RECENT OBSERVATIONS OF SNOW METAMORPHISM AND MICROSTRUCTURE

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ABSTRACT: Snowpack stability and avalanche formation depend on the microstructure within a snow layer. These layers form as snow is added to the pack or as metamorphism distinguishes existing layers from their neighbors. It is common practice for snow scientists and practitioners to characterize each snow layer with the size and shape of disaggregated snow grains. However, desegregation destroys the microstructure and much of the information needed for avalanche prediction. Using high-resolution digital imaging and serial sectioning we created three-dimensional reconstructions of snow samples. These reconstructions allow us to examine the intact structure of the snow and learn about the microstructure within a single snow layer.

KEYWORDS: snow, snow metamorphism, snow microstructure, snow properties

1. INTRODUCTION

Snow metamorphism causes ice crystals within a snowpack to bond with their neighbors and form an intricate network of ice and air. The nature of the resulting structure affects the thermal, mechanical, and optical properties of the snow cover. Snow scientists and avalanche workers disaggregate snow grains and characterize their size and shape to identify weaknesses with the snowpack. They use conceptual models to anticipate how the structure will metamorphose and the future impact on snowpack stability. Although this is the most common technique used to characterize the snow structure, it destroys the structure prior to examination and thus many of the features that we strive to record.

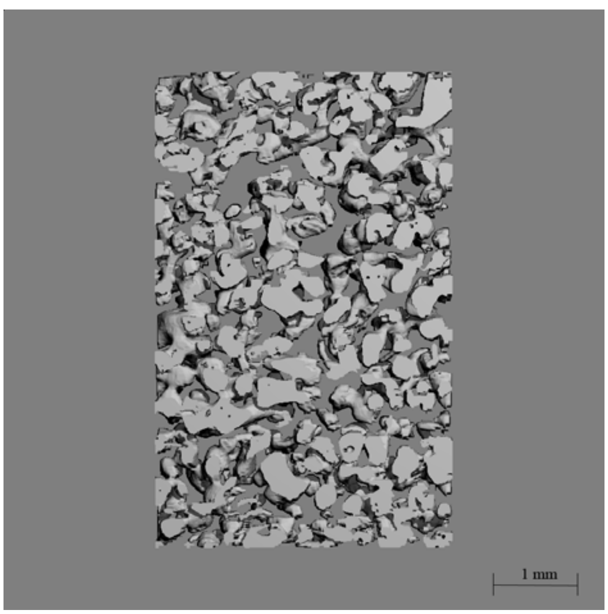

Figure 1: A three-dimensional reconstruction of snow with rounded grains.

Recent advances in image acquisition, image processing, and three-dimensional reconstruction have been applied to snow to observe its original structure (Figure 1). These techniques allow us to visualize snow in its undisturbed state and examine the structure without disaggregation.

2. METHODS

In this study we collected snow samples from the field and brought them into the lab to observe their metamorphism in a controlled environment. Using paired samples, we made casts of snow samples in dimethyl phthalate prior to metamorphism and then after they were subjected to a large temperature gradient (80-120 K/m) for five days. We then made vertical cuts through the cast samples with a microtome and collected high-resolution images of the surface every 12 µm. Using image analysis software, we stacked these images into a three-dimensional dataset and separated the ice and dimethyl areas (pore spaces).

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3. RESULTS AND CONCLUSIONS

Three-dimensional reconstructions obtained from serial surface sections show a complex microstructure within a single snow layer. Under a large temperature gradient, the samples change from a regular and round structure, to complex structure within a few days (Figures 2 and 3).

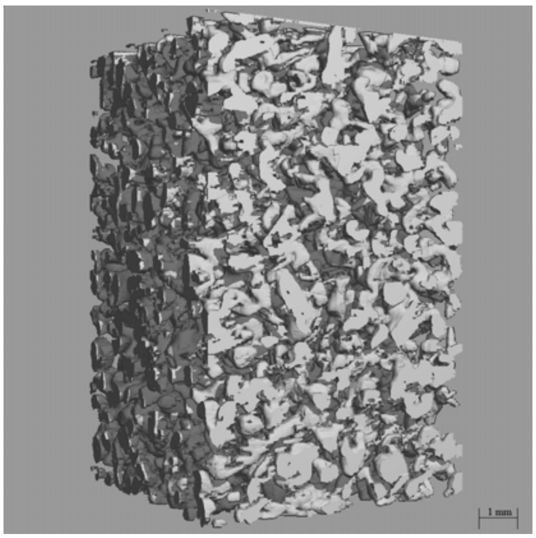

Figure 2: A three-dimensional reconstruction of a sample collected from the field and before the laboratory metamorphism experiment.

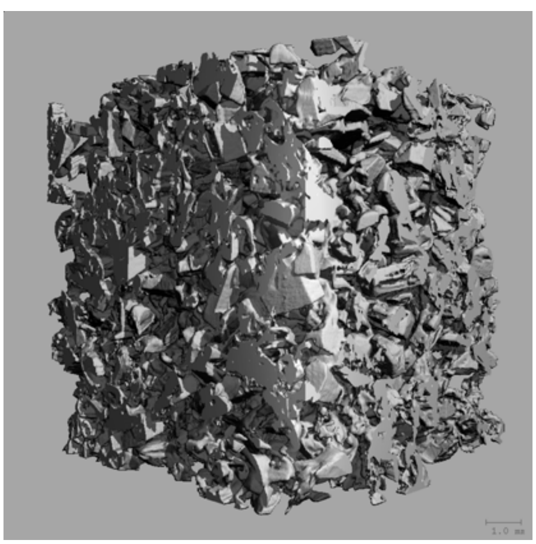

Figure 3: A three-dimensional reconstruction of a sample after being subjected to a large temperature gradient for five days.

The results indicate that a snow layer with a large flux of mass contains both growing and eroding features with a large array of shapes and sizes. In addition, this technique allowed us to observe many intricate features such as several types of hopper crystals (Figure 4).

Figure 4: A three-dimension reconstruction of snow formed through kinetic-growth metamorphism. Features such as hollow cups (hopper crystals) and scrolls are represented within the resolution of the model (voxel size is 12 x 12 x 12 µm).

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