COLORADO DEPARTMENT OF NATURAL RESOURCES

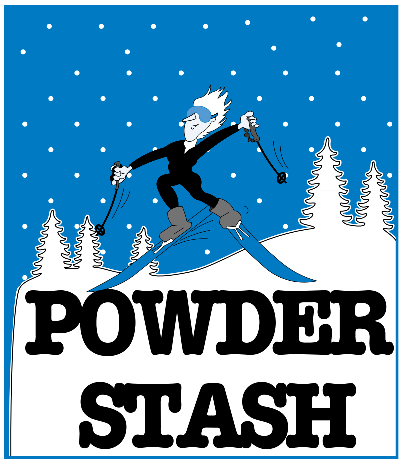
A Newsletter for Friends of the CAIC

Winter 2002 ❄ Volume 6 Number 2

THE Beacon

"Avalanches can not be readily subdivided, reconstructed, or reduced in laboratory scale… They are best observed in their native habitat, and this is an occupation something like trailing a wounded African Buffalo."

—Monty Atwater



by Scott Toepfer

We are now in the heart of winter, but back in November there were many nervous people in Colorado, waiting for summer to change over to winter. That has become a yearly phobia as everyone from dishwashers to executives freaks out when there is no snow by Halloween. It's as though we can't get to winter fast enough. Of course we always do, and this season has been no exception. Significant snow on the ground in early November is the exception, not the rule. Without snowmaking it was generally into December before ski areas could open any runs at all.

There is no escaping that we live in the desert southwest; the weather is just nice most of the time. That is part of the attraction to living in Colorado. Honestly, a couple more bike rides, a beautiful fall hike to timberline, a few extra casts into the riffles: not too harsh a price to pay while we wait for winter to hit. But as any snow fanatic can tell you, spring is the best time to be out there anyway. Still, it doesn't hurt to "Think Snow."

On November 28 the first avalanche fatality of the season in Colorado (2nd in the US) was reported from the Rollins Pass area west of Boulder. Two men had been skiing a slope that dropped on to the shores of Yankee Doodle Lake. Not only was this another tragic accident, it is also one of the most amazing stories of survival I have ever heard. Here's what happened.

After taking several runs on the same slope for the last two days, two Boulder County residents started another run. As the first skier stopped in what he thought was a safe spot, he turned to watch his partner, and at that moment a large hard slab released and carried both men about 600 vertical feet onto the 10-inch-thick ice of Yankee Doodle Lake. The force of the slide was so great that the ice fractured and a 12-foot-high wall of water crashed onto the far shore. Both men were submerged in the frigid water; only one survived.

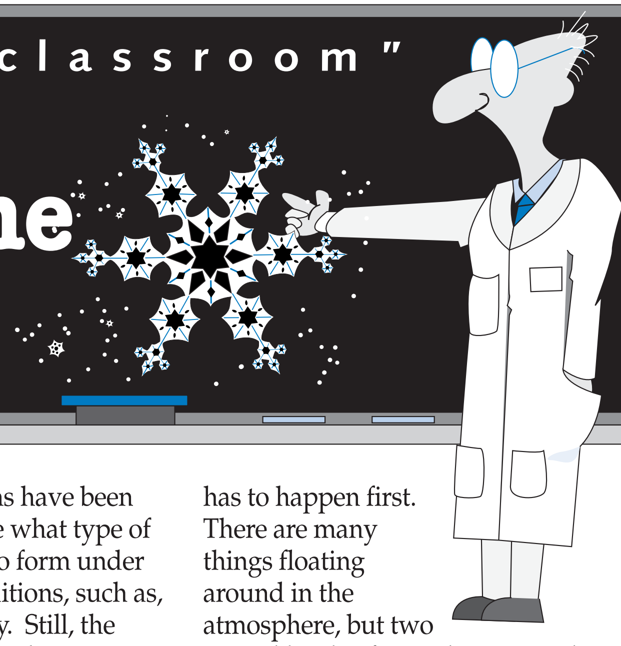
The survivor was actually the man further towards the center of the lake, about 190 feet from shore. He somehow managed to climb and swim through the fractured ice and crawl onto the far shore. He turned his beacon to receive but could not pick up a signal from his friend's beacon. He also could not call for help as his cell phone was completely water logged. After searching for a bit he then amazingly hiked about 5 miles to the Eldora Ski Area where he met up with Professional Ski Patrollers heading out for sweep at the end of the day. The ski patrol alerted Alpine Search and Rescue and a full scale rescue attempt was mounted. The survivor was then hospitalized and treated for frostbite and hypothermia. You can find more details and photos on this and other avalanche incidents on our home page (www.geosurvey.state.co.us/avalanche).

This lake and the same avalanche path have met on at least one other occasion. Peter Birkeland, a Friend of the CAIC and father of Karl, one of the leading avalanche researchers in the United States, had reported a slide into the same lake several years ago and had photos of large ice chunks washed well up onto the far shore. The November accident brought about the sixth death known of an avalanche victim swept into a lake or river, in the U.S. since 1950. ❄

“professor flake’s classroom”

Snow Crystal Formation in the Atmosphere

by Scott Toepfer



I think Henry David Thoreau said it best back in 1856: “How full of creative genius is the air in which these are generated! I should hardly admire them more if real stars fell and lodged on my coat.”

In our last issue of *The Beacon,* Professor Flake looked at the appended history of snowflake research from around the world. It wasn’t until 1929 that scientists started to connect atmospheric conditions with type of snow crystal produced. Ukichiro Nakaya was pretty much the first person to really do research into all the aspects of snow crystal formation in the atmosphere. Professor Nakaya of Japan conducted research through the University of Sapporo at two field stations, one at Sapporo, and the other at Mount Tokachi, which is located near the center of Hokkaido Island.

Since that time many people have looked into the nature of cloud physics, a daunting task given the user-unfriendly laboratory associated with clouds in the atmosphere. There is still much to be learned, but several graphs have been developed which describe what type of snow crystal is expected to form under various atmospheric conditions, such as, temperature and humidity. Still, the atmosphere remains a complex environment; there are many more secrets to be discovered before we are able to forecast more accurately.

For snowflakes to form, certain criteria must first be met. All snowflakes, rain drops, hail pellets, all precipitation, first starts out as water vapor in the atmosphere. If enough water vapor gets together and cools sufficiently via lifting, a cloud will form. The higher altitude the cloud, the more likely it will be composed mainly of ice crystals. Outside of the tropics most clouds around the earth consist primarily of ice particles (1). If the air close to the earth is above freezing, most likely these ice crystals will become raindrops before they hit the earth. In January it is highly unlikely that rain will fall in Colorado’s mountains.

Even with cold temperatures, water may not necessarily freeze at 32° F (0° C); something special has to happen first. There are many things floating around in the atmosphere, but two special kinds of particles are condensation nuclei and freezing nuclei. These nuclei act as catalysts for vapor to condense into droplets, and for droplets to freeze into ice crystals, without being cooled to extreme temperatures. The freezing kind is much rarer the condensation kind. At about 14° F (-10° C) there are about 10 active freezing nuclei per cubic centimeter; at -40 (-40° F is equal to -40° C) water droplets will freeze by themselves without the aid of a freezing nuclei (3). Things like dust and chemical pollutants have the correct molecular structure so that water vapor and droplets will coalesce, grow and fall as rain, but snow crystals require a special particle. Snow crystals need an incredibly small, molecularly-correct speck to which they will freeze and grow. These freezing nuclei vary in relation to air temperature too, making the whole process even more complex. Even after snow crystals have grown larger and their weight should help them to fall to earth, clouds will still not readily release their bounty. Snowfall does not come easily, but eventually, thankfully, it does.

For powder addicts the best fix is dry light powder. In Colorado snow can contain as little as five-percent water, making our mountains about the best den in the world for powder. The best crystal type for satisfying this special addiction is the stellar dendrite. The word dendrite comes from an old Greek word that means “branched like a tree”.

Groups of stellar dendrites make up snowflakes. (In 1887 a snowflake was measured at 15" across in Fort Keough, Montana (2)). The biggest dendrite crystals form when the air temperature is about 5° F (-15° C). These crystals typically form thousands of feet above the ground so air temperatures at the ground are generally around 20–25° F (-7 to -4° C). ***See Figure 1.*** As a rule of thumb, 14" of this type of snow would melt down to about an inch of water (i.e., 7% density snow).

Another type of snow crystal, much simpler in shape, is the needle. This type of snow crystal forms when the air temperature is from 20–25° F (-7 to -4° C). ***See Figure 1.*** Needles compact closer together than stellar dendrites, so the density or percent of water will be greater. There is some speculation that needle crystals will form a more slab-like snowpack. In this instance 10" of needles will measure close to 1" of water, or 10% density.

There is also this to consider: needles develop around 23° F (-5° C) and snow crystal formation increases multi-fold as temperatures drop. For example, more

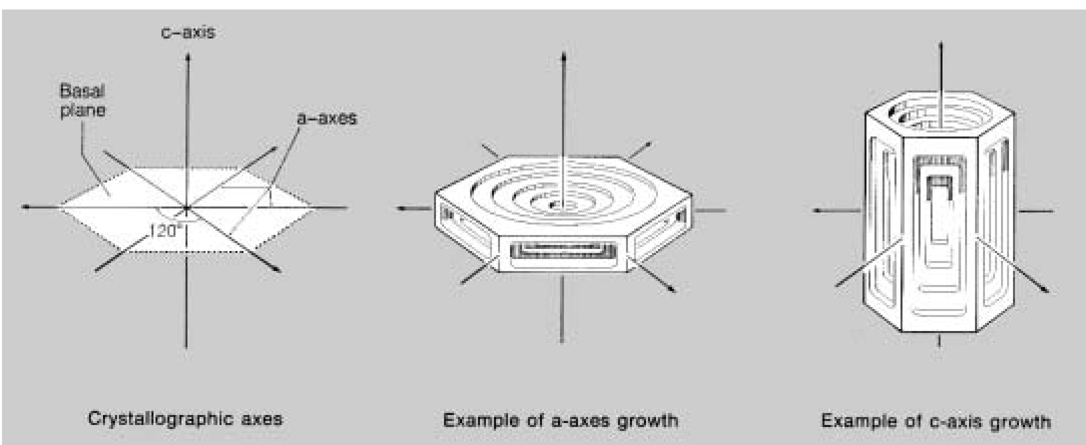


Figure 2. (3)

than a thousand times as many crystals form at -31° F (-35° C) as at -27° F (-33° C). Of course as the air gets colder there is less available water vapor so snow crystals tend to get smaller. When it is really cold we call these small snow crystals "diamond dust," and they contribute to forming optical phenomena called halos and sun dogs (2). It never really gets too cold to snow (e.g., Yellowstone National Park has reported measurable snow at -20° F (-29° C) and colder) but amounts are negligible at very cold temperatures (1).

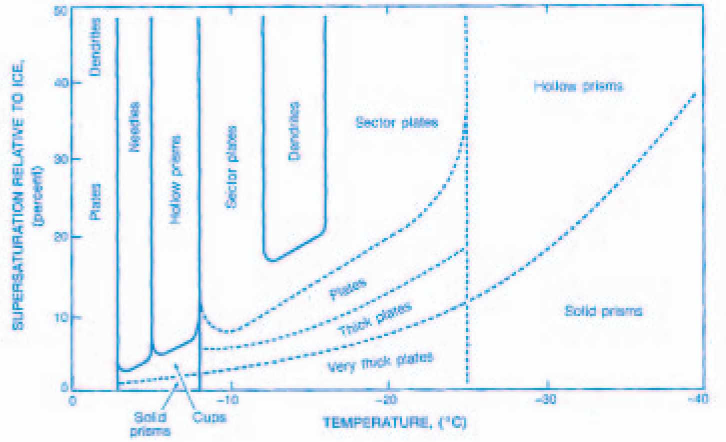


Figure 1. (4)

It is probably true that no two snow crystals are alike. Take for example this scenario, from *Sky Watch: The Western Weather Guide:* "Each snowflake is made up of thousands of billions of billions (sextillions) of water molecules that can be arranged in quadrillions of septillions of centillions of ways. The number of flakes that fall annually on earth is in the sextillions—far, far fewer than the number of possible different flakes. So it's likely that in the entire lifetime of our planet, there will never be a snowflake that's identical to any other past, present, or future flake." However, there is one scientist, Nancy Knight, who claims to have found two identical snowflakes in 1988 (2).

Finally, let's look at how snow crystals grow. Snow crystals grow along two separate axes. Different temperature and water vapor regimes cause snow crystals to grow along either of these two axes. These are called the "A" or horizontal axes and the "C" or vertical axis. ***See Figure 2.*** If the temperature or super-saturation regime changes as the snow crystal falls through a cloud, a different growth pattern may develop over the original form, leaving such odd looking things as capped columns, or radiating assemblages of plates.

So what causes an ice crystal to grow along the "C" axis (like columns, sheaths, and needles) or the "A" axes (like plates or dendrites)? Primarily it is driven by excess water vapor near the surface of the crystal, as well as temperature. When the atmosphere is a little low on excess water vapor at any temperature, the primary growth direction is going to be along the "C" axis. In general, as water vapor super-saturations increase, so too does growth along the "A" axes. As the growth rates along the "A" axes increase, water vapor moves along the crystal surface to the points where water vapor density is the highest (along edges and corners), thus forming the idealized six-sided snow crystal (3).

So the next time you're out on a tour and it's snowing, check out the crystal types and see if you can tell under what regime they formed. Water in the solid form is one of the most amazing substances you will ever see.

For more information on the facinating science of snow crystal formation in the atmosphere, visit this excellent website: www.its.caltech.edu/~atomic/snowcrystals.

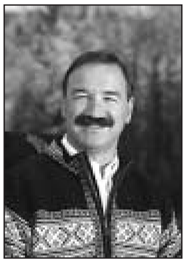
References:

(1) *Sky Watch: The Western Weather Guide* by Richard Keen

(2) *Discovery Channel: Weather* by Discovery Books

(3) *The Avalanche Handbook* by McClung and Schaerer

(4) *The Physics of Clouds* by B. J. Mason



Roger McCarthy: A Lifetime On Snow

A Question and Answer Interview by Scott Toepfer and Knox Williams

Roger McCarthy was born in Auckland, New Zealand, and grew up skiing at Mt Ruapehu, an active volcano on New Zealand's north island. In 1971 Roger traveled on a working holiday to Whistler, British Columbia (an advantage of belonging to a Commonwealth Country). Roger started ski patrolling there in 1974. His ski related career took him to such places as Blackcomb, BC, Tremblant in Quebec, and Companie des Alpes in Europe where he served on the Board at Courmayer in Italy. Even though he loved flying to Paris for meetings and the creative side of figuring out where we take this goofy business, he has a six year old, and 200 days of travel per year just didn't fit the needs of his family. Roger is currently living in Breckenridge where he works for the Breckenridge Ski Area.

Q: What is your current position at Breckenridge and what are you responsible for?

Senior Vice President and Chief Operating Officer at Breckenridge Ski Resort. At almost 1.5 million skier visits, we are the second busiest ski resort in the US. I am responsible for all aspects of financial performance, daily operation, and short and long term planning as it relates to expansion and ongoing enhancements. Also, marketing, pricing and real estate planning and approvals.

Q: When you started your career in the ski industry, were you quickly drawn to the avalanche field? What stirred your interest in snow?

In the winter of '72/73 I worked on the T-bar at the top of Whistler. If there was more that 4" of snow or 15 mph of wind for several hours the hazard required avalanche control.

I was recruited on a regular basis to carry loads of bombs or rounds for the avalaunchers. I became fascinated: why would it slide one time and not the next? I joined the patrol in '74 and took every course I could on weather, snow and avalanches.

Q: Whistler is a pretty big place. How difficult was it to get the mountain open during times of avalanche control?

In those days the top of lift access was the T-bar so we had to hike to the ridgelines to do the control work. On weekends we ran only four pro patrollers to do the avalanche control. We would bring in extra guys for snowfalls. Occasionally we would be caught by a surprise storm, and four of us would do the whole mountain. It was exhausting and we wouldn't finish until 1:30 in the afternoon, and were incapable of any other tasks for the rest of the day. We used avalaunchers extensively but in the deep coastal snowpack they were often ineffective. Ski compaction was minimal, so deep releases were common.

Q: What forms of control work were you able to utilize?

We had three avalaunchers and did extensive control work with a helicopter. Handcharge routes covered what we could hike to and still get open the same day.

Roger McCarthy (standing left), Chris Stethem (sitting) and Bernie Protsch (right) loading the avalauncher at Whistler, British Columbia.

Q: Have you had any close calls with avalanches and if so what did you learn from them?

Yes, Several good rides, one in Europe. Lessons learned:

A.) Throw bigger bombs, and more of them. Ski cutting cranks your pulse for a reason: it can be very dangerous;

B.) In Europe, avalanche control inside lift-serviced areas is a fairly loose concept. I took a ride and was buried waist deep at Les Deux Alpes in a place we would have nuked in North America.

Q: Were control policies in Canada fairly open-ended when you worked with avalanches or were explosive issues tightly monitored back in the 1970's?

Explosive procedures were well regulated by the Workers Comp Board but avalauncher and helicopter procedures were being written as we went. Chris Stethem and I spent many hours drafting and redrafting procedures, which became the standards for Western Canada. Some of these procedures were lessons we learned the hard way. We had great teachers like Norm Wilson, Ron Perla, Peter Schearer, etc.; they were always passing on knowledge.

One of the treasures of my experience was working with Chris Stethem; he was the Patrol Director at Whistler when I started there. He had negotiated with government agencies and worked with Ron Perla to set up a Cold Laboratory in Whistler to do fracture-line profile work. For several years I followed Chris around, helped with the fracture-line work and then spent hours helping Chris in the cold lab photographing crystals and getting hypothermic. His tolerance was amazing—I reached the stupid stage long before he did.

Q: I visited Whistler/Blackcomb on a ski patrol exchange quite some time ago. Being from Colorado I was pretty impressed with how steep the terrain was, that it actually held snow, people were skiing everywhere. What did you find to be the biggest concern when trying to open this kind of terrain for the first time each season?

Not having easy access to the high alpine ridges made the cornice control difficult and often dangerous. The cornices grow to massive proportions during storm cycles. We also had some glaciers and permanent snowfields in the high alpine where the bond between the early snow and the glacial ice was always of concern. It was not uncommon to have large avalanches release at any time of the year and have hard slabs release right to the ice.

The most challenging thing from a forecasting/avalanche control perspective was being so reliant on avalaunchers. A skier jumping off a cornice could hit the starting zone with far greater accuracy than we ever could with an avalauncher.

Q: In maritime climates new snow is the biggest problem concerning avalanche hazard. You worked at Whistler for 20 years. Were there years when the snowpack resembled more what we have here in Colorado where backcountry avalanche occurrence can occur days to even weeks after the last storm?

In 1977 we had classic depth hoar with crystals up to 10 mm everywhere. We had some huge cycles—moguled runs sliding right to the ground. It was pretty interesting. Most of the slide paths have never run bigger than they did in '77—something about putting a maritime snow climate on top of a Rocky Mountain base. Now with two high-speed lifts into the high alpine, the accessible terrain is pretty amazing and of course the ski compaction has changed the stability substantially.

Q: Surface hoar seems to come up often when reading about avalanche accidents in the western provinces of Canada, certainly in British Columbia. From an avalanche perspective, were rain on snow events more of a concern than surface hoar for control teams?

Surface hoar can grow to critical sizes overnight. Once buried it can be a layer which causes problems for a long time. I had a close friend killed in an avalanche that ran on surface hoar. The same layer had been removed by a strong north wind on all the same exposures both inside and outside the ski area boundary, but the slope my friend had skied was protected from the wind by a moraine downhill.

As far as rain events, huge lows march in off the Pacific and occasionally when they are big enough to push out a strong high pressure, they suck warm air in from the south. You can start out with feet of snow in a storm, which finishes up with rain. The loading will test most weak layers but the new surface crust becomes a buried layer eventually and creates some dynamics both below and above the crust which cause failures.

Q: Granted, you have enormous responsibilities and time constraints with your current management job, but have you gotten a chance to get out into the Colorado backcountry, hut trips, ski tours etc.?

Not as much as I would like.

Q: What advice would you have for friends of yours from Canada that were planning a first time backcountry winter trip to Colorado?

Some very low-angle slopes release in this climate. Remember three important factors:

1.) Strength over weakness. (weakness is substantial)

2.) Bonds per unit area among large snow grains are few.

3.) Large grains take a long long time to get smaller (if ever) and gain strength.

Q: You mentioned "Strength over weakness", could you clarify that a bit?

Strength over weakness—the lingering depth hoar issues of the Rockies leave the underlying weakness for the whole winter in lots of areas. The snowpack overlying that weakness develops a strength which people who live in the Rockies learn to evaluate and safely recreate on. That knowledge and hazard evaluation is a distinct understanding of the

continued on page seven

Roger preparing for a helicopter bombing mission, Whistler, British Columbia.

New Wind Chill Chart

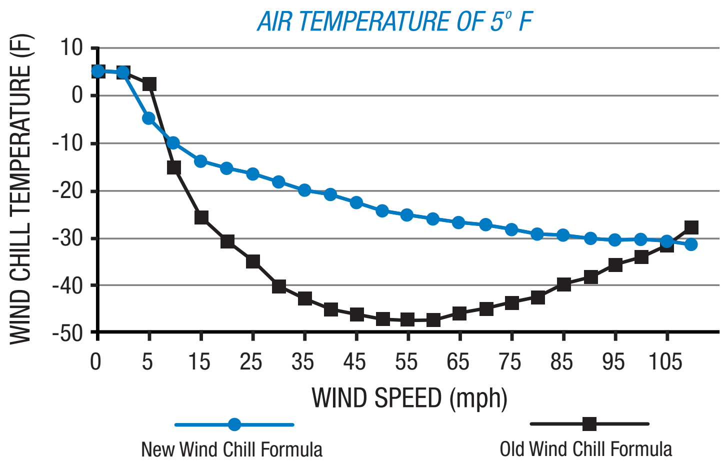
by Scott Toepfer

During the fall of 2000 the National Weather Service (NWS) and Meteorological Services of Canada (MSC) along with several universities and other federal agencies formed a special group to reevaluate the old Wind Chill Temperature (WCT) chart that has been around for almost 60 years. Thanks to big improvements in computer modeling abilities and advances in other technologies and sciences a new WCT chart was released on November 1, 2001. With help from the International Society of Biometeorology a set of clinical trials were performed using computer generated human face models and years of data from wind instrumentation to build this chart, based on several new factors. Some of these were:

- Incorporate modern heat transfer theories
- Use a consistent standard for skin tissue resistance
- Assume no impact from the sun

By 2002 the chart may also include various daylight sky conditions as well, such as partly cloudy, sunny, etc. We have included the new chart with this issue of The Beacon as well as a comparison graph of the old and new readings. As you can see, the old chart made us feel much colder than we actually were, great news for outdoor enthusiasts.

Wind Chill Temperature Comparison
(Old vs. New)



WIND CHILL CHART

TEMPERATURE (°F)

WIND (mph)

Calm	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5	36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63
10	34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72
15	32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77
20	30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81
25	29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84
30	28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87
35	28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89
40	27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91
45	26	19	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86	-93
50	26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88	-95
55	25	18	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68	-75	-82	-89	-97
60	25	17	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69	-76	-84	-91	-98

FROSTBITE TIMES ☐ 30 minutes ☐ 10 minutes ☐ 5 minutes

Roger McCarthy

continued from page five

inherent strength over the underlying weakness. Earlier you alluded to the coastal mentality of "snow sticks to everything and if it holds snow you can jump on to it from 40 or 50 feet up and it will be stable enough for you to do whatever comes next". Those are suicidal concepts in the Rockies.

Q: Where do you see the ski industry headed and what are its biggest challenges?

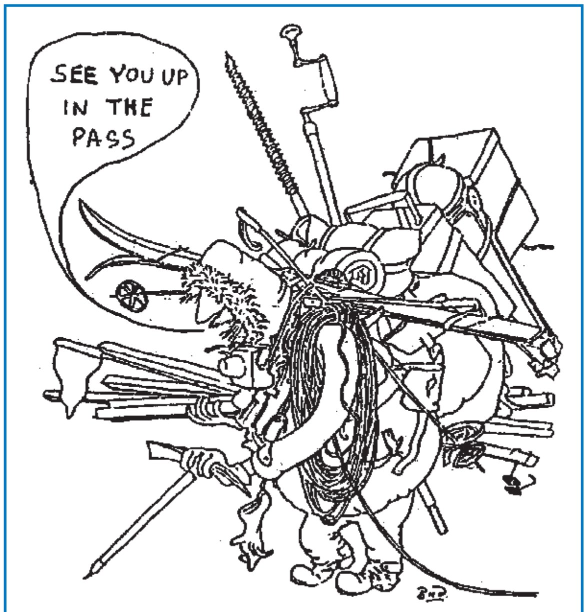
Skiing has never been safer or easier to learn. The industry (that's what we call it, but it is far from anything I would call an "industry") is focused on destroying the barriers, the hassles, and getting people to the sliding point faster and in a hassle-free way. The growth of skiing as a sport…into lifestyles as seen in the growth of mountain villages and snowboarding as a complete lifestyle involving music and the daily portrayal as a cool thing to do by the media and advertising agencies worldwide…has positioned our sport in a way it was seen to be in the 60's. 57 million visits last winter are indicative of the strength of our sport. There is nothing that matches the sensation of sliding down a mountain, it is universal in appeal across skill sets and age groups, it is unparalleled. The challenge will be managing our success, the need for expanded terrain at some resorts, and the balancing of private and public interests.

Q: Can you remember and describe your best day of skiing?

I love the wind, the snow and the solitude of skiing during a storm cycle. My wife and I had an amazing day on Peak 7 last year on closing day of the season. It was waist deep, snowing like crazy, run after run, April 23 and full-on winter—gotta love it!

Q: One last question, what do you like best about Breckenridge?

1.) 300 days of sun per year.
2.) I have seen it snow at 38° F.
3.) The people.



Avalanche Forecaster at Work

(◀Cartoon: *Survey*, 1975, artist unknown) (▲Photo: Scott Toepfer)

Renewal Notice (or recruit a Friend)

Yes, I will join the Friends of the Avalanche Center. Enclosed is my donation of:

- ❏ $30*, which gives me a CAIC window decal (if I am a new Friend), *The Beacon* newsletter, the Avalanche Wise booklet, and a morning forecast by e-mail.
- ❏ $45*, which gives me all the stuff above, plus an afternoon forecast sent by e-mail.
- ❏ Please accept my additional donation of $________*
- ❏ I'm a renewing member.
- ❏ I'm a new member. Please send a CAIC decal.

* Your donation may be tax deductible and your canceled check is your receipt.

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e-mail ______________________________ Phone # ______________________

Please mail this form & your check payable to "CAIC" to: Colorado Avalanche Information Center • 325 Broadway, WS1 • Boulder, CO 80305

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(Photo: Scott Toepfer)

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