CHANGES IN SNOW STRUCTURE INDUCED BY TEMPERATURE GRADIENTS

Abstract

by

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INTRODUCTION

Many earlier studies have emphasized the morphological changes of individual snow crystals in response to a temperature gradient. The accepted picture is that some crystals grow and others shrink as water vapour is transported across the gradient. However, snow crystals are interconnected within the snowpack, and there is a supplementary description which emphasizes changes in the interconnected ice skeleton.

The present study covers a series of experiments performed during 1980-83 on snow samples which were exposed to either very intense or vey weak gradients, and studied as disaggregated grains and as an interconnected skeleton of grains using the method of plane surface.

INTENSE GRADIENTS

Cylindrical snow samples (2.5 x 10^5 mm^3) were collected at a study plot in the Sunshine Ski Area (elev 2200 m), Banff National Park, and transported in snow-filled insulated boxes to a refrigerated laboratory in Canmore, Alberta. Each sample was weighed to determine its density, and then split into three smaller cylindrical disks (25 mm thick x 50 mm diameter). One snow disk was immersed in supercooled dimethyl phthalate and frozen solid. A plane section through the solid disk was microtomed, dyed, polished, and photographed using incident reflected light. The second snow disk was disaggregated into grains which were photographed using transmitted polarized light. The third snow disk was sealed in a small plexiglass container and then subjected to temperature gradients up to 2000 °C/m across the disk thickness (25 mm). The gradient was maintained using two thermoelectric plates, cooled with circulating water. The apparatus was set inside a small freezer which held the ambient temperature at a value which minimized the gradient orthogonal to the main gradient. To reach 2000 °C/m one plate was held at -40 °C, the other at 0 °C, and the ambient at about -20 °C.

In order to maintain a preset gradient is was necessary to continually increase the heat delivered to the redistributing the ice throughout the pore space.

WEAK GRADIENTS

Attempts were made to hold snow samples in an environment of near zero temperature gradients for periods up to 6 months. Cylindrical samples, collected as above, were divided into three groups for storage at -35 °C, -5 °C, and -1 °C. These temperatures were held within ± 0.5 °C except when storage boxes and cylinders were opened for observations involving plane surface preparation and photomicrography of disaggregated grains. Observations were taken one day, one week, one month, three months and six months after the collection date.

Metamorphism in the presence of weak gradients involved grain growth toward rounded morphology; however, faceting was not fully suppressed even at -1 °C. There was much less of a tendency toward the fibrous and diffuse structure observed in the presence of intense temperature gradients. The fastest crystal growth as well as the largest tendency toward a diffuse structure was observed for samples stored at -1 °C.

The observed faceting and diffuse structure may be traceable to the difficulty of completely eliminating temperature gradients.

warmer plate. This indicated that the ice skeleton was metamorphosing to increase thermal conductivity as Nature attempted to force the system toward equilbrium.

After 100 hours the snow disk was removed from the container and the metamorphosed snow was photographed as a "plane surface" and as a collection of disaggregated grains. Our results matched Akitaya's classification of temperature gradient morphologies. Snow of high porosity metamorphosed toward a loosely connected skeleton of "stepped" and "cup-like" grains, whereas low porosity snow metamorphosed toward a strong, crusty texture of interconnected fibers without the expected stepped and cup-like morphology. In all cases, the temperature gradient boundary conditions altered drastically the initial crystal morphology by