

The Facet Factory

An Introduction to Snow Metamorphism

By: Eric Knoff

Gallatin National Forest Avalanche Center

From the time snow crystals fall from the sky to time they melt in the spring, the shape and structure of each crystal never stops changing. This is known as snow metamorphism.

Snow metamorphism determines if individual snow crystals are rounding (becoming stronger) or faceting (becoming weaker). The relationship between snow crystals ultimately dictates what kind of layer, strong or weak, is formed. The interaction between individual layers determines snowpack stability.

Three main variables drive change within the snowpack; temperature gradient, temperature, and pore space size. Of these three, temperature gradient is the most influential in determining crystal formation in an alpine snowpack (Avalanche Handbook, McClung/Schaerer).

Temperature gradient is the difference in temperature over a distance. If the temperature within the snowpack differs more than one degree Celsius per 10 centimeters of snow depth, a strong temperature gradient is present. These conditions cause individual grains to become angular and faceted. Faceted crystals can form weak layers that may persist within the snowpack for long periods of time.

Three primary types of persistent weak layers form in the northern Rockies; depth hoar, surface hoar, and near surface facets. These distinct weak layers form under strong temperature gradients and often produce dangerous avalanche conditions.

Depth hoar forms when a shallow snowpack is exposed to an extended period of cold and clear weather. Large cup-shaped facets form and may reach 4-10 mm in size. These grains are cohesionless and have a hard time bonding due to their angled structure and large size. Once depth hoar forms, it can be preserved in the snowpack by subsequent storms and create instability for weeks or even months.

When the snowpack becomes deeper, only the top 15-20 cm's of the snow surface will be affected by air temperature fluctuations. When the snowpack surface is subjected to fluctuating daytime and nighttime heating and cooling cycles (called diurnal fluctuations), the snowpack surface will begin to facet. The longer the snow surface is exposed to these temperature fluctuations, the weaker the snow surface will become.

A common type of facet layer formed by diurnal fluctuations is near surface facets. This persistent weak layer forms in-between storms and is responsible for nearly 60% of all avalanche accidents in southwest Montana (Birkeland, 1996). Near surface facets are smaller in size than depth hoar (1-2 mm) but they are quite pesky and can persist in the snowpack for long periods of time.

An equally dangerous weak layer is surface hoar. Surface hoar forms on cold clear nights - it is essentially frozen dew. What sets surface hoar apart from other types of facets is that it is created through the growth of new crystals and not the metamorphism of existing snow crystals. Surface hoar is fragile and is easily knocked down by wind or sun – it may remain standing in some areas and disappear in others. Once buried, sporadic distribution can make this layer very unpredictable. Buried layers of surface hoar are renowned for fracturing far and wide and can create avalanches that are capable of propagating into low-angle terrain.

The long and the short of it is that as snow sits on the surface of the Earth, its structure is in a constant state of flux until it melts or blows away. Knowing the processes by which the snow crystals change gives riders an advantage. Riders are ahead of the game when they can anticipate snowpack changes. Becoming an active observer of snow metamorphism can help riders make more educated decisions when riding in avalanche terrain.