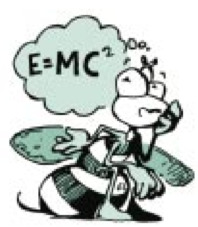
Excuse Me While I Flow My Snows

What Makes an Avalanche Happen?

Meet Dr. Karl Birkeland:

I like being a scientist because I get to play detective. I search for answers to avalanche problems faced by people who work and play in the mountains. I became interested in avalanches in college while I was working as a ski patroller. Being an avalanche scientist combined my love of skiing, mountains, snow, and science.



Thinking About Science

Natural resource scientists help to solve some of society's problems by discovering new information about the environment. Sometimes, just learning new things about the environment helps citizens make better decisions. In this study, the scientists were interested in discovering which weather and snow conditions can create avalanche conditions. This is important because avalanches can be dangerous and even deadly for snow skiers and other people who go into snow-covered mountain areas. If people know which weather conditions are favorable for avalanche formation, they can avoid going into snowy mountain areas during those weather conditions. In ways such as this, the work of natural resource scientists can help people make decisions that keep them safe.

Thinking About the Environment

Avalanches are snow masses that suddenly release and flow down a hillside. Avalanches are most common on steeper slopes, such as those over 30°, and can travel faster than 100 mph (160 km/h) (Figure 1). Even the weight of skiers or other

Dr. Karl Birkeland

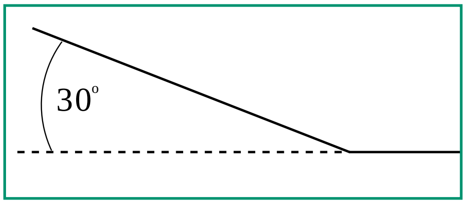


Figure 1. 30° slope.

mountain travelers can trigger avalanches during unstable conditions. Avalanches are one of nature's large-scale forces, similar in *scale* to landslides, floods, and tornadoes. Such large-scale environmental forces usually occur naturally. However, when humans are affected, their impact may be *disastrous* for individuals and society.

Introduction

Slab avalanches are the most dangerous kind of avalanche. A slab is a layer of new snow sitting on top of a layer of snow, called a weak layer. Scientists call this a weak layer because the bonds that hold the snow crystals together are weak. Added weight, such as more new snow, may be piled on top of the weak layer. When this happens, part of the new slab can break off and slide down the mountain. The scientists in this study wanted to learn how the weak layer is formed. Although there had been studies of the formation of other weak layers of snow in other places, no one had studied this particular weak layer in Montana.

Although the scientists knew that these weak layers were being formed, they did not know how snow temperatures are related to this process. Dr. Birkeland and his colleagues conducted this research to better understand the relationship between daytime and nighttime snow temperatures and the formation of the weak layer of snow. They also wanted to observe whether any avalanches were *associated* with the weak layer.

Reflection Section

- The scientists wanted to study the temperature of the snow at its surface and below the surface. If you were the scientist, how would you measure snow temperature at these locations?

- What danger, if any, did the scientists face when they conducted their research? How do you think they reduced the danger to themselves?

Methods

The scientists wanted to measure snow temperature at the surface and down to 20 centimeters into the snow. (How many inches is this? Multiply 20 by .394 to find out!) They measured the snow temperature by glueing thermometers along a plastic pipe. They protected each thermometer by placing all but its end in a stainless steel tube before glueing it to the pipe. They glued two thermometers to the top end of the pipe, 1

Glossary:

scale (sca(uh)l: When you observe something close up or far away, you are observing at different scales.

disastrous (di **zas** trus): Causing suffering or disaster.

associated (uh **so** she a ted): Closely connected with another.

relationship (re **la** shen ship): Being related or connected.

water vapor pressure (**wä** tür **va** pür **pre** shur): The amount of pressure put forth by the water that is in air at different temperatures.

crystallize (**kris** tuh liz): To form crystals. Water crystals are formed when water vapor cools and water molecules are pulled together.

manager (**ma** ni jür): A skilled person who directs or manages something.

Pronunciation Guide

a	as in ape	ô	as in for
ä	as in car	u	as in use
e	as in me	ü	as in fur
i	as in ice	oo	as in tool
o	as in go	*ng*	as in sing

centimeter apart. Then, they placed the remaining thermometers at 5-centimeter intervals (Figure 2). (Can you tell how many thermometers were placed under the snow? Divide 20 centimeters by 5 centimeters.) The thermometers automatically recorded the temperatures at certain times during the day and night. They placed the pipe with the thermometers into the snow (Figure 3). The scientists were interested in studying avalanches on steep slopes. However, they made

Figure 2. The thermometers used by the scientists.

Figure 3. The placement of the thermometers in the snow.

Weak layer and new layer of snow.

their temperature measurements in a flat area at the bottom of a steep slope because it was safer and a more convenient place to record snow temperatures.

The scientists were interested in comparing the snow temperature at the different depths and times of the day and night. Then, when the weak layer had been buried by a new layer of snow, the scientists observed its *relationship* to avalanches in the area.

Reflection Section

- Do you think the snow's surface temperature changed more or less between day and night than the snow temperature under the surface? Why?

- What are two advantages of using a device to measure temperature automatically?

Results

Dr. Birkeland and his colleagues found that the snow's surface temperature changed a lot between daytime and nighttime. During the daytime, the snow surface was warmed by the sun and was much warmer than the snow under the surface. At night, the snow surface cooled and became much colder than the snow under the surface. The snow under the surface stayed close to the same temperature the whole time (Figure 4). With such wide variations in temperature between the surface snow and the underlying snow, the *water vapor pressure* in the snow also varied widely. During the cold night, water vapor traveled toward the surface. While near the surface, it became very cold and froze on nearby existing crystals. During the warm day the process reversed. Some of the crystals became water vapor again, and the vapor traveled down into the snow. When water vapor recrystallizes near the surface, it becomes crystals with sharp angles and flat sides (Figure 5). When new snow falls onto the old layer, it does not stick well to the flat crystals. This creates dangerous avalanche conditions.

Following the formation of the layer of crystals, new snow fell in the area of the study. For up to 9 days, there were avalanches in the region. The avalanches were formed because the new snow could not stick to the weak layer.

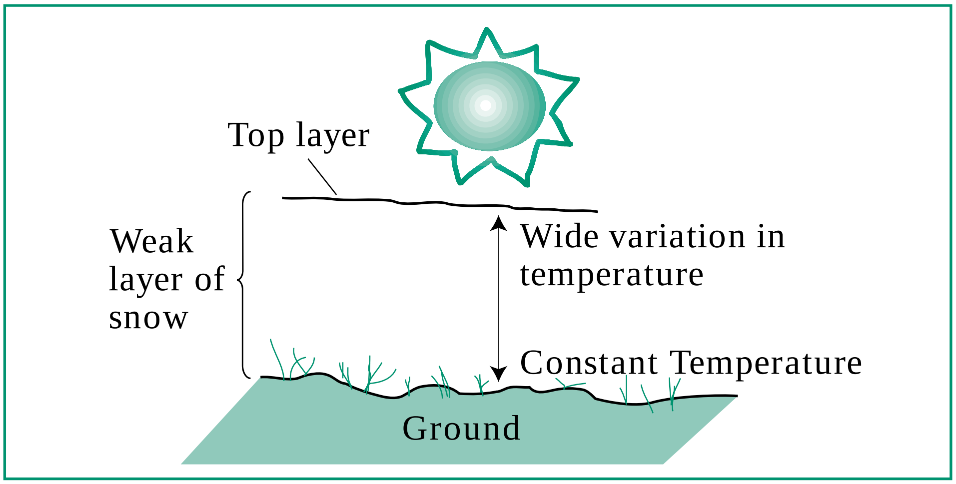


Figure 4. Comparison of temperature gradient between the top and lower layers of snow.

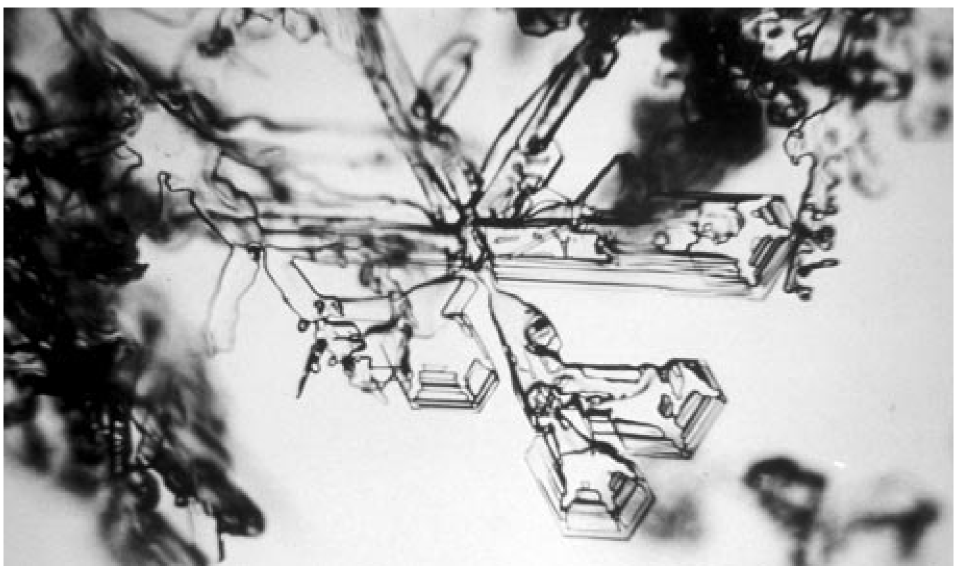


Figure 5. A crystal from a weak layer of snow.

The new snow built up so much weight that it broke apart on the weak layer. Once it broke apart, huge pieces slid down the slope in an avalanche.

Reflection Section

- Why do you think the snow under the surface stayed about the same temperature, regardless of whether it was day or night?

- Once an avalanche begins, what force makes it continue? Can you think of two other things that allow an avalanche to continue to slide?

Implications

The scientists discovered that a weak, crystallized layer of snow is formed during periods of clear, sunny days and clear, cold nights. Under these conditions, the snow surface temperature varies widely compared to the temperature under the snow. This causes variations in the water vapor pressure. The wide variation in water vapor pressure causes the water vapor to recrystalize at night near the surface. When it does this, a weak layer is formed that new snow may not be able to stick to. Skiers and other visitors to snowy mountain areas should be particularly careful during periods of clear weather followed by new snowfall.

Reflection Section

- Imagine you are the *manager* of a snow-covered mountain area. A group of skiers come to you and want to go skiing during a period of clear weather and new snowfall. You know the conditions are right for an avalanche. What would you tell the skiers? Why?

- What can a manager do to increase the safety of ski areas?

FACTivity

Get a cardboard box about 2 foot square. Fill it with Styrofoam peanuts. Take it outside into the sunlight. Get three thermometers. Place one thermometer into the center of the box, right in the middle of the Styrofoam peanuts. Lay the second thermometer under one layer of the peanuts. Place

Snow web-surfing

Avalanches can be dangerous for people out in snowy mountainous areas. Utah has a combination of large mountains, lots of snow, and cities totaling a million and a half people right at the base of a large mountain range. More people die from avalanches than from any other natural hazard in Utah. To increase people's safety, 2002 Games planners teamed up with the Forest Service's Utah Avalanche Center. They wanted to find ways to tell people about dangerous avalanche conditions. One way to do this is through the Internet. The Avalanche Center made its website easier to use. By visiting the website, people can find out which areas and weather conditions are dangerous for avalanches. They can even learn more about what makes avalanches happen. If you are interested in learning more about avalanches, visit www.avalanche.org or www.csac.org

SPIRIT OF THE LAND™
SLOC ENVIRONMENTAL PROGRAM

SALT LAKE 2002™

the third thermometer just outside of the box. Record the temperatures on all three thermometers every hour throughout the day. You may use the chart below or make one of your own. You will have to take the thermometers out of the box, then replace them in the same places after recording the temperature. Create a bar chart from your table. Study the table and the bar chart. What do they tell you about the insulating characteristics of Styrofoam? How is Styrofoam like snow? How is it not like snow?

Based on this FACTivity, consider the following questions:

1. Why is it useful to measure the air temperature as well as the temperature in the box?
2. How is this FACTivity similar to what the scientists did?

Sample Chart:

Date	Temperature in the box	Temperature on top layer of box	Air temperature
9:00 a.m.			
10:00 a.m.			
11:00 a.m.			
12:00 noon			
1:00 p.m.			
2:00 p.m.			

3. Of the temperatures inside the box, which has the greatest change in temperature? Why?

From Birkeland, Karl W.; Johnson, Ron F.; and Schmidt, D. Scott (1998). Near-surface faceted crystals formed by diurnal recrystallization: A case study of weak layer formation in the mountain snowpack and its contribution to snow avalanches. *Arctic and Alpine Research*, 30(2): 200-204.

Website:

http://www.avalanche.org/~uafc/
Kid's snow page:
www.teelfamily.com/activities/snow
Snow crystals page:
www.its.caltech.edu/~atomic/snowcrystals/primer/primer.htm