had the program installed, so we didn't have to buy anything. It is easy to use Access to create user-friendly forms, queries, and reports. It can store different type of files like photos, videos, or Photoshop files. These can easily be opened from the database itself while viewing a control route, weather event, specific snowpack, or any other event that these files may be related to.

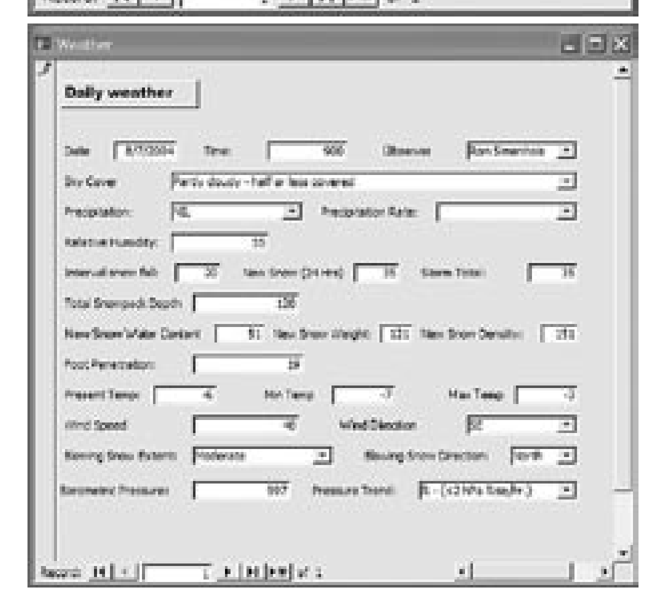
The database is designed to be flexible, meaning it is easy to add and change routes, add queries and has self-learning capabilities for location names on a specific route. Therefore it can easily be adapted to different ski areas or other operations that control avalanches.

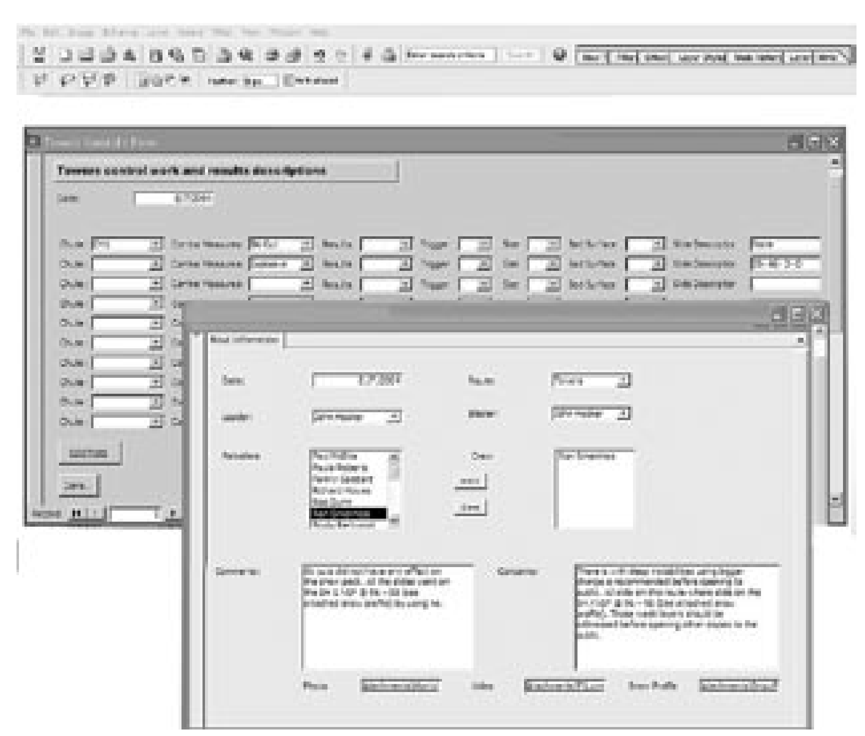
The database has an easy-to-use interface with a drop box for every fixed value or name. The user friendly interface helped some of the less computer savvy patrollers (with big support from our Snow Safety coordinators at Copper) to get with the program and create positive reaction to the system. The database is compatible with the weather, snowpack, and avalanche-observational guidelines. This helps the reporting patroller concentrate on the story at hand and not on how to tell the tale.

The database has a set of filters to retrieve information related to dates, weather events, or patrollers on the route. For example, after a 45cm snowfall, a snow-safety technician can retrieve all the history of the control work done after a similar weather event, i.e., 45 cm or more of new snow. This information includes a list of route descriptions with patrollers' names, textual and graphical descriptions of those routes, and any related information that exists, like digital photos and video of control results, fracture profiles, etc. The ability to add more filters to the database on demand is important to accommodate the needs that may be presented in the future and not been addressed in the initial design.

Any database has its limitations. It's important to understand those limitations and know what to expect from the system. The quality of the database is directly related to the information that is being entered in it. Retrieving information related to weather events or snowpacks will produce poor results if snowpack observations are rarely taken and weather data is not being entered.







The database is working hand in hand with Adobe Photoshop Elements 2.0. These files are big and when they are stored on the network (to allow information sharing), loading them can take time.

As for further development:

- I am currently working on logging weather data directly from Campbell units in addition to manual observations.
- We are hoping to put the control work information on a shared database for use by other ski areas in the region.
- Future plans for the system include being able to analyze snowpit profiles and generate recommendations according to terrain and local history.

The Snow Safety Database is a useful tool in helping us make decisions, be more efficient, effective and safe in negotiating the tasks ahead. But under no circumstances is this system a substitute for a well-trained, sound-thinking, snow-safety technician.

Ron splits his year patrolling at Copper Mountain and Mt. Hutt, New Zealand. He has his masters degree in math and computer science from The Israeli Technical Institute. Ron Simenhois, Copper Mountain Ski Patrol, PO Box 3001, Copper Mountain Ski Resort, Copper Mountain, CO 80443, 970-262-3820, ron_si@yahoo.com ❄

SNOWMACHINERS ONLY

The Manti-La Sal Avalanche Center's First Level 1 Class for Riders

Story and photos by Evan Stevens

Glenn Zumwaldt notices a natural avalanche, which affects the group's decisions for the day's travel plans.

At first, Max Forgensi (fellow avalanche forecaster and educator for the Manti-La Sal Avalanche Center) and I didn't know how much interest we would be able to generate for a snowmobiler-only avalanche class. It has been hard enough to get riders to come out to free evening awareness classes. We decided that the best way to give people no excuse was to offer the class for free. So we planned a two-and-a-half day classroom and field-based level I course based on the Level I curriculum from The American Institute of Avalanche Research and Education (AIARE). After a key phone call to a local shop owner and snowmobile patriarch, Glen Zumwalt, our registration quickly surpassed our 14-person limit, so we bumped the class size up to 18. Max and I hunkered down and tinkered with our presentations and teaching methods to be able to cater to snowmobilers. The results of the January 14-16 class couldn't have been better.

The course turned out to be a learning experience for us as well as the students. To start off, we were amazed that five of the 18 participants had been caught and either partially or fully buried in avalanches before the class – these were aggressive riders with the best equipment hitting avalanche terrain on a regular basis. One of the best teaching tools we had were the crowns and debris piles from the previous week's huge natural avalanche cycle. These visual aids really helped us hammer out the points of safe travel techniques, as riders could see where they were or were not safe to watch their buddies high-mark slopes or cross basins.

We quickly realized the best things we could teach these students. First and foremost was getting everyone dialed with their beacons and illustrating the importance of having a beacon and a probe as well. Second was a huge emphasis on the human factor – getting everyone talking and helping to make decisions as a group, showing people to get off their sleds and check out the snow, and understanding and utilizing the simple practices of safe travel techniques. The beauty of being on a snowmobile is you get to observe 100 times more avalanche terrain and snow conditions than someone on skis or a snowboard. Teaching these riders how to recognize avalanche terrain and showing them to ride one at a time and watch from safe zones were points that were easily digested. What we didn't emphasize a lot were snowpits and pit tests – as per the AIARE Level 1 curriculum. We focused on teaching them good decision-making tools; showing them how to recognize terrain, weather, and snowpack information that is telling them about the avalanche danger; and explaining how to use the avalanche bulletins to help them do this. We all know that some of the basics of playing safely in avalanche terrain are simple concepts, and it was great to show these folks how easy it can be to play it safe out there.

Max Forgensi gets ready for the day – his snowmachine is running and so is his beacon.

With the clock ticking, class members dig furiously to uncover a "victim" during a rescue drill.

We would love to share information and discuss ideas and concepts about how to better reach the snowmobile community. I was also able to take a ton of photos of riders snowmobiling in avalanche terrain and playing it safe, doing beacon searches, and so on…so if anyone needs some photos to bolster their slide shows, let us know!

Evan Stevens works as a backcountry avalanche specialist for the Manti-La Sal Avalanche Center. He has previously assisted at the Utah Avalanche Center, where he liked to cuddle with Powder the Polar Bear. He mastered his avalanche skills while racing down the mountains of southern New York. In his spare time he breaks holds off many of the classic rock climbs in Moab. He has taken this talent all the way to Greenland on climbing expeditions. This summer he is fulfilling the dreams of many – marrying a wonderful Canadian woman and moving to B.C. ❄

Students in the Manti-La Sal Level I learn from some great visual aids.

Avalanche Education Today

Story by Sarah Carpenter

If you dig deep into your memory bank, or maybe not so deep, can you remember your first avalanche course? The first time you heard words such as facets, depth hoar, freezing nuclei? Maybe the abbreviations ET and TG? The concepts of temperature gradients and stored energy as they apply to snowpack?

As educators, it is invaluable to us to remember this first exposure to snow science – to recall the vast amount of information our instructors were trying to fit into a period of one, two, or three days, or maybe just three hours. It's important to reflect on what stuck with us from that first level 1 or avalanche-awareness course and why. It is also important for us to reflect on the amount of knowledge we have gained since that initial exposure. What are the most essential tools we've gained? How did we gain them? What created the "ah-ha" moments in our learning careers?

On a recent avalanche course in the Teton Valley, Michael Jackson, co-chairman of the AAA education committee, gave a presentation on the state of avalanche education today. He began by introducing the traditional avalanche-education model for decision-making. This model does not distinguish between student groups. Regardless of experience and knowledge base, most students in avalanche courses are taught to:

- **Identify objectives**
- **Examine available information**
- **Compare alternatives**
- **Decide**

Although this model may be effective for our more advanced students, the gathering and analyzing of information by beginners may create confusion and frustration. This population may have no previous experience to reference and no knowledge of how to prioritize information gathered. The decision-making model offered by this "traditional" tool may therefore create ambiguity, confusion, and frustration, rather than offer an effective way to make decisions.

It is important, as educators, to offer useful tools for our students to use outside of the classroom. These tools need to take into account the knowledge and experience base of our student groups. Effective teaching techniques and tools vary based on this previous experience base.

As a foundation for his talk, Michael broke down the populations that we are educating into three distinct groups, each with a different learning style and focus.

THE BEGINNER is in the "know that" stage of learning. This is the student who states, "It's all new to me." He/she is being exposed to the facts and figures for the first time. This student is new to travel in avalanche terrain and therefore has no tools with which to prioritize information. This student needs clear rules and guidance to aid him/her in the decision-making process. Rule-based decision-making tools, such as ALPTRUTH or the Munter 3x3 reduction method can prove extremely valuable to this student.

THE INTERMEDIATE is in the "know how" learning stage. This student understands the facts and figures presented. During this learning stage, he/she is beginning to put theory into practice. This student is developing a system of sorting and prioritizing information, but still falls back on rule-based decision-making.

THE EXPERT is in the "know why" learning stage. This student can see a problem and come up with a solution based on previous experience. During this stage, situational awareness replaces rule-based decision-making.

Michael's presentation of the different learning stages then evolved into a discussion on effective teaching techniques for each group. Students and instructors alike agreed that clear goals and expectations for an avalanche course must be present, no matter who the audience. We agreed that recognizing these different learning stages and effectively teaching to them could improve the quality of avalanche education offered in the U.S. We also all felt strongly that students must be placed in real situations and forced to make real decisions.

The students of this particular level 2 course were all winter instructors for the National Outdoor Leadership School (NOLS). They all had experience teaching an avalanche curriculum to beginners. Based on this experience, and Michael's breakdown of student groups, they thought heuristics were extremely effective with this population. Offering students a rule-based decision-making tool, such as ALPTRUTH (McCammon, 2000) or the Munter 3x3 Reduction method, creates a clear framework for decision-making in avalanche terrain. It is important to point out the traps that students can potentially fall into using these rule-based tools – Familiarity, Acceptance, Commitment, Expert Opinion, Tracks, Social Proof (FACETS) – and what these sound like.

Intermediate students are becoming apprentices in the avalanche world. Rule-based decision-making may still be the fall-back decision-making tool, but these students are beginning to question these rules. A tool that we can offer to these students is the avalanche triangle and applying a red, yellow, or green rating to each side of the triangle (adapted from *Snow Sense*). This may be effective; these students are beginning to recognize patterns and effectively sort and weight information gathered throughout a travel day.

Other effective learning tools for intermediate students are case studies and accident reports. The ability to read and hear what human factor traps such as summit fever or the lemming syndrome sound like can prove valuable. These event-based stories may also help to emphasize the observational skills that we want students to develop. By taking the time to have students review the clues – snowpack, weather, terrain, and human factor, we help to reinforce learning that took place earlier on in the course. It is important to have students recognize what groups did well in addition to "what went wrong" while doing these case studies.

When teaching "expert" students, we may not be offering a lot of new skills, but instead helping to hone existing observation and decision-making skills. Establishing very clear goals for the fine-tuning of skills during higher-level courses can be an effective teaching technique. The primary goal of this particular NOLS Level 2 was to have participants make quick, efficient, and accurate decisions. We pushed participants to take in information efficiently through quick, accurate "test plus" pits, when and when not to dig, how to sort information gathered while traveling. We then asked them to safely and efficiently manage a group of people in the backcountry. We placed realistic constraints and pressures on them – the request for "long ski shots," time pressure in the form of impending darkness, a group of three to five "clients" to manage. The tools we offered to these students were not ALPTRUTH or red, yellow, green, but instead the stability wheel (see *Strength, Energy, and Structure* by Don Sharaf & Ian McCammon, TAR 23/3) and pointing out traps and pitfalls that "experts," both professionals and recreationalists alike, fall into. Case studies and accident reports are another great learning tool for this group of students.

For example, during the five day NOLS Level 2, we had very clear goals and expectations for our students. We outlined them on day one and wove them into all of our teaching and field sessions. As a result, students were, to borrow from Iain Stewart-Patterson's article *Developing Good Decisions*, able to come to the elegant solution more and more frequently. We pushed students to make efficient, quicker, more accurate decisions throughout the course. We fine tuned pit-digging skills, route finding, group management, and communication, thus achieving daily our goal of the elegant solution.

In Michael's discussion that evening, we concluded that curriculum should be designed specifically for each learning stage. Students learn more when goals and objectives are clearly defined, so instructors should be sure to outline these early. It is also important for students in all three of these learning stages to be placed in real situations and make real decisions. This requires supervision from the instructor, as well as open lines of communication.

Our discussion about stages of learning and how to best facilitate learning in each group then shifted to the state of avalanche education in the U.S. today. In a room full of educators, one question that was quickly posed was, "Are there standards for Level 1, 2, & 3 avalanche courses in place?"

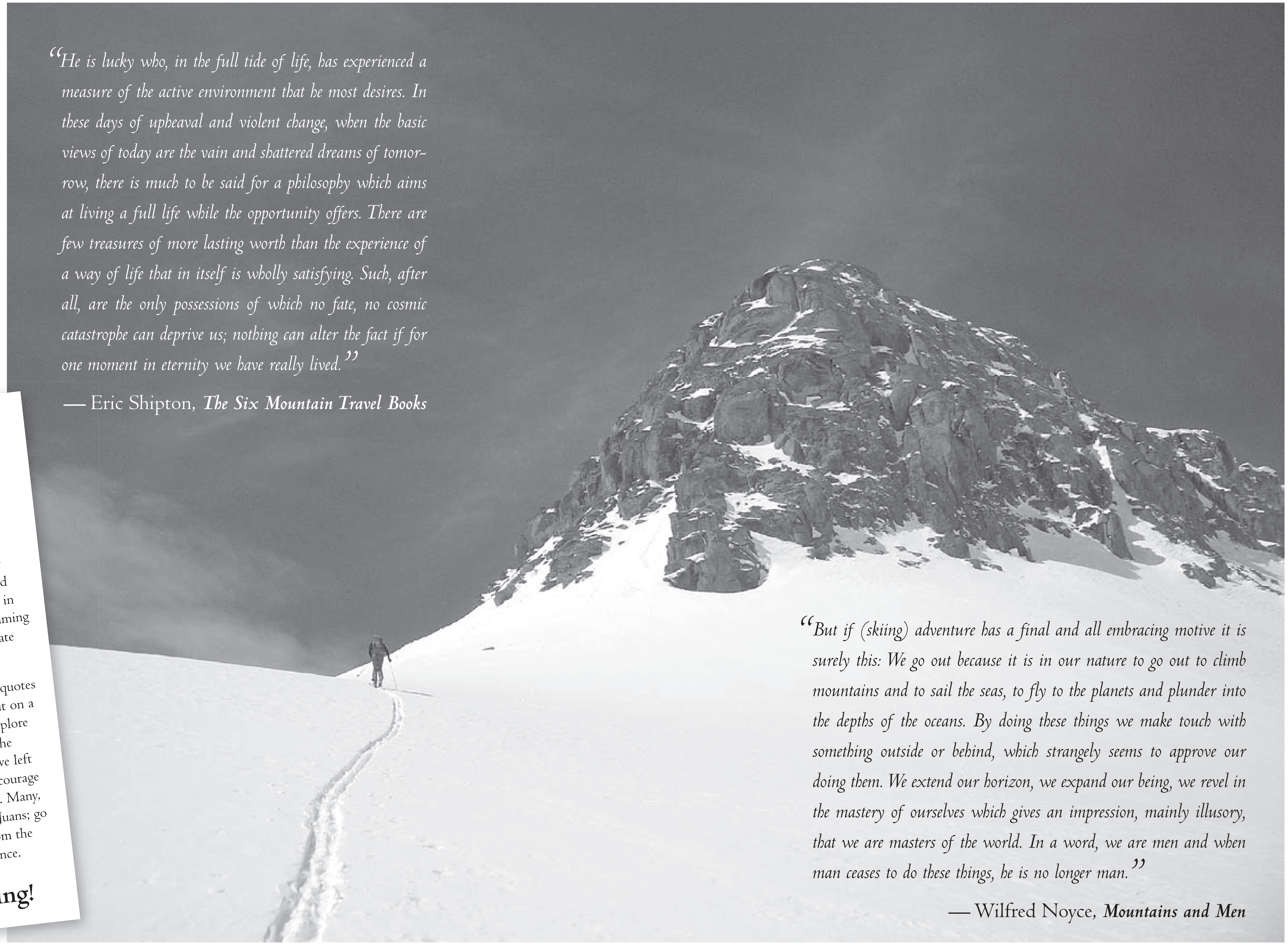
Michael did a great job facilitating a discussion around this question. Some of the topics and questions that were discussed and that many of us still have questions about include:

- **AAA guidelines from 1999 exist for level 1 and 2 courses.**
- **Are these guidelines up-to-date? If not, can we update them? Who will do this?**
- **Can guidelines be accompanied by expected outcomes?**
- **With no curriculum standards in place, what does a Level 1 certification mean?**
- **How can one tell if a person with a Level 1, 2, or 3 card is competent with that skill set?**
- **Can we create two different tracks in avalanche education: a recreational track and a professional track?**
- **If these are created, can a person cross over from a recreational track to a professional track? How?**
- **Who is going to be the driving force for change?**
- **Can/will industry ever be a driving force towards standardizing curriculum?**

As educators, we have a responsibility to offer our students tools that they can take into the real world. Designing curriculum with the three different learning stages in mind and offering tools appropriate to the skill level of our students will set them up for success and enjoyment in the backcountry. We should continue to reflect on our personal "ah-ha" moments and translate the teaching techniques that brought on these moments into real-life practice with our students. We should stay up-to-date with new developments in avalanche research and incorporate these changes into our teaching. A state-of-the-art education should be something we all strive for. The world of avalanche research is a dynamic, ever-changing, and evolving field. Avalanche education should follow suit.

Michael Jackson credits his presentation to the work of Iain Stewart-Patterson, Ian McCammon and Don Sharaf, and Steve Conger that appeared in TAR 23/3.

Sarah Carpenter spent much of her winter teaching avalanche courses and skiing powder in Teton Valley, Idaho. Her next projects include getting used to married life and designing/ building a straw-bale home. ❄



From: Denny Hogan
Snow Ranger BLM/FS
Silverton, Colorado
2/12/05

Here is what I have for the 23/4 issue of TAR. Hopefully this reaches you for the deadline of Feb. 15.

Real busy with lots of snow this winter! We are currently 153% of average in the San Juan Mountains. This should give us excellent springtime skiing conditions down here in southern Colorado. Many skiers are busy planning/dreaming of ski trips to do in the vast San Juan Mountains this late winter and early spring!

I give you five photos to inspire TAR readers and two quotes to inspire as well. The important thing is to launch out on a ski trip or expedition this spring. Get out and Ski! Explore your backyard or a new range of mountains. This is the essential foundation for the study of avalanches! I have left out any maps or route descriptions on purpose; I encourage all of us to explore the area but leave only ski tracks. Many, many un-crowded "Haute-Routes" exist in the San Juans; go and find yours! You can venture in any direction from the town of Silverton and have a wonderful ski experience.

Have a great spring skiing!

snow science

The Winter of our Discontent—
The Continental Snowpack in the Maritime Climate of the Cascades, 2004-05

Story and photos by Jon Andrews and Mark Moore

Part 1: Stevens Pass

December 23, 2004: Bull wheels aren't turning, ski lodges are sitting empty and the winter mood here in the Northwest is dismal. Sixteen inches of snow on the ground, cold and clear. The snowpack at hand is mostly facets sitting on a crust near the ground.

December 28, 2004: Finally, we open the Stevens Pass ski area with light, fluffy continental snowfall and limited operations. Most ski areas in the Northwest open or were open on a limited basis at this time.

The last time we had a late opening like this was the 1989-90 season. In 1989 we had 16 inches of snow on the ground through the month of December with clear and cold weather and surface hoar and facets throughout. We opened January 3, 1990, with a cold and windy 30-inch snowstorm. Avalanche control during the month of January brought one of the largest avalanche cycles we had seen (Figures 2 and 3). Real tricky, cold wind slab running on surface hoar and a thin layer of facets on a crust near the ground. We received 242" of snow that month and did 21 days of consecutive avalanche control. One day you blasted a slope and things propagated, settled, stabilized, but didn't release. The next day you re-shot and the whole slope avalanched.

Back to 2004-05. From the time we opened to January 12, the weather remained cold with temperatures ranging from –2°F to 16°F. Snow tests on the 10cm of facets on the rain crust near the ground were not very interesting – Rutschblock scores of 7, compression and shovel shear tests were not clean, and explosives brought mostly minimal results. Right up to January 12, all the ingredients for slab avalanches were there except the load.

January 11–16, 2005: The night of the 11th and into the 12th we had high gusty winds of 80mph+. Snowfall appeared to be moderate to heavy throughout the day. Most of the ski lifts were not operating due to wind holds. During the day of the 12th small pockets of wind slab were reported but nothing significant. The night of the 12th it was supposed to taper off and stop snowing in most areas, which it did; however, late in the afternoon the forecast changed as the convergence shifted back over Stevens Pass. The gusty winds subsided to a steady 25mph and the snowfall was steady all night. On the morning of the 13th the wind subsided, but the temperature remained cold. Avalanche control in the morning began an all-day avalanche cycle with ski- and explosive-triggered wind-slab releases two to six feet in depth. Rutschblock scores were 1 (Q1) at this time. We got the best results throwing single charges in places that the slabs were shallower and around rock outcrops. Many avalanches were surprise skier-triggered from the shallower part of the slabs (Figures 4-6); but the end results were not shallow – some slides stepped down to six feet in depth. This storm was deceiving at times.

In this climate we look for trends, especially temperature trends, as potential stabilizing factors. A warming trend during a storm in the Cascades is typical. However the storms of January 12-16 remained cold and associated snow fell on an unusually shallow and weak snowpack structure, at least for the Cascades during a typical winter. Our usual forecasting techniques for the Maritime climate did not work in this snowpack. At times when you would not see results, you might think the slabs are settling down and starting to stabilize. But then you moved to a different area and ski-triggered a big one. I think it was a matter of hitting the right spot. The instability remained until after the warm up, and the rain, and the warm up, and more rain....

This avalanche cycle lasted for four days (Jan 13-16), with many skier-triggered avalanches outside the ski-area boundary. Inside the boundary, we kept hammering on these wind slabs and getting results on occasion. It was tricky or sometimes lucky to find trigger spots in these slabs. With 10cm of relatively dense facets on the crust, it took a real localized energy to make things happen. Or was it the strength of slab that hid these trigger spots?

This type of snowpack – a combination of crusts, facets, and slab – occurs a couple times per season on average. Many people may be unaware of these conditions. Most skier-triggered avalanches in this type of snowpack are triggered from the shallower part of the slabs and happen on blue-sky days when the skiing is phenomenal. It's hard in this more unusual snowpack to think about skiing terrain differently. All the ski- and explosive-triggered avalanches we observed in the January 2005 cycle were triggered from shallower parts of the slab.

It's hard not to ski from point of safety to point of safety, like rock outcrops and tree islands, but instead to stay out where the slab is thickest and the force of a skier can't penetrate the weak spots. Weighing the consequences is tough. Lots of questions come to mind. The skiing is excellent, but am I willing to accept the risk? Do I want to take the risk of getting raked over the rocks and through the trees or do I want to risk being buried in an avalanche?

While the combination of facets, crusts, and slabs may occur several times a season in the Northwest, the overall faceted, ultra-shallow and weak snowpack we had in the Cascades through early to mid-January of this year is much more unusual. Since the snowpack is very thin, you can't ski the way you normally do nor where you normally ski. Fortunately such a snowpack condition in the Northwest happens only every 10-15 years or so. Table 1 gives a glimpse into our unusual snowpack evolution this winter.

January 17–18, 2005: In most situations, unusualness doesn't last long, hence the attribute. And this 10-15 year unusualness went the way of dinosaurs when January 17 brought five inches of freezing rain, which shut down lifts at 10:30 am. On January 18, Stevens Pass recorded 6.87" of rainfall and lost over 20 inches of snow. The reason for so much settlement was the cold, low-density snowpack with lots of air space throughout the layers.

This weather event shut the ski area down until we got more snow. This storm and avalanche cycle was a short one, but a lot happened in those four days. Our avalanche-control crew worked very hard to get parts of the mountain open that had not yet been opened, and they worked very hard to keep things open in a very tricky snow pack. And then, all of a sudden, it was over – the rain came and shut us down. We went from an average of 6°F and powder skiing for the four days of avalanche control to 47°F, rain, and picking garbage in the parking lots in just a few hours.

This same scenario – a late opening, rained out in January, re-open in late February with a few big snowstorms – happened back in 1976-77. At least it never gets dull here in the Cascades. The weather and snowpack change continuously. In a matter of minutes snow conditions can change from pretty stable to get-the-hell-out-of-the–mountains-and-down-the-road-before-it-closes kind of stability. Pretty interesting, plenty scary, always changing.

Snowmobile meets creek; creek wins. Main ski run after 6.78" of rain Jan 18, 2005.

```
CLIMATOLOGICAL SNOWDEPTH INFORMATION
NORTHWEST WEATHER AND AVALANCHE CENTER SEATTLE WASHINGTON
DAY  1  MONTH  2  YEAR  2005
WAZ012-017-018-019-025-042-ORZ011-

DATA IN INCHES, -99 DENOTES MISSING DATA
```

	CURRENT DEPTH	CLIMATE AVERAGE	PER CENT OF NORMAL	LAST YEAR	THRU 2004 MAX/YEAR	THRU 2004 MIN/YEAR
HURRICANE	10	79	13	96	162/1999	12/1981
MT BAKER	20	124	16	145	234/1933	17/1981
STEVENS	25	87	29	96	152/1964	10/1981
SNOQUALMIE	17	79	22	85	154/1964	8/1977
STAMPEDE	0	88	0	87	228/1946	2/1977
MISSION	10	40	25	38	62/1997	8/1976
CRYSTAL	13	59	22	78	112/1999	6/1977
PARADISE	42	133	32	170	240/1969	27/1977
WHITE PASS	0	53	0	80	88/1997	0/1977
TIMBERLINE	40	119	34	176	238/2002	10/1977
MEADOWS	23	101	23	121	184/1974	15/1981

```
THIS TABLE PRODUCED ON THE 1ST AND 15TH BETWEEN 15 NOVEMBER AND 1 MAY.

AVERAGES, MAXIMUMS AND MINIMUMS EARLY IN THE SEASON MAY BE INACCURATE
DUE TO LIMITED DATA.

RECORDS BEGIN: HURRICANE 1979, MT BAKER 1926, STEVENS 1939,
SNOQUALMIE 1929, STAMPEDE 1943, MISSION RIDGE 1970,
CRYSTAL 1967, PARADISE 1926, WHITE PASS 1976,
TIMBERLINE 1973, MT HOOD MEADOWS 1974.
```

Weather Pattern Comments

When the winter weather is unusual in one place, it's often unusual in lots of places, since the patterns of ridges and troughs that encircle both hemispheres are all connected. And that connection extends all the way from the western US into the tropics and subtropics: enter El Niño. Although what atmospheric, oceanic, or cosmic aberration is to blame for a particularly unusual bout of nasty weather can be a hot topic, and El Niño often becomes the culprit, we must also take into account that a variety of cyclical or other long-term weather factors may be acting to influence seasonal, annual or more long-term weather patterns, including the Pacific Decadal Oscillation (PDO), Arctic Oscillation (AO), Madden-Julian Oscillation, (MJO), Global Warming, etc. That said, for this short discussion we'll concentrate on El Niño and whether or not it is to blame (and besides, discussing all of the other possible variations, some of which are not fully understood, would make this a reeeeaaaaaIllllyyy long article).

Although the atmospheric mechanisms and adjustments that result from this unusual or periodic eastward warming of the equatorial tropical Pacific (El Niño) can be unreliable or inconsistent, depending on the strength of the warming episode, these adjustments can nevertheless exert a significant though not easily forecast influence on winter weather in the US. As most of us have realized by the way our various snowpacks have evolved or not evolved this winter, each region is being blessed with an unusual snowpack from both the norm and from each other. And when we have these unusual conditions, we have unusual snowpacks from which may stem some or perhaps even many of the avalanche incidents that have engulfed us so far this winter. Are such conditions attributable to what most professional climatologists term a weak warming event? While some might argue that such conditions may be directly associated with El Niño, the official word from the Climate Prediction Center (www.cpc.ncep.noaa.gov/products/predictions/long_range/fxus05.html) on January 20 is that the current warm event should have only a limited influence on the remainder of the winter and at least some of the unusual circulations observed thus far this year are not typical of El Niños.

> *This El Niño should have only a very limited influence on the US Climate for the remainder of the cool season. Central Pacific El Niños in the past (such as 1963-64, 1968-69, 2002-03) have a much less reliable signal than basin-wide El Niños where warm SSTs extend to the South American coast.*
>
> *The US temperature response to central Pacific El Niños is usually colder than normal over the southeast with a slight tendency for wet conditions across the southern US. Recent heavy precipitation in California in early January is the result of unusual circulation patterns in the north Pacific Ocean that are not typical of El Niños. Early January precipitation patterns observed in Florida and the Ohio valley are opposite of the usual El Niño signals, further suggesting that conditions in the first half of January are due to unusual circulation patterns unrelated to El Niño.*

During significant warm episode events, one of the effects of El Niño and the associated increased transfer of heat from certain equatorial regions toward the poles is to develop an abnormal and relatively strong southern branch of the jetstream in the eastern Pacific Ocean. The Coriolis force from the rotating Earth acts to deflect the unusually strong northward flow of upper-level air from the equator toward the right, or toward the east in this context. This subtropical jetstream enhances westerly flow and moisture across much of the southern tier of the US and intermittently tends to split the jetstream off the West Coast. Such a split can and often does encourage development of a semi-persistent upper-level ridge either in the Gulf of Alaska or along the West Coast, depending on the magnitude and eastward extent of the underlying tropical warming. The results of all of these atmospheric adjustments can result in periodic oscillations between the two preferred branches of the westerly flow – that is, between heavy precipitation and warming in the southern branch and colder and drier in the northern branch. And we all know what that swing can bring, and has brought to us this winter. In the southern Intermountain and southern Rockies, this has resulted in periods of heavy loading of that unstable bag of potato chips; while in the Northwest and across the northern Intermountain and northern Rockies, an unusually cold, weak, and shallow snowpack for the early part of the winter has been recently loaded and/or replaced by a much higher-density snow (can you say 100%) and a rather warm, fuzzy, wet feeling.

How long will this unusualness persist? Although no definite projections are possible for such long terms (I personally feel uncomfortable with forecasts extending beyond a few minutes because of the *Unusual Factor*), during most recent winters in which a weak El Niño has been a factor, the effects of the warming episode have waned considerably during the latter part of the winter and spring. So the odds are that we're more likely than not to return to a more normal flow pattern by springtime. But once again the question is when exactly, and what's normal anyway, since in some areas of the West it seems like spring now? The National Weather Service long-range forecasts for precipitation for most regions of the US tends toward equal chances (EC) or climatology in the spring, but a bias continues toward warmer-than-normal temperatures in the April-June time frame (see temperature outlook below and look on the Web at www.cpc.ncep.noaa.gov/products/predictions/long_range/lead03/off_index.html).

But then what's normal except a series of unusual events averaged out over time? Unfortunately this can paint a pretty good picture about reliability of long term forecasts – especially during a weak event such as this winter. Current teleconnections (global correlations of weather patterns) just don't have much predictability when you're dealing with a weak warm episode. Whatever weather association there is with this weak El Niño, it may persist for a few more weeks or as long as few more months. To quote the National Center for Environmental Prediction/Climate Prediction Center's ENSO Diagnostic Discussion (www.cpc.ncep.noaa.gov/products/analysis_monitoring/enso_advisory/index.html) issued on January 6, 2005:

> *Based on the recent evolution of oceanic and atmospheric conditions and on a majority of the statistical and coupled model forecasts, it seems most likely that weak warm episode (El Niño) conditions will persist for at least the next three months. However, there is considerable uncertainty concerning future developments in the extreme eastern equatorial Pacific (the classical El Niño region).*

And how about the impacts of such continued warming?

> *Expected global impacts include drier-than-average conditions over portions of Indonesia (through early 2005), northern and northeastern Australia (through February 2005), and southeastern Africa (through March 2005). If the warming in the tropical Pacific strengthens and*

Continued on page 15 ➡

Skier-triggered wind slabs from the shallow part of the slab.

CAPPING —
A Replacement Term for BRIDGING

Story by Dan Moroz

BRIDGING is a term that has been used for years to try to explain the phenomena of supportive layers over a weak snowpack. Commonly it has been used in the continental snow climate to explain stiffer and denser layers covering weaker, faceted layers to the point that it will support more load without failure. In this simplified explanation, what is implied is that bridging induces strength within the snowpack and some degree of safety for those traversing a bridged snowpack.

The problem with the above is that the term bridging infers a linear strengthening between two points or anchors. (Webster's dictionary definition of a bridge is, "A structure that spans and provides passage across an obstacle.") Since there really isn't a space between the denser spanning layers over weaker faceted layers and we really don't want to relate to a safe passage over doom, the term has been questioned.

I would like to introduce the term **CAPPING** instead. If you read Webster's definition, it states quite simply, "To lie over: to cover." This is much closer to what is really happening within the snowpack. Bridging infers strength where as capping only relates to the occurrence of a covering. Wind slabs are notorious cap layers that can hold enormous amounts of stored energy (usually tensional stresses as the slab is being pulled downhill by gravity). A wind slab will allow a greater load to be added to the snowpack, but when it fails often produces catastrophic results as the stored energy within the slab is released. (An example is a snowpack with Rutschblock scores > 5 and a quality of shear = 1 [RB6-Q1].) This can produce a widespread and deep fracture which can have disastrous results if human triggered.

The edge or boundary of a bridging layer is commonly thin and can be a failure point as a person traverses this zone. Capping layers once again don't have the implication of strength or anchoring. If slabs were thicker at their edges then strengthening at anchor locations would exist, but this is rare. In certain terrain features we see a slab within a depression where the slab boundaries will "lens out" and become thinner at the edges. For lack of a more descriptive term, this saucer of slab can also be set into motion as the shear strength between the slab and weaker snow underneath can be poor.

Where wind slabs are deposited in starting zones and are continuous to the flats above, the slab is under large tensional stress. The slab may be so thick at the breakover that it is hard to cause a failure, but place an explosive or a well-laid ski-cut downhill where the slab is thinning and a failure well above this zone can occur. Once again, a bridging slab in a starting zone can be very dangerous.

A cap layer or capping, on the other hand, has no inferences to strength and only refers to the act of one layer covering another. The adjectives used to describe the capping layer can also describe the strength or weakness of the cap. "Brittle wind slab in the starting zone," or "shooting cracks within the new soft slab," or "bomber slab" are statements we have all used to describe a capping layer. We can have cap layers in all shapes and sizes that will not have linear characteristics. As with a cap on your head, it can have a 360-degree shape although irregular at its boundaries.

A cap layer can be like a veil where a slab exists in the starting zone but downhill it quickly thins out due to the end of the wind effects. Along the length of a ridge this cap veil can extend hundreds of feet linearly and also tens of feet vertically down the fall line. This ridgeline cap can possess enormous tensional stress and can fail catastrophically over long distances.

Under certain other conditions a cap layer of moderate to dense new snow over facets can have long-distance failure implications. In the continental climate extended periods of time can separate snowfall events. If in early season there is a typical cold start with some snowfall, the entire snowpack can become faceted. Bury this with a significant snowfall without much wind effects and a widespread and uniform cap layer will form. The danger is when something causes the underlying faceted layer to vertically collapse and a cascading falling domino propagation of far-reaching failure occurs. This type of failure can be dramatically seen when a snowcat enters an area for the first time and sets off a slide hundreds of feet away where the slope angle increases. Whumping over a long distance is another sign of a cap-over-facets failure. More deadly, however, is when these snowpack conditions occur and a person cuts across the compression area of a slide path collapsing the facet layer. The cap layer fails up the slope; the slope avalanches from above and buries them deeply.

Springtime melt-freeze processes can also develop cap layering. During the freezing state, a widespread crust (cap) is formed over the snowpack. In isothermal conditions a hard freeze could form a supportive MF crust cap layer several centimeters thick over still wet and poorly bonded grains underneath. As this cap layer warms up and begins to melt, avalanche probability increases as the integrity of the cap layer decreases.

The above are only a few examples where the term cap layer can be used. Many more exist, but the purpose here is to introduce a new term that might help us describe a phenomenon that occurs often and we have a difficult time explaining. Having a term that doesn't have any hidden agendas concerning strengths or weaknesses is perhaps more useful. Using graphic adjectives to describe a cap layer will help us better illustrate what we are seeing and potential problems with the snowpack.

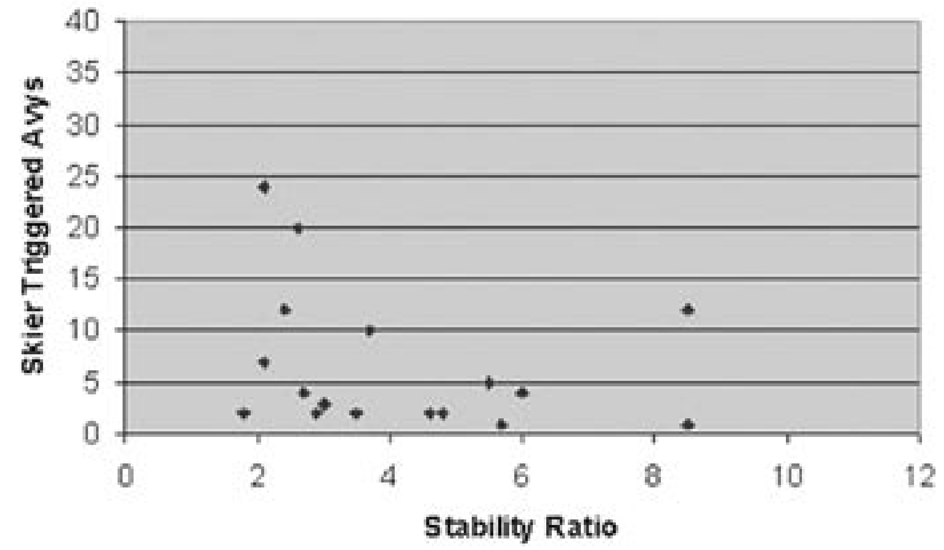
Dan Moroz is in his 30th year working at Copper Mountain Ski Resort, Copper Mountain, Colorado. He is currently a snow safety coordinator with the ski patrol and is an AAA certified instructor. Dan can be reached at moroz@colorado.net or through the Copper Mountain Ski Patrol.

Evaluating the Stuffblock and Tilt Board Snowpack Stability Tests

Story and photos by Peter Carter, Matt Heavner, and Eran Hood

Snow-avalanche forecasting relies on, among other factors, an assessment of snowpack stability derived from careful observation of snow cover stratigraphy. Snowpack profiles and stability tests provide quantifiable information about the location and strength of weak layers in the snowpack. This study found:

1) good comparative results between the stuffblock and compression tests and,
2) a relationship between tilt board test results in level study sites and skier-triggered avalanches.



Stability Ratio and Skier-Triggered Avalanches

The best way to get direct information about snowpack stability is by observing avalanches and by making snow-stability measurements in the field. Collecting consistent snow-stability measurements to assess snowpack stability is difficult due to avalanche hazard, rapidly changing conditions, spatial variability, methodology problems, and the challenges of performing laboratory experiments in adverse weather.

Avalanche forecasters use a variety of tests to assess stability. This study, conducted at Eaglecrest ski area over the winter of 2003-04, assessed the operational utility of the stuffblock and tilt board tests evaluated against the compression test, the shear frame test and triggered avalanches. Professional ski patrollers mitigating hazard triggered the avalanches observed in this study.

The shear frame test, developed by the Swiss André Roch, has been used extensively to index the shear strength of weak snowpack layers (Föhn 1987). The test uses a frame placed just above a weak layer and pulled with a gauge that records the maximum force. The shear strength is calculated by dividing the maximum force by the area of the frame.

The tilt board test is a simple method for avalanche forecasters to observe the stability of the surface 40cm of the snowpack. This test was first outlined in the Canadian Avalanche Association (CAA) Observation Guidelines and Recording Standards (OGRS) as part of the process to identify weak layers to be tested using a shear frame. The test puts a block of snow extracted from the snowpack on an angle (and tapping it if necessary) to identify the shears within it. The test has recently been promulgated as a stand-alone stability test by the American Avalanche Association (AAA) and USDA Forest Service National Avalanche Center.

The compression test was developed by Canadian park wardens in the 1970s. This test identifies weak layers within 1.2 meters of the snow surface using increasing dynamic force applied to a shovel blade resting on an isolated test column of snow (Jamieson, 1999).

The stuffblock test, developed in Montana in 1993 (Birkeland, 1996, 1999), is also performed on an isolated test column of snow using a nylon stuff sack filled with snow and dropped on the column until a shear failure occurs.

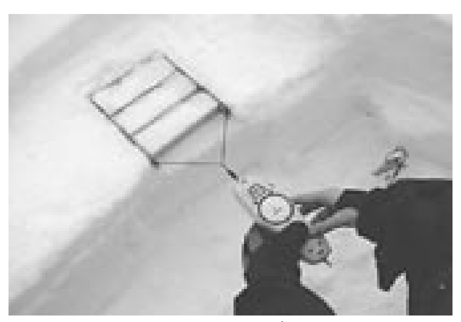
SITE DESCRIPTION AND METHODS

Study Site

The 300ha ski area located five kilometers west of Juneau, Alaska, is on Douglas Island at the headwaters of Fish Creek, a northwest-facing drainage. Eaglecrest rises in elevation from 400 to 820 meters above sea level. Snowpack observations made at treeline snow study plots located at 720m and 790m were in accordance with OGRS as required by Eaglecrest's subscription to the CAA Infoex data exchange.

Snowpack Observations

Thirty-four snowpack profiles were observed between November 22 and March 28. The profiles recorded weather, snowpack stratigraphy, temperature, density, and snow water equivalent (SWE). Profiles also include the stability tests outlined below, as well as other observations not part of this study.



Shear Frame Test

Shear Frame Test

Shear strength of weak layers is best measured with the shear frame (Schweizer, 2003). The baseline data for this study came from 40 shear frame tests conducted in the level snow-study plots. Shear frame tests were also conducted in test profiles in avalanche start zones and along avalanche fracture lines.

Conducting shear frame tests requires discipline, particularly in adverse weather conditions. While providing quantifiable shear-strength data, the test is time consuming and difficult (Perla and Beck, 1982). Each shear frame test was conducted at least five times to ensure shear results were accurately reproducible. The equipment used for the shear frame test included a 100cm2 shear frame, 2kg and 5kg Imada pull gauges, digital and mechanical weigh scales, two sampling tubes and a large putty knife.

Shear frame test results are used to calculate a unitless stability ratio to formulate stability indices for the triggering of avalanches (naturally or artificially). Snow stability is a ratio of strength to stress on a weak layer or interface. The shear frame measures the strength of a snow layer, while snowpack weight determines the stress on the layer. Stability ratio is calculated as shear strength divided by the weight of snow per unit area, thus an increase in the stability ratio is indicative of an increase in snowpack strength.

Stuffblock Test

The stuffblock test is a variation of the compression test. A 4.5kg weight is progressively dropped higher in 10cm increments onto a 30cm by 30cm isolated column. The tests were conducted in profiles on 35° to 40° slopes with generally north aspects representing avalanche start zones (below).

Conducting a Stuffblock Test at Eaglecrest

Tilt Board Test

The tilt board test was primarily conducted at the 790m treeline weather plot. Tests were conducted at the 720m study site when severe weather conditions affected the results obtained at the higher study site. The test isolates a 30cm by 30 cm column, tilting the extracted column to 15° angle and gently tapping until a shear is identified. In this study, very easy shears are defined as failure on tilt, easy shears with failure after one gentle tap, moderate shears with failure after the second gentle tap, and hard shears with failure after three or more taps.

The equipment used for the tilt board tests included tilt boards located at both treeline study plots, each equipped with a 30cm by 30cm metal cutting plate and a crosscut saw used for extracting the test snow sample from the snowpack. Irrespective of the depth of new or storm snow, the maximum test depth was 40cm from the surface of the snowpack. When the snow tested exceeded 200kg/m3, the test depth was less than 40cm.

RESULTS AND DISCUSSION

From December 11, 2003, to April 3, 2004, 658.1cm of snowfall (with 113.2cm SWE) was recorded at the 790m snow-study site. During the winter there were eight major avalanche cycles with each cycle producing numerous natural avalanches outside the ski area. On 40 days, 416 avalanches were triggered within the ski area ranging from destructive size 0.5 to 2.0. Of those, 227 were triggered using explosives and 189 were skier triggered. The triggered avalanche activity reflected new snow or surface instabilities. A destructive size 2.5 natural avalanche occurred within the ski area. There was an avalanche involvement just outside the ski area boundary on March 5 with a snowboarder carried 200m without injury.

Shear Frame Test – Stability Ratio

A comparison of skier-triggered avalanches with the stability ratio calculated from the shear frame measurements shows that high stability ratios tend to be associated with lower numbers of triggered avalanches (above). This study supports previous research showing that stability indices measured in level study plots are effective predictors of snow stability on proximate slopes (Jamieson, 1995).

Avalanche forecasters develop stability ratio indices specific to their operation. Comparing shear frame test stability ratios and skier-triggered avalanches at Eaglecrest is a start to the development of an index specific to the Juneau area.

The outlier in Figure 3 occurred January 8. On that day the shear tested was 11cm from the surface at the interface between a moist slab (described as "sticky") and dry old snow. Although the stability ratio was calculated at 8.5, one natural, 18 explosive-triggered, and 12 skier-triggered avalanches were recorded. There were variably wind-distributed, near-surface facets observed in the study plot. These findings suggest that the shear-strength interface between moist new and dry (faceted) old snow needs further study.

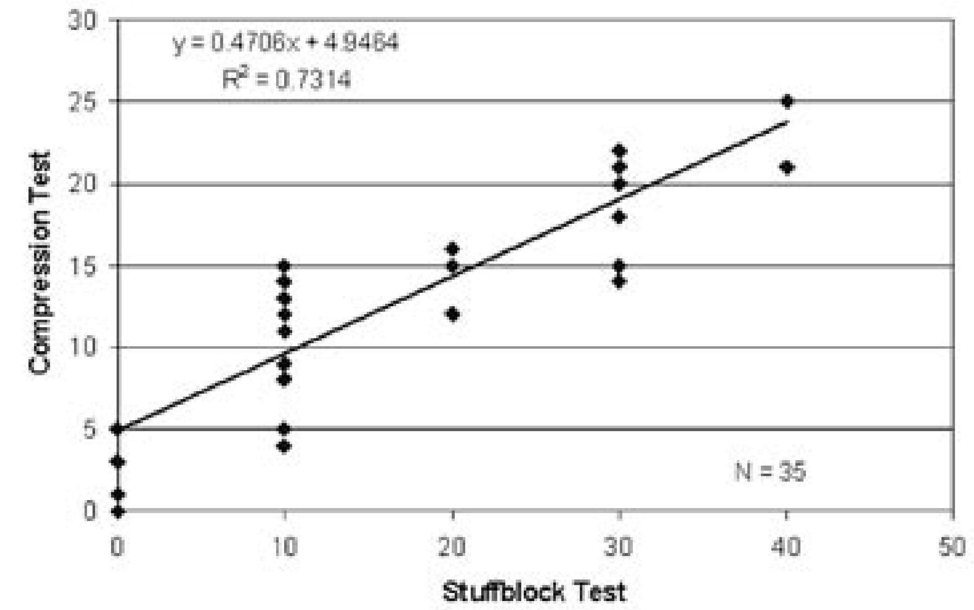
Our tests also revealed that although the shear frame, stuffblock, and compression tests all introduce rapid loading, often an easy shear was observed with the stuffblock and compression tests, yet the pull gauge would reach its maximum limit of 50 newtons force without shear failure. This suggests a difference between the dynamic shock of the dropped stuffblock (or tapping of the compression test) and the increasing static force applied with the pull gauge (or shovel shear test).

Stuffblock Test

Thirty-five stuffblock shears were compared against the compression test where a strong relationship was found (top of next page). The stuffblock test results were better replicated between observers than the compression test because of the consistency of the force applied (4.5 kg weight and increments of 10cm drop heights).

Comparison of these tests also revealed:

1) that stuffblock tests of less sensitive, or hard, shears appeared to reproduce more consistently than the compression test and,
2) that stuffblock tests of more sensitive, or easy, shears appear to suggest the stuffblock test may be a less sensitive test than the compression test. Part of the reason may be because easy shears are recorded only when the failure occurs with the static load of the stuffblock sitting on the isolated column tested (SB0) or with a drop height of 10cm (SB10) or 20cm (SB20). Very easy shears, that is, failure while isolating the column are recorded as SBV.



Stuffblock Test results measuring height of dropped weight compared with the number of taps of the Compression Test

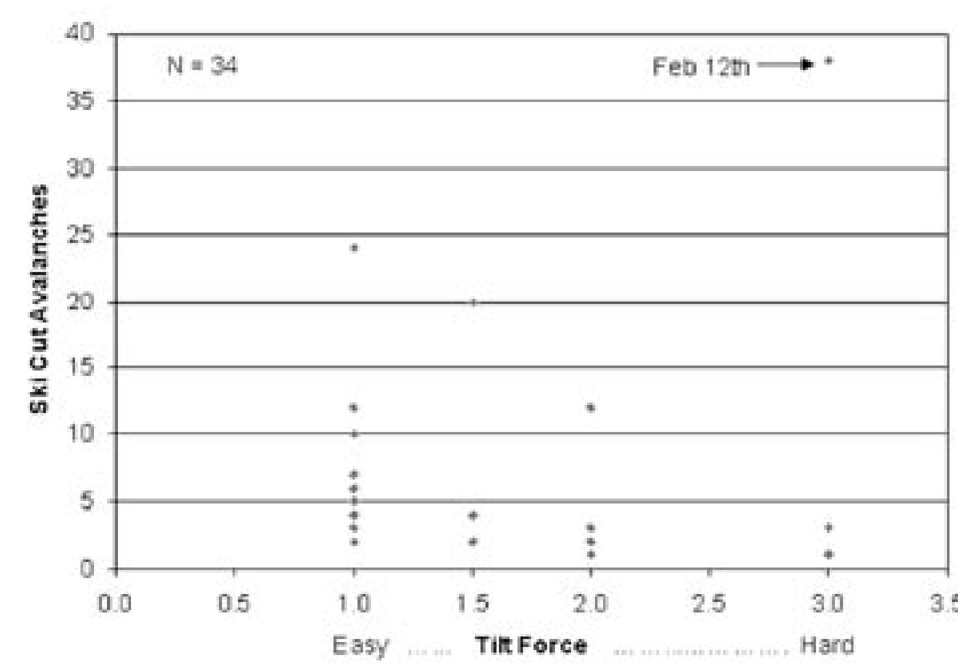
A SB10 was often recorded where the pull gauge would reach its maximum limit of 50 newtons force without shear failure. We were unable to test any SB20 or greater with the shear frame. Again this suggests a difference between the dynamic shock applied with the stuffblock and compression tests and the increasing static force applied with the pull gauge.

Tilt Board Test

Tilt board tests were conducted on 107 days. This was the second season using this stability test at Eaglecrest. The tilt board test was compared with 189 skier-triggered avalanches (Figure 5). We found this test to be a quick and easy method to obtain pertinent information about new snow slab and shear characteristics.

The tilt board test gives the avalanche forecaster an opportunity to quickly and safely test the top 40cm of the snowpack. While the test primarily identifies shear location, it also provides information about the bond between new and old snow, the weak-layer shear quality (Birkeland, 2003, Herwijnen, 2003), and the slab thickness and hardness. For example, a thick hard moist slab over a moderate to hard rough shear has operational consequences quite different than those for a thin dry soft slab over an easy smooth shear.

The tilt board test worked well with dry snow. Data scatter occurred with moist and wet snow. The outlier in the graph below occurred February 12 where a hard tilt was recorded along with 38 skier-triggered point-release avalanches. On that day there was 20cm of 260kg/m3 moist new snow on a melt-freeze crust. Similar tilt results occurred under similarly wet conditions on other days suggesting the need for further study of shears involving moist new snow and wet old snow.



Tilt Board Test and Skier Triggered Avalanches (0.0 = failure on isolation, 0.5 = failure on tilt, 1.0 = failure with one tap, 1.5 = failure on second tap, 2.0 = failure on third tap, 2.5 = failure on fourth tap, 3.0 = no failure with gentle taps)

CONCLUSIONS

While natural avalanches are the best indicator of instability, this study used the shear frame test to provide quantitative baseline data and focused on the shear strength of a weak layer relative to applied stress (mechanical instability).

Against shear frame data and observed triggered avalanches, this study compared stuffblock test results with compression test results and evaluated the suitability of the tilt board test as a simple method for avalanche forecasters to identify the properties of new snow and near-surface instabilities.

This study showed the stuffblock test compared well with the compression test and has good replication between observers. The tilt board test readily identifies shears with good replication between observers. However, the forces applied for the delineation of easy, moderate and hard shears needs further study.

The issue of stability tests using dynamic versus static loads also needs further study. Differences were observed in the stresses or forces applied to the weak layer between the static force of shear frame test and the dynamic force of the stuffblock test and tilt board tests.

In summary, this study showed the value of both the stuffblock and the tilt board tests for avalanche forecasters.

ACKNOWLEDGEMENTS

Funding for this project came from the University of Alaska Southeast Chancellor's Special Project Fund and the Eaglecrest ski area. We thank Bruce Jamieson for the shear frame specifications and Sarah Carter, Kanaan Bausler, Brian Davies and Brooke Munro for data collection and administrative support. The Canadian and American Avalanche Associations allowed Eaglecrest ski area to become the first American subscriber to the daily CAA Infoex data exchange. The Juneau Ski Patrol paid the Infoex fee.

LITERATURE CITED

American Avalanche Association, *Snow, Weather, and Avalanches: Observational Guidelines for Avalanche Programs in the United States*, 2004.

Birkeland, K.W., Johnson, R.F., 2003. Integrating Shear Quality into Stability Test Results. *Avalanche News*. Canadian Avalanche Association.

Birkeland, K.W., Johnson, R.F., Herzberg, D., 1996. The stuffblock snow stability test. *US Forest Service Tech. Rep*. 9623-2836-MTDC, 20 pp.

Birkeland, K.W., Johnson, R.F., 1999. The stuffblock snow stability test: comparability with the rutschblock, usefulness in different snow climates, and repeatability between observers. *Cold Regions Science and Technology*. Volume 30, Issues 1-3, December 1999, Pages 115-123.

Canadian Avalanche Association, *Observation Guidelines and Recording Standards for Weather, Snowpack and Avalanches*, September 2002, National Research Council of Canada Technical Memorandum No. 132.

Carter, S., Eaglecrest Weather and Snow Observations: Three Experimental Study Plots, Environmental Science Practicum 2004, University of Alaska Southeast.

Fohn, P.M.B., 1987. The stability index and various triggering mechanisms. In Salm, B. and H. Gubler, eds. *Avalanche Formation, Movement and Effects, International Association of Hydrological Sciences* Publ. 162 (Symposium at Davos 1986), 195-211.

Herwijnen, Alec van and Jamieson, B., 2003. An Update on Fracture Character in Stability Tests. *CAA Avalanche News*. Volume 66, Pages 26-28, (updated in 2004, Volume 68, Pages 38-41).

Jamieson, Bruce, 1999. The Compression Test – after 25 Years. *The Avalanche Review* 18(1), 10-12.

Perla, R.I. and T.M.H. Beck, 1983. Experience with shear frames. *J. Glaciology*, 29(103):485-491.

Perla, R., Beck, T.M.H., Cheng, T.T., 1982. The shear strength index of alpine snow. *Cold Regions Science and Technology*. Volume 6, Pages 11-20.

Schweizer, J., Lutschg, M., 2001. Characteristics of human-triggered avalanches. *Cold Regions Science and Technology*. Volume 33, Pages 147-162.

Schweizer, J., Jamieson, J.B., Schneebeli, M., 2003. Snow Avalanche Formation. *Reviews of Geophysics*, 41(4).

Schweizer, J., Jamieson, J.B., 2001. Snow cover properties for skier triggering of avalanches. *Cold Regions Science and Technology*. Volume 33, Pages 207-221.

Schweizer, J., Wiesinger, T., 2001. Snow profile interpretation for stability evaluation. *Cold Regions Science and Technology*. Volume 33, Pages 179-188.

Schweizer, J., Jamieson, J.B., 2003. Snow Stability Measurements, Seminar on Snow and Avalanche Test Sites, Grenoble, France, 22-23 November 2001, CEMAGREF Editions: 317-331.

Peter Carter_1,2, Matt Heavner_1, and Eran Hood_1
1 Environmental Science Program, University of Alaska Southeast, Juneau, Alaska
2 Eaglecrest ski patrol, Juneau, Alaska
Corresponding author address: Peter Carter, University of Alaska Southeast, Juneau, AK 99801; 907-364-2692; peter.carter@uas.alaska.edu

DISCONTENT

continued from page 13

spreads eastward to the South American coast, then wetter-than-average conditions would be expected in coastal sections of Ecuador and northern Peru during March-April 2005, and drier-than-average conditions would be expected to develop in Northeast Brazil during February-April 2005. Expected US impacts during northern hemisphere winter include warmer-than-average conditions in the West and in the northern Plains, and cooler- and wetter-than-average conditions for portions of the South and Southeast.

So are we confused yet? First there is no effect from El Niño and then there is an effect. I guess since no one seems willing to attribute the record-breaking weather (either drought or flooding) of this winter to any long- or short-range climatological oscillations of note other than the weak En Niño (with perhaps some enhancement by the MJO) – which really has no precedent for establishing or maintaining rex blocks (upper closed highs over upper closed lows) of this magnitude, we'd better hope that this current non-event just goes away. At least there is some hope here as the following synopsis of the February 10 CDC update indicates:

Synopsis: A transition from weak warm-episode (El Niño) conditions to ENSO-neutral conditions is expected during the next three months...Based on the recent evolution of oceanic and atmospheric conditions and on a majority of the statistical and coupled model forecasts, it seems most likely that weak warm episode (El Niño) conditions will gradually weaken during the next three months and that ENSO-neutral conditions will prevail during the last half of 2005.

At this point it should have become painfully obvious that long-range climatological forecasting is a still budding and largely mysterious science with each potential climate affecting oscillation superimposed upon and interacting in some fashion with every other. Quite simply though, our climate is as complex as any interaction between the ocean, atmosphere and cosmos should be. And unfortunately we have a rather limited database of unusual or abnormal events from which to predict future weather. If we had thousands of years of these events to study, or at least something more statistically significant than what we have, maybe we could start to draw more conclusive and more meaningful correlations. So wherever you are and whatever your weather is, enjoy it, because it just might continue or it might change into something really good – or perhaps something much worse!

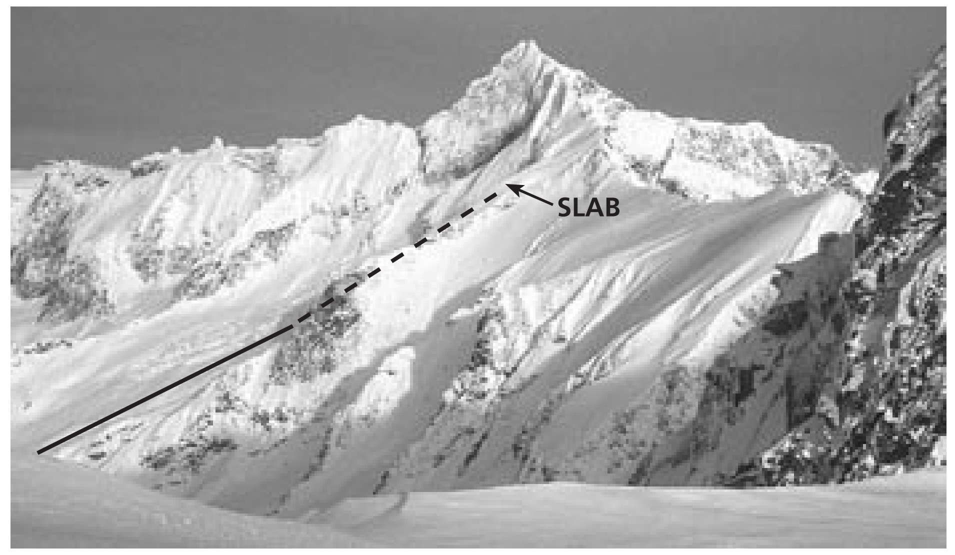
Mark Moore is director of the Northwest Weather and Avalanche Center. As of February 3, Mark is being asked to leave the Northwest for two weeks in hopes it will bring more snow. [Ed. Note: Apparently he didn't leave, as the dry weather persists…]

Jon Andrews is Avalanche Forecaster at the Stevens Pass ski area. As of February 1, Jon is shoeing horses with his wife and son and going riding in the Cascades where there is normally 10 feet of snow.

crown profiles

Observations on Faceted Crusts

Story by Gary Brill



Forbidden Peak, showing slab location and route. We were carried essentially the entire length of the route shown. *Photo by Gary Brill*

Oh, Boy, What a Surprise!

During the El Niño winter of 1997-98, temperatures averaged considerably above normal in the Pacific Northwest with periods of better-than-average weather. Snow depths at high-elevation sites were normal, and there were numerous periods of good and relatively safe powder skiing. During one such period, March 4-6, a friend and I skied the Coleman Glacier route on Mt. Baker. The skiing was great with 18" of low-density powder. Temperatures were very cold, near 0°F at higher elevations. By mid-March it had become quite warm. Precipitation amounts were seasonally light the entire month (see data table).

Conditions on Sahale

Freezing levels lowered somewhat beginning March 16. CJ and I began a trip to Boston Basin on March 19. We established a camp near tree line and then continued up the Quien Sabe Glacier for a late-afternoon ski from the summit of Sahale Mtn., 8715' elevation. Conditions were "early spring" – from corn snow at low elevations to a small amount of well-settled dry or wet snow higher up. By making an afternoon ascent we minimized skiing a troublesome crust on the WNW-facing upper part of the mountain. The plan went well: rains of a few days before and subsequent warm sunshine had consolidated the snowpack. Clear nights allowed for re-freezing, and below 6500' there was good corn skiing. Above, settled dry snow slowly increased, reaching perhaps 15" above 8000'. All evidence (pole testing and other field stability observations) pointed to a stable snowpack, although we didn't dig a pit. We crossed only one very small potential avalanche slope on Sahale under these conditions.

The Trip Up Forbidden

The following morning, we decided to take advantage of the good weather and ski up onto the SE shoulder of Forbidden Peak via the familiar lower part of the East Ridge climbing route. This route is moderately steep from a climbing perspective with a couple of short, steeper pitches. Far from being an extreme ski, it is nonetheless high and very alpine. Its main appeal was a bit of adventure and its terrific scenic vantage. An early morning traverse across Boston Basin required imaginative route-finding to minimize exposure to rock-hard, frozen snow. Near 6200' we began ascending directly towards the eastern part of the Taboo Glacier with 7-10" of crusted snow softening in warming temperatures. Climbing with ski crampons, we ascended an ever-steepening SW-facing gully, still hard-frozen above 7400'. Eventually the gully steepened and narrowed so much as to require a traverse onto a steep and lightly crusted, powdery, west-facing slope. We set our track to minimize exposure to this 40- to 45-degree slope, and at its top, near 7750', we had to remove our skis to climb another short but 40-45 degree, hard-frozen section of the gully. The temperatures were already warm at 10:30am, but I remember thinking that, with but a short way to go (8200' maximum elevation on skis), we were early enough to avoid wet-snow avalanche hazard. We put our skis on our packs, kicked steps up the final steep portion of the gully through frozen sun balls, and exited onto a narrow shoulder. At 7800', the aspect shifted to SE from SSW at a familiar, steep wind-scoop at the base of a large, rounded drift (permanent snowfield) which is the exit from the gully onto the gentler ridge above. We kicked steps up the 40-foot-high scoop, and then the angle kicked back to a little over 30 degrees. We were now boot-top deep in powdery snow which we felt was well anchored to a consolidated dry snow base (pole testing showed good strength and a settled structure 18-24" beneath the surface).

We each agreed that rather than change to skis mid-slope, we would continue another 200 feet to easy ground. CJ was breaking trail 10 feet above me when we heard a deep, muffled, and progressive "whumpf." We looked at each other, then after one to two seconds, I sensed movement and shouted dumbfounded, "It's going to go! Run!" Just 40 feet or so from safe ground, I began to climb rapidly up the still intact slab. CJ attempted to brace.

Riding the Wave

I managed 10-12 steps on the slab surface before a chest-high wall of snow hit me and immediately entrained me in its volume. Almost instantly I seemed to pour, as if in a waterfall, over a steep precipice on the west flank of the gully. I was forced along the bed surface of the track headfirst and facing downhill. In darkness, I put my hands and arms in front of me to protect me from objects I might strike in the rapid headlong descent. As the avalanche slowed to a moderate pace, I tried to twist about into the feet-first position, but my skis on my pack immediately forced me head-first. The ride was gentle, roller coaster-like, but I could feel considerable pressure from the snow.

Briefly, it got somewhat brighter, then as the slide began to slow to a crawl, it got very dark and the pressure became greater, immobilizing me. I thought, "So this is how it ends." Suddenly, I rushed over another drop-off, and in this instant, I gambled. Instead of making another futile attempt to pivot feet-first, I flipped so that I was still head-first, but facing up. I hoped that in this position my skis might plane to the surface. The risk was that if a second wave of snow were to slide over me as I stopped, I probably wouldn't have an air pocket. Still rushing rapidly, I began to move closer to the surface, as evidenced by more brightness. Finally, I saw the sun and distant peaks over my shoulders just before I stopped. I prepared to fight violently for air as more snow came over me, but it didn't. I was on the surface.

Dizzied by the ride, out of breath from being under the snow for more than a minute, and still pinned by the debris, but with my face and hands free, I assessed our situation. From the corner of my eye I could see CJ's skis some distance from me, though I doubted he would also be lucky enough to be ok. Still breathless, it took perhaps two to three minutes to expose my pack strap, unbuckle it, and sit up. Now I could see CJ's skis still on his pack perhaps 50 yards above me, but not CJ. Trying to think clearly, I turned my transceiver to receive, and it seemed to indicate CJ was near his skis. I removed my shovel from my pack and began to climb as rapidly as I could toward CJ's skis and pack, confirming the position of his transceiver a second time. When I reached the skis, I could see him lying head first, face down, pinned by the heavy snow covering much of his body, his pack, and his skis. He said, "Hey, buddy." I started to dig, slowly, carefully, to remove snow surrounding most of his face, then unbuckled his pack strap and helped him up. Somewhat in shock, we returned to our camp and skied out, minus poles and sunglasses.

The Avalanche - Why?

The avalanche began with a mild and progressive collapse and only very slowly began to move. It was a slab at least 2-1/2 feet thick, and because a four-foot wall of snow overrode the slab to strike me, quite likely four feet at its deepest. In one to one and a half minutes, we were carried about a half mile from nearly 8000' to just above 6500'. It entrained a considerable amount of snow along its path, cutting about two feet down into the snowpack along the lower part of the track. Because of the change of aspect, there was no reasonable, representative pit location available except in the middle of the slope that slid. So why did this avalanche take place?

In retrospect, the human factor is obvious. We incorrectly analyzed the conditions. The terrain was alpine, continually exposed to avalanche hazard. According to the new Parks Canada Avalanche Terrain Exposure Scale, this terrain would have been defined as COMPLEX: "Exposure to multiple overlapping avalanche paths or large expanses of steep, open terrain; multiple avalanche starting zones and terrain traps below; minimal options to reduce exposure. Complicated glacier travel with extensive crevasse bands or icefalls." In terrain like this, even a small avalanche is potentially fatal, and there are a lot of avalanche dragons. Nonetheless, this was far from an extreme ski, with the steepest terrain at 40-45 degrees where it was necessary to boot up. The majority of the terrain doesn't exceed 35 degrees, but all around are steeper couloirs, rock cliffs and faces.

This slope lies above the forecasting elevations of the regional avalanche forecasting center for Washington and Oregon, the Northwest Weather and Avalanche Center (NWAC). The avalanche forecast of LOW was not for terrain above 7000'. A review of the weather data indicates a couple of points of interest: the cold weather of early March (with light winds and sunshine), strong winds during subsequent storms that deposited moderate snow amounts leeward to create a hard slab, and a rise in freezing levels at the time of the accident. In fact the freezing level at the time of the accident was 8200-8700' at Quillayute on the coast, though most likely lower in the Cascades, This freezing level was higher than the highest preceding one of some 7300' on March 13. The stiffness of the windslab, accelerated creep from warming temperatures, and a faceted weak layer were presumably factors. The crunching, progressive whumpf sound this slab made as it broke at the weak layer is a familiar one from my travels in the Cascades; it is one that I've associated with a recently loaded, relatively weak crust. I'd always wondered whether this structure – a recent layer of new, relatively warm snow over a recent crust – could do more than collapse mildly, absent more loading or further weakening. The slab's slow acceleration, plus weather and terrain data, suggests to me a faceted suncrust that formed on the SE aspect of the failed slope during sun, without wind, late in the cold period, perhaps on March 6 or 7.

Thoughts on the Formation of Faceted Crusts

I have come to find faceted crusts particularly fascinating and complex snowpack layers. Crusts can develop subsequent to warming, solar effects, rainfall events, or rain changing to dry snow. They can be very strong and uniform over terrain, or very weak and spatially discontinuous. On first examination, it seems that they should have been once well-settled because of their mode of formation, but later, in avalanches, they often act unpredictably and unexpectedly. The wet snow that refreezes to form crusts initially results from warming temperatures, solar radiation from UV rays, absorption of re-radiated long wave radiation, or rainfall. Whatever the cause of the warming, one would think it should have settled the layer that eventually forms the crust, even if not the underlying layers.

What could flow better than wet snow? The wetter the snow and the longer the duration of the warm or wet period, the more one would expect the wet layer should settle. For instance, along the west coast, rainfall events can total 10" or even more. In recent years, these rains seem to be invading British Columbia more often, with rainfall in mid-January 2005 reaching at least to the top of Little Tahoma at 11,117' in the Cascades and reports of heavy rainfall to 8500' or higher in B.C.

Not surprisingly, rain crusts can be quite thick, with the February 2005 re-frozen wet layers reaching two-feet thick in Washington. Of course, crusts can also be quite thin, and on the lower end of the spectrum, barely discernible. Presumably, the saturated wet snow that re-freezes to form a thick rain crust must have settled a great deal during a major warm and wet event, yet even a thick crust can weaken through faceting at a later date. As it refreezes, and I believe this to be the key, a thick crust appears to stop (or at least slow) settling. In a recent snow profile, a crust had begun refreezing to become a 5"-thick pencil to 1F hard layer. Saturated wet snow beneath the crust was still 4F, gradually trending to 1F perhaps a foot below the crust. It appeared that the wet snow was slumping or settling away from the more rigid crust, lowering the density of the upper portion of the wet layers. Clearly, faceting was not yet occurring, because the snow beneath the crust was still wet and unfrozen (no ice). My understanding is that the snow beneath the crust continues to settle, but only by becoming pliable in warm temperatures, or by breaking, could a stiff crust be expected to settle at near the same rate as these wetter and more viscous underlying layers in the initial process of re-freezing.

At increasing depth below the crust, the wet snow layer becomes increasingly dense, hard and stronger. The wet snow beneath the crust appears to be settling from its own mass, with less settlement at the crust and more settlement in the wet snow below the crust. It is apparent that larger pore spaces exist immediately below the crust than at depth and should impede thermal conductivity in this region. The insulation of the saturated air in these larger pore spaces guarantees that the temperature gradient and corresponding vapor pressure gradient is greater in this region, even if temporarily.

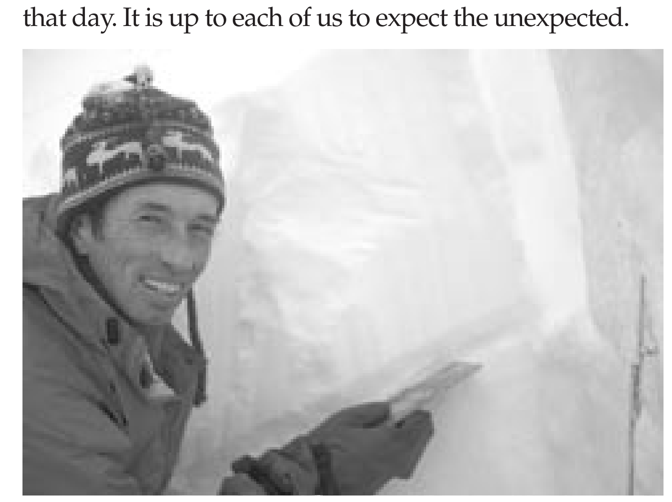
A vapor barrier effect has been suggested as a fundamental reason for faceting beneath a crust, and that may well be the case. But I have observed (as I am sure others have) that even in cases where the crust has weakened through faceting to the point of being porous (vapor barrier not intact), the faceting process can continue unabated within and beneath the crust. Less-efficient heat conduction in regions having low ice mass density seems to be part of this equation (see Mark Moore's 1982 ISSW paper).

Sun crusts and warming crusts are often much less dense and thick until late spring. They are even more problematic than thick rain crusts. The snow may remain cold beneath the surface as the surface snow warms, or remain subfreezing at the surface and warm beneath the surface from radiation absorption. The result can be very strong gradients on a micro-scale such as with radiation recrystallization, surface hoar formation, and diurnal recrystallization. Because these are near-surface layers, they often cool very rapidly after the warming through radiational cooling if skies are clear. Thin crusts often facet rapidly, and are so smooth, that they may fail in tilt tests before tapping. And they are stiff, rigid but weak. They can resist settlement with light to moderate loading at a non-critical rate, but can propagate energy for a long distance because of their stiffness. When they fail, they present a slippery weak layer of facets and may shockload any overlying slab, thereby causing the slab to fail in tension and release.

Variable Faceting Effects

The faceting process further differentiates or accentuates any differences in crust thickness or hardness. It is not surprising that, in many avalanche accidents, humans are not effective at dealing with such highly variable and unpredictable layers. Test results are effective only as long as the test results don't underestimate the instability within the release zone, and are most effective if some extrapolation to adjacent terrain is possible. Even a localized thin and faceted suncrust or raincrust can be a dangerously unstable weak layer when loaded by recent snows or weakened by warming.

In retrospect, only two choices or changes in behavior would have been successful at avoiding the Forbidden accident in my view: 1) A more accurate expectation of instability for the slope that slid, based on projections of spatial variability with aspect and altitude. The problem was that the only effective pit location would have been on the slope that slid. Or 2) simply making a more conservative terrain choice on that day. It is up to each of us to expect the unexpected.

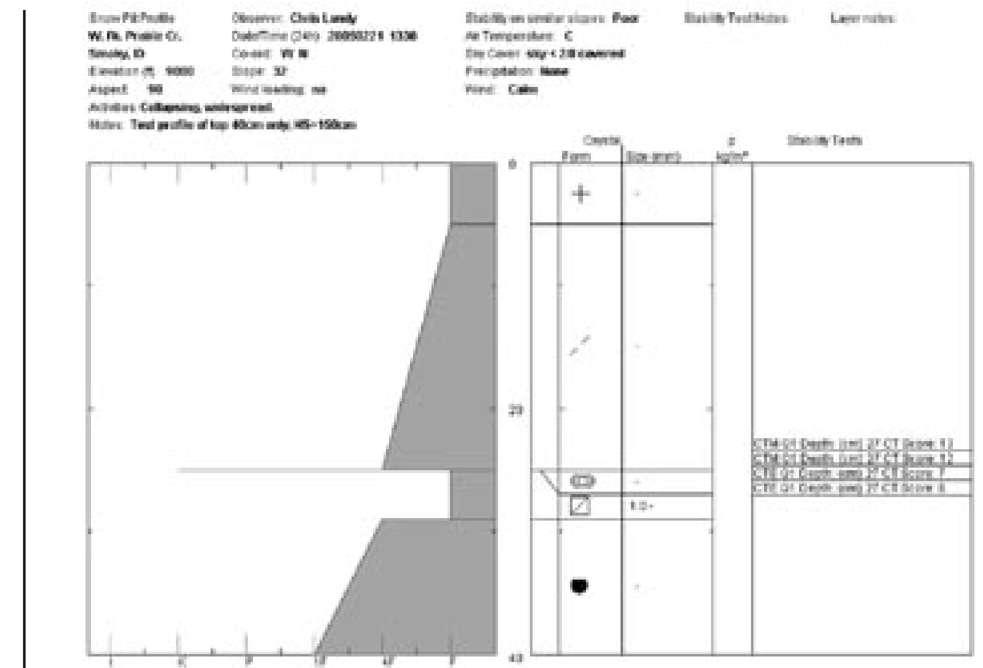


The author with a faceted melt-freeze rain crust. *Photo by Saskia Von Michalofski*

Gary Brill has worked as a climbing and ski guide since 1980 and as an avalanche educator since 1986. He is currently employed by Cascade Alpine Guides. He is also an active climber, off-trail hiker, and photographer. Gary continues to backcountry ski as often as possible and loves to seek destinations off the beaten track. ❄

The "Surprise" Data Table

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1				Mt. Baker - 4200'					Crystal Mtn. - 6800'					Average
2		Freezing Level		Temp.		W.E.	New	Total	Temp		W.E.	New	Total	1 hr. max
3	March	4:00 AM	4:00 PM	5:30	Sky	Precip.	Snow	Snow	Hi	Lo	Precip.	Snow	Snow	Winds
4														
5	1	4900	4300	30	O	0.53	12"	180"	32	26	0.30	5"	76"	26
6	2	3800	3200	31	O	0.70	9"	184"	29	14	0.74	4"	80"	29
7	3	2400	2300	24	O	0.35	9"	189"	27	14	0.13	5"	92"	13
8	4	2400	2600	19	O	0.13	T	189"	23	14	0.00	2"	90"	13
9	5	2900	2500	Mssg.	O	0.00	Mssg.	Mssg.	25	15	0.00	0"	90"	18
10	6	3100	3000	17	O	0.00	0"	189"	24	13	0.00	0"	89"	8
11	7	3100	2900	24	O	0.00	0"	189"	26	14	0.00	0"	88"	14
12	8	3800	3200	27	O	0.00	1"	189"	27	19	0.24	1"	92"	27*
13	9	3300	3200	30	O	0.24	7"	191"	27	22	0.56	2"	98"	27*
14	10	4200	7300	29	O	0.41	10"	195"	30	24	0.06	7"	95"	35†
15	11	6500	5800	36	O	0.25	T	195"	34	28	0.00	0"	92"	25
16	12	6500	8100	42	O	0.13	0"	195"	43	32	0.01	0"	89"	38#
17	13	7300	6900	40	O	0.02	0"	179"	45	33	0.00	0"	87"	26#
18	14	6100	6200	37	O	0.61	0"	173"	41	30	0.00	0"	86"	13
19	15	6100	5800	38	O	0.04	0"	173"	34	26	0.00	0"	85"	5
20	16	5700	3200	30	O	0.30	2"	170"	26	17	0.29	2"	87"	9
21	17	3400	3600	25	O	0.37	T	170"	30	18	0.00	0"	85"	10
22	18	4700	5200	30	O	0.00	0"	170"	40	23	0.00	0"	84"	7
23	19	8200	8700	30	O	0.00	0"	170"	44	27	0.00	0"	83"	13
24	20	8000	7400	37	O	0.00	0"	165"	51	34	0.00	0"	82"	8
25														
26	KEY:	O Clear		O PC		O Cloudy		O Overcast				O Obscured		
27														
28	Notes:	1) Precipitation water equivalents at subfreezing temperatures yield ten times or more												
29		as much snow and are a good indicator of load.												
30		2) The new snow totals at Mt. Baker are thought to be exaggerated.												
31		3) Freezing levels are at Quillayute on the NW tip of the Olympics. Snow levels in the												
32		Cascades average 1000' lower than the freezing level and may be much lower												
33		when east winds blow through the passes.												
34		4) Because this is a high elevation study, temperature and wind data from the higher												
35		elevation site (6800') at Crystal Mountain may be useful.												
36		5) Winds are maximum one-hour sustained winds in a 24 hour period												
37														
38	* On 3/8 and 3/9			SW winds remained above 20 mph for a 12 hr period										
39	† On 3/10			E winds were stronger than 20 mph for a 12 hr period										
40	# On 3/12 and 3/13			SE winds blew between 20 and 35 mph for a 28 hr period										
41														
42														
43														



Test profile of the top 40cm of the snowpack performed a half hour prior to triggering the slides. The pit was on a small roll of similar aspect but 250m lower than the avalanches.

Conspiracy Theory

Story by Chris Lundy

On February 21, 2005, I was skiing through rolling terrain at the head of the West Fork of Prairie Creek, in the Smoky Mountains northwest of Ketchum, Idaho. For about 2km I experienced continuous collapsing – the kind you can feel and hear rumble off into the distance. Digging a quick test pit on an east-facing, 32-degree roll at 2700m (9000'), I found 25cm of new and decomposing snow on an eggshell-thin melt-freeze crust. Beneath the crust there was 4cm of near-surface facets that produced easy/moderate compression test scores with Q1 shears (see profile).

At about 2pm, following one of many more collapses, I watched a small avalanche initiate on the ridge above me, then saw two avalanches, and eventually I lost count as several more small, unconnected pockets on the same ridge avalanched. All told, I remotely triggered seven small avalanches D1-D2 in size, 25-30cm deep, and up to 15m wide (see cover photo). The trigger point was 70m from the base of the slope. The starting zone faced east through northeast at an elevation of 2950m (9800'), and the slides ran up to 150m vertically.

Never before have I seen such tremendous instability capable of producing so little. Usually collapsing and fracture propagation over great distances are associated with large slides. On this day, several factors conspired to create a unique situation where an extremely obvious and acute instability was just barely capable of producing avalanches:

- A widespread layer of near surface facets formed during a month-long dry spell prior to Valentine's Day. Strong diurnal temperature fluctuations on easterly aspects caused these grains to develop striations in some locations.
- Warm daytime temperatures during the dry spell also formed a variety of thin crusts above, below, or sandwiching the facets. In the location where I did the test pit, a thin crust formed the interface between the recent snow and the facets. Anecdotal evidence suggests that a crust adjacent to facets or surface hoar accentuates the propagation capabilities of the weak layer.
- On Valentine's Day, this area received 20-25cm of low-density snow, with another 5cm falling nearly a week later on the night prior to my tour. It was our consensus at the Avalanche Center that this was not providing a sufficient slab to overload the facet/crust layer, especially in the absence of wind. Avalanche activity was limited to very small pockets in wind-loaded areas where the slab was slightly thicker and more cohesive.

When I fractured the weak layer in the flats, it propagated up into the ridge above me and then rippled about 200m across the slope releasing small slides in its wake. Why didn't the whole ridge avalanche? From prior observations I believe the weak layer was continuous and widespread, and that the most plausible explanation is that the slab was just a little thicker in the areas that released. As the weak layer fractured these pockets had just enough mass to succumb to gravity.

- February 21 was markedly warmer than previous days. The high temperatures at 3000m (10,000') during the two days previous had been –5°C (23°F), and the skies had been cloudy. The day I triggered the slides, the high was –1°C (30°F) under fair skies. Changing slab properties may have increased the propagation potential of the instability.

Diminish just one of these factors and I'm convinced the collapsing and remote triggering wouldn't have occurred, and this would have been just another ho-hum day on a low snow year. But like the JFK enigma, I'm left only with theories, and I'll never know which of these factors pulled the trigger.

Chris Lundy recently moved to Ketchum, Idaho, to work as an avalanche forecaster with the Sawtooth National Forest Avalanche Center. Prior to moving to Idaho, he spent 11 years in Montana studying under the avalanche masters in Bozeman, patrolling at Bridger Bowl, avalanche forecasting in Glacier National Park, and pursuing other, less productive activities. His masters research focused on validating the Swiss SNOWPACK model and sequential CT scanning of faceted snow. Chris is currently saving money for a condo in Sun Valley and a Mercedes SUV. ❄

"There's no substitute for watching an avalanche fall."

—Ed LaChapelle on early avalanche experiments. Bozeman, MT, Feb 4, 2005

"Avalanches don't like people watching them."

—Colorado Avalanche Information Center Intern Susan Hale during the memorable January 8-15 avalanche cycle on Red Mountain Pass

In January, three class-five avalanched ripped out of Elk Point, running over 4000'. *Photo by Bruce Tremper*

Utah Avalanche Center: Winter 2004-05

Unusual Conditions bring Unusual Avalanches

OCTOBER— After a few early storms in September and October that brought snow to the mountains, winter kicked into high gear on October 1 with measurable snow falling every day but one through Halloween. Alta ski area recorded a phenomenal 122" of snow over those two weeks with 14.85"of water. Much of the deluge came in warm on a southwesterly flow which evenly blanketed the northern mountains, but kept the snow levels around 8000' and higher. We looked back to the old Atwater/LaChappelle records dating back to 1945 and confirmed that not only did we smash snow and water records for October, but did so in just two weeks! We went through a couple small natural cycles, but for the most part, instabilities settled out rather quickly. Also of note was a rime crust deposited on the 29th, which factored into a number of the slides around the turn of the month.

NOVEMBER— If October went out like a lion, November came in like a lamb. Except that it stayed that way for most of the month. Snow and water totals at Alta were a paltry (by comparison) 59.5"/4.51", leaving us feeling like we'd started the first course with the most expensive champagne one can buy, only to chase it with a Utah-grade Budweiser. Clear skies and cooler temperatures kicked in the faceting process on the surface and provided the northern mountains with at least one and, in some areas, two layers of surface hoar. The faceting on the surface allowed the skiing to remain good for much of the month as we thanked our lucky stars for the prodigious early and dense snowfall that prevented depth hoar from forming at the base of the snowpack. A couple of back-to-back storms just after Thanksgiving added over 40" of snow on top of the weak surface snow and the party started. The danger quickly jumped to High, with numerous natural and human-triggered slides occurring in the backcountry during this cycle. The instabilities remained persistent as human-triggered slides occurred every day into early December, ahead of the next blockbuster storm.

DECEMBER— From December 7-9, an unusually warm, moist, and windy storm slammed the mountains of northern Utah with over 40" of snow and nearly 7" of water weight. Accompanying winds were sustained at 25-45mph out of the southwest and west, prompting our office to issue an Avalanche Warning on the 8th and keeping the danger at High or Considerable for the next several days. Not surprisingly, the heavy snow and strong winds made for perfect avalanche conditions, falling on the thinly buried November facets and surface hoar, and our first major cycle of the year was under way. Unfortunately, the old aphorism about most avalanches occurring during the storm and most avalanche incidents occurring on the first few sunny days after the storm held true. Between December 10 and 11, we recorded four fatalities in three separate incidents with two very near misses. On December 10, a 24-year-old skier triggered and was killed by a 1-3' deep avalanche while traversing back to Twin Lakes pass. The next day, two snowshoers were killed in upper Mineral Fork of Big Cottonwood Canyon as a large avalanche engulfed them in the valley bottom. It was not known whether it was a spontaneous avalanche or whether they triggered the slide from below. Also on the same day, 40 miles to the east in the Uintas, a snowmobiler triggered and died in a very large avalanche above Strawberry Reservoir, in a drainage called Trout Creek. Up north in the Bountiful mountains, a snowmobiler filming his friend riding up a steep slope was buried in a large slide triggered by his friend. Buried for 20 minutes and losing consciousness, he was extricated, resuscitated and survived with minor injuries. Backcountry recreationists continued to trigger avalanches until the 13th. Most of these were 1-4' deep and a couple hundred feet wide, many were remotely triggered, with some taking out the previous run's tracks.

Avalanche forecasters examine an avalanche fracture in Dutch Draw. This is just half of an avalanche that killed a snowboarder on January 14, 2005, Wasatch Range, Utah. *Photo by Bruce Tremper*

A day after Christmas, a strong southerly flow developed, literally shaking the Wasatch with sustained 30-40mph winds along the ridgelines and even damaging most slopes at the mid-elevations, making the snow-surface conditions complex with crusts and patches of weak-faceted snow on the more protected shady slopes. Heavy snowfall began on the 29th and lasted through the 2nd, with snow and water totals of 68"/6.83". Favored by this type of flow, the southern end of the Park City ridgeline took the brunt of the storm, and by the 30th, we had issued a Special Avalanche Advisory with a HIGH danger in the backcountry. A natural avalanche cycle was underway with the strong southerly winds with a few notable very close calls following into the New Year.

JANUARY— The most notable incident occurred on the 1st in the Hell's Canyon area, an out-of-bounds area adjacent to the Snowbasin ski area. A party of four entered this steep northerly facing slope, triggering a 1' by 400' wide avalanche, carrying three of them nearly 2000' down the path. They made a large withdrawal from the karmic bank as none of the individuals were wearing transceivers and miraculously ended up only partially buried. One sustained a fractured femur and pelvis. Each was able to extract themselves from the debris only to straggle out of the way as another ski party triggered an even larger avalanche down upon them. Over in Park City, ski patrol teams were finally able to get up into the higher terrain and reported slides up to 12' deep off the Jupiter ridgeline taking out trees in the runout zones. And as icing on the cake, dormant layers of faceted snow became reactive as three slides broke into old snow, with one lucky snowboarder escaping with only a knee injury after washing over some cliffs in the Brighton backcountry. Another monster, triggered remotely on the Park City ridgeline was 2-4' deep and 300' wide, taking out the entire bowl.

After a few days to catch its breath, the next series of storms on a southwesterly flow pushed into northern Utah with storm totals of 47"/1.97" from the evening of

Continued on page 20 ➡

Recreation and Avalanche Hazards in the Western Uinta Mountains

Story and photos by Dave Ream

The Uinta Mountains are situated just south of the Wyoming border in the northeast portion of Utah. The range is a broad uplift that runs east to west, which is rare for mountain ranges in the U. S. The range is also very old; the exposed, highly glaciated, Precambrian shale and quartzites at the tops of the peaks date back almost 560 million years. The millions of years of erosion have shaped a range of large plateaus capped off with steep weathered peaks of Uinta Purple Quartzite.

The range is approx 150 miles long, 35 miles wide and contains approximately 3,300,000 acres. 460,000 acres in the core of the range is managed as wilderness. The area is managed by the Wasatch-Cache and Ashley National Forests. The western side of the range, where Craig Gordon and I work, is bisected by the Mirror Lake Highway which winds its way 78 miles from Kamas, Utah, to Evanston, Wyoming, crossing over two 10,700' passes nestled between the many jagged peaks. During summer, the highway allows people to quickly access the high country and any one of a number of great hikes to the top of the 11,000' to 12,000' peaks surrounding the Mirror Lake basin.

In the winter, this highway allows the same quick access, though to some formidable and dangerous avalanche terrain. Twice a week during winter, the state of Utah grooms this highway and Forest Road 056 running 30 miles south into the Strawberry River basin. This grooming provide a 100-mile, silky smooth corridor for mainly snowmobilers to access enormous riding areas where they can test their skills. Boondocking through the snow-covered meadows and forested areas is popular. So is highmarking large, steep avalanche-prone bowls, faces, and chutes and playing in the runout zones of these features.

For the last three years, Craig Gordon, with his unique and educational forecasting style, has kept track of and reported on avalanche happenings on the western side of this large and unique mountain range for the Utah Avalanche Center. This winter, between the hundred or so "Know Before You Go" avalanche education programs he teaches and his five-day-a-week avalanche forecast, he has been a very busy boy.

Luckily for Craig, he has a hard-working group of partners made up of seasoned Forest Service employees, local catskiing guides, ski patrolmen, retired forecasters, and local snowmobile clubs, along with several very experienced backcountry skiers. This last winter all of these folks helped with the forecast, gathered observations, and kept our one remote weather station running when its mast snapped in half during our major wind event last January.

The weather in the Uintas is unique. The east-west orientation of the range presents a very different profile to storms coming from the north and the south than the north-south orientation of the Wasatch just 20 miles away. We tend to see better snowfall on southerly flows than the Wasatch, which tends to see better snowfall with a northerly or northwesterly flow. The Great Salt Lake has a lot to do with this pattern, feeding copious amounts of water vapor into approaching storms before they slam into the Wasatch. This winter, the Uintas and Wasatch had a huge two-week wind event that led into a correspondingly huge and deadly avalanche cycle.

The snowpack in the Uintas is continental, much like Colorado. The Uintas receive less snow and are slightly colder than in the Wasatch, but like the Wasatch they still have the greatest snow on Earth – just a little less of it. Depth hoar on the ground and buried near-surface facets sandwiched between layers throughout the snowpack are common. We routinely see very low rutschblock block scores with failures at the ground.

Unfortunately this winter, we had our first avalanche fatality since Craig began forecasting in the western Uintas. An experienced rider and his partner failed to recognize the obvious signs of instability and rode straight into a narrow steep basin, triggering a very large slide that buried one of them. Unfortunately again, his partner did not have a beacon and after several minutes of futile probing with a tree branch, the partner went to find help. By the time he returned with help and they found the victim with a beacon, it was too late.

We still often see experienced riders without beacons and shovels, so it's heartening to see the new beacon-basin park at Noblitts trailhead being used regularly now. [Ed. Note: See article on page 4 in the **What's New** section of this issue] Noblitts is one of the larger, more popular snowmobile trailheads in the area. Two other beacon parks were also installed this winter at Snowbird and The Canyons by the Wasatch Backcountry Rescue group. All of these beacon parks are generating lots of interest, and between these three we now regularly see snowmobilers, snowboarders, and backcountry skiers practicing their beacon skills. This change is a good thing; I am constantly amazed watching snowmobilers center-punch large bowls or diving headlong into steep narrow chutes with reckless abandon during or right after a storm. I'm very impressed with the riding skills these people display but not necessarily with their judgment.

Luckily, during the big avalanche cycle in the Uintas this last January, the machine the state uses to groom the highway was broken down. The deep snow and large wind drifts made it nearly impossible for anyone to ride very far from the trailhead. I believe this kept many riders close to home and off of the steep terrain when the mountains around here were coming apart at the seams.

Dave Ream began trying to understand avalanche phenomena after taking a couple of exciting rides skiing the backcountry around Jackson Hole, where he grew up during high school. He patrolled at Alta for more than a decade then worked as a Forest Service Snow Ranger in Little and Big Cottonwood canyons for another 10 years. He helped Bruce Tremper with avalanche planning for the 2002 winter Olympics in Salt Lake City and now works as a recreation manager on the Kamas Ranger District for the Wasatch-Cache National Forest. ❄

Craig Gordon and Ted Scroggins discuss the next forecast while admiring the view.

Above: Large, full-depth release last January off Murdock peak affects a popular snowmobile play area.Below: Riders' highmarks on the same path.

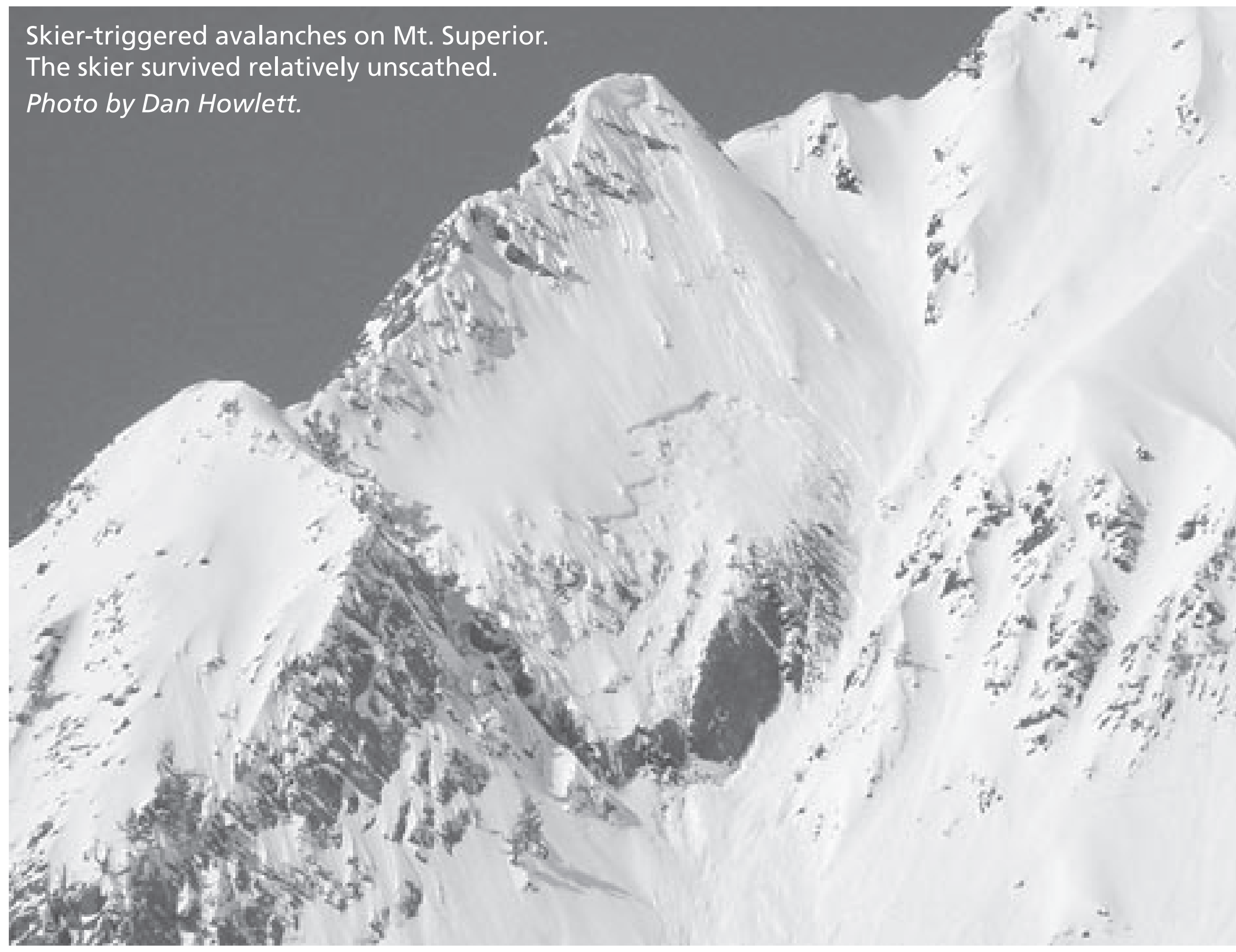
Craig stands atop a rutschsblock; it failed on depth hoar after his second knee flex.

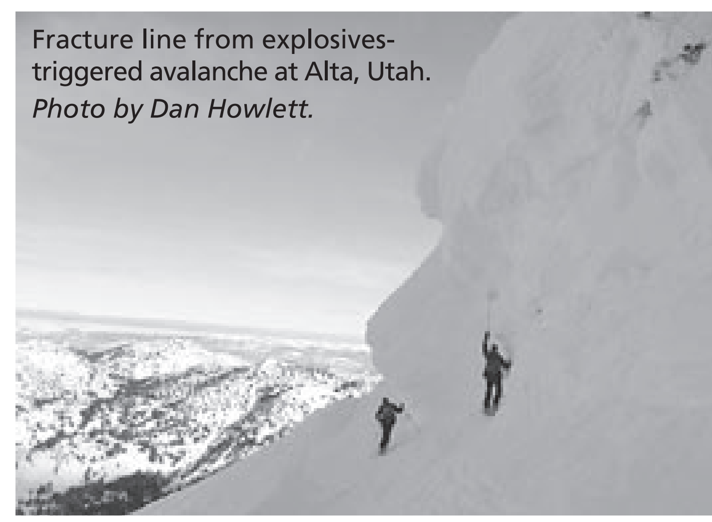
Craig examines a persistent weak surface-hoar layer in a pit off the Mirror Lake Highway.

UAC WINTER

continued from page 18

the 3rd until the afternoon of the 6th. The snow fell right side up with storm densities an amazing 4-5%! Those out playing in the mountains said it was the best snow of the year. Again. Halfway through the cycle, a skier triggered a deep slab in Main Days and was carried nearly 1000' down to the flats, apparently unscathed. This was only a portent for things to come with the next series of storms through the 12th. Between January 7 and the morning of the 12th, another wet heavy storm on a southerly track slammed the Wasatch with 52"/7.78". Strong southerly and then westerly winds accompanied the onslaught, and by the afternoon of the 7th, the danger jumped back to HIGH. Two days later, a snowmobiler and snowboarder died in separate incidents on the Wasatch Plateau not 20 miles apart within an hour of each other. By the morning of the 10th, the Provo mountains shed much of their winter coat during a widespread natural avalanche cycle. With control work, Slide Canyon crossed the Provo Canyon road three times, Bridal Veil naturalled into and then dammed the river, and three class-five avalanches ripped out off of Elk Point, running over 4000', taking out mature timber and obscuring the lower part of the alpine loop road. Things were only beginning. Between the 11th and 16th, natural, human- and explosive-triggered avalanches pulled out avalanches down to the faceted snow from November up to 10' deep, with some running half a mile. Finally, with good weather on the 13th, one could see the aftermath and carnage from one of the most dramatic cycles in years from Provo to Logan. Hundred-year-old trees were taken out, alpha angles were recorded less than 20 degrees, new avalanche paths were created, and even the oldtimers were left scratching their heads. Control work pulled out 4-7' deep avalanches in heavily compacted terrain, with one naturalling down to the same faceted layer overnight at one of the ski areas. On the bluebird afternoon of the 14th, a tragedy occurred in Dutch Draw that made national news. In a backcountry area adjacent to The Canyons resort, a skier triggered a 6-8' deep avalanche 700' wide that consumed him and an unknown number of others on the slope and down below. As of the 16th, only one individual was confirmed dead with a possible four or five more thought to remain buried in the debris. Search and rescue efforts continued for another couple days until the sheriff's department determined that no other bodies were believed to be buried in the slide. High pressure built for the remainder of the month as the dreaded January inversion capped the valleys with smog while the bluebird sang the approach of our second corn cycle of the year.

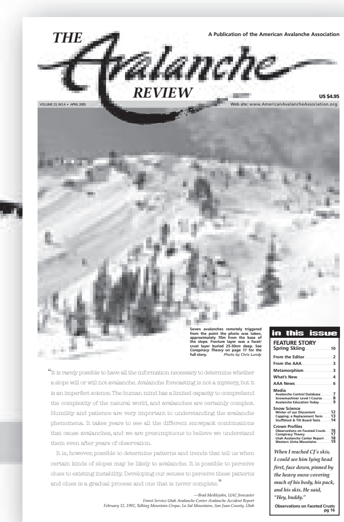

Skier-triggered avalanches on Mt. Superior. The skier survived relatively unscathed. *Photo by Dan Howlett.*


Fracture line from explosives-triggered avalanche at Alta, Utah. *Photo by Dan Howlett.*

THE Avalanche REVIEW

A Publication of the American Avalanche Association

VOLUME 23, NO. 4 • APRIL 2005



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