TESTS OF NEW SNOW DENSITY SAMPLERS

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INTRODUCTION

Snow sampling, be it for density profile determination or for study of the variation in concentration of snowpack contaminants along the vertical profile, sets high requirements on the accuracy of the samplers used. It also demands that the samples be capable of high vertical resolution. These requirements are not easily met. The shape of the sampler may bias the sample. For example: tubular samplers such as the CRREL tubes or the NRC Snow Kit cutters give greater weight to strata that cut across the center of the tube. The wedge-shaped density sampler that has been designed by Defence Research Establishment Suffield also has this shape bias. Furthermore, the cutting performance of the sampler in different snow conditions may cause the operator to bias the sample by selectively choosing strata which are easily sampled.

This paper describes some preliminary field tests of two new snow density samplers which are intended for use in both snowcover density and specific conductance measurements.

DESCRIPTION OF SAMPLERS

Two new snow density samplers were used. One was developed by Hugo Weichel of the Swedish Defence Research Institute in Stockholm and is hereafter referred to as the 'Swedish sampler'. The second sampler was developed by Hardy Granberg and Gregory Crocker of the Department of Geography, McGill University and is referred to as the 'G-C sampler'. Both samplers have been described in greater detail elsewhere (Granberg, 1984; Granberg and Crocker, 1984).

THE SWEDISH SAMPLER

The Swedish sampler (Fig. 1) consists of a rectangular scoop with a hinged lip which cuts off the snow sample at the front end of the scoop. A sliding lid cuts the top off the snow sample to give a nearly rectangular slab of five cm height and a volume of one litre. The sample which is completely enclosed by the sampler is weighted using a spring balance of good precision which attaches to a hole in the sampler handle.

The spring balance has a capacity of 1 kg. Since the tare weight of the sampler is approximately 300 g the sampler can theoretically handle snow up to a density of 700 kg per cubic metre. In practise, however, the upper limit for the sampler is between 400 and 500 kg per cubic metre. At greater densities the sampler begins to deform upon insertion.

The sampler is manufactured from brushed aluminum which has a low sliding friction with ice. This facilitates cleaning of snow from the sampler. It also minimizes errors due to edge effects during sampling. The use of aluminum makes the sampler light and corrosion resistant. However, for sampling of snow chemistry, some inert coating of the sampler would be desirable, to reduce contamination of the retrieved samples by the sampler.

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Despite its inability to handle very dense snow the Swedish sampler is a most useful field device. It allows fast and accurate determination of snow densities and can, with special care, give densities to within plus or minus 1-2 kg per cubic metre. Part of its speed in density profiling is due to its ability to extract samples without need for extra tools to cut the front end of the sample, once a snow pit has been cut. Part of its speed also derives from its ability to cut sequential samples down the profile without any need to prepare the pit wall for the next sample (Fig. 2). Although it is theoretically possible to obtain a vertical spacing of 5 cm between samples, experience indicates that a 7 cm spacing is achievable in the field.

THE G-C SAMPLER

This sampler has the capacity to give both bulk snowpack density measurements and individual density measurements over selected intervals in the snow column. The intervals can be selected in multiples of one centimeter.

The sampler (Fig. 3) consists of five main parts:

1. A tubular cutter
2. A set of slicers which section the core
3. A pod to suspend the sampler for bagging samples
4. A precision spring balance for weighing bagged samples
5. A wooden dowel.

Sampling operations also require the use of a shovel.

The tubular cutter consists of an aluminum tube of 16 cm diameter and a wall thickness of approximately 3 mm. Slots have been cut half-way through this tube at 1 cm intervals to allow insertion of the core-slicers.

The core-slicers are made from thin galvanised steel plate and are shaped so as to close off the core tube internally between individual samples. The side that is inserted into the tube is sharpened to provide a cutting edge.

To obtain a sample the cutter tube is inserted vertically into the snow cover. A pit is then dug alongside the sampler to allow insertion of the slicers. The bagging of the samples is accomplished by placing a ziplock bag beneath the suspended sampler and removing the lowest slicer. If the sample sticks inside the tube it can be released by a light tap with the wooden dowel.

METHODS

Comparable snow density profiles were obtained by using the two samplers side-by-side usually within a horizontal distance of less than 50 cm between the profiles. The samples were bagged in pre-washed Ziplock sample bags for transfer to the laboratory. In the laboratory the snow was melted in the closed bags and specific conductance was measured at a standard temperature of 25 degrees C. Specific conductance was used as a general indication of snowpack contamination. No attempt was made in this preliminary survey to identify individual chemical compounds.

RESULTS

Figures 4 to 6 show a set of profiles which were all obtained on frozen bog surfaces near Schefferville, Quebec. They illustrate some of the problems of sampling snow density and snow chemistry.

Figure 4 represents a portion of the basal layers of the snow cover where samples over 2 cm intervals were obtained using the G-C sampler and samples using the Swedish sampler were obtained at 5 cm intervals by staggering the samples. The measured densities using the G-C sampler are generally lower than the densities observed using the Swedish sampler (Fig. 4a). Although spatial variations in the density profile are possible, the probable main cause of this difference is the friction between the snow and the slicer which forces the snow adjacent to the slicer to move forward during the insertion of the slicer. The error increases with decreasing thickness of the slices.

Figure 5b illustrates how the problem of contamination by the sampler increases with increasing vertical resolution by the sampler. In the lower portion of the profile samples have been obtained at 1 cm intervals using the G-C sampler while in the upper portion of the profile larger sampling intervals have been used. The difference in surface area per sample slab is the most likely cause of the large difference in specific conductance readings near the ground surface. In the upper portion of the profile the G-C sampler gave slightly lower specific conductance values than the Swedish sampler, possibly indicating that aluminum contaminated the snow more than the zinc-plating on the slicers of the G-C sampler.

Figure 6 illustrates the effects of an ice lens and its inclusion or omission from the profile measurements. Two ice lenses were present in the snow cover, the lower of which was sufficiently thick that it could not be coped with by the Swedish sampler. The G-C sampler, however, had no great difficulty cutting through the ice lens and it could be included in the profile by appropriately adjusting the intervals for inserting the slicers. The lens produced a considerable spike in the density profile (Fig. 6a).

The conductance profiles (Fig. 6b) shows a clear connection between ice crusts and the concentration of contaminants in the snow cover. The sampling resolution is insufficient, however, to indicate whether it is the crust itself or the layers immediately above or below the crust that is contaminated.

CONCLUSIONS

These preliminary tests of the two snow density samplers show that although a high resolution along the vertical axis is desirable, it is not easily accomplished. The sampler and the vertical sampling resolution influence errors associated with the cut surfaces of the sample. The density measured by the G-C sampler is lower as a result of friction against the slicers when the vertical sampling intervals is small. A small vertical sampling interval also increases the ratio of the contaminated surface area to the total volume of the sample.

In general, these preliminary results indicate that both the samplers and the sampling techniques may have a significant influence on the results in sampling of both snow densities and snowpack contaminants.

ACKNOWLEDGEMENTS

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The research was carried out at Schefferville, Quebec, using the McGill Sub-Arctic Research Station as base.

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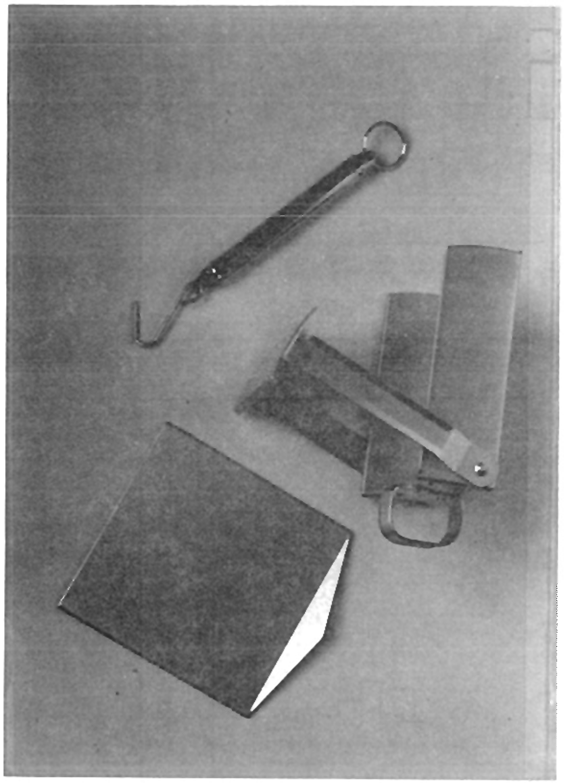

Fig. 1 The Swedish snow sampler

Fig. 2 Snow pit work using the Swedish snow sampler

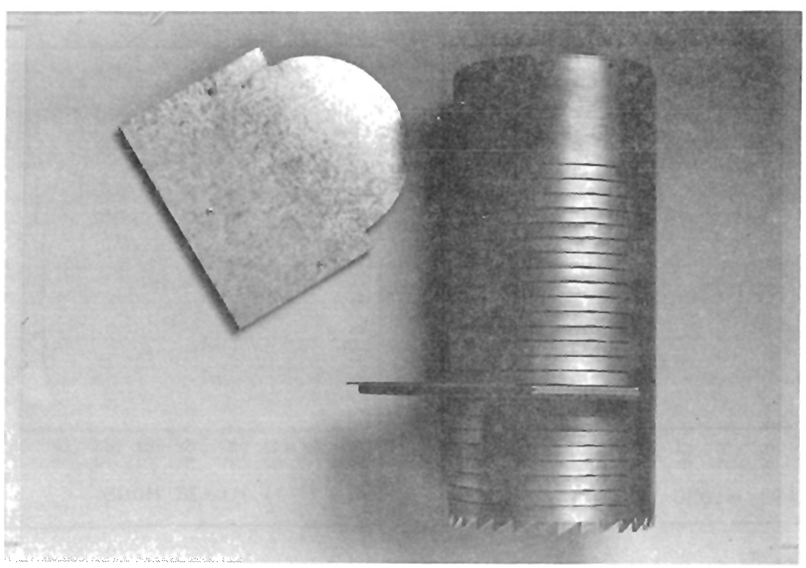

Fig. 3 The G-C sampler

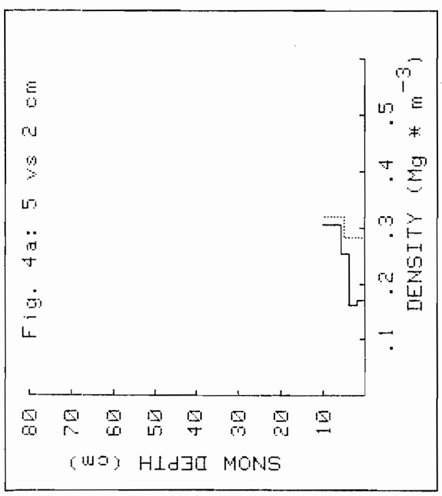
Fig. 4a: 5 vs 2 cm
SNOW DEPTH (cm)
DENSITY (Mg * m-3)

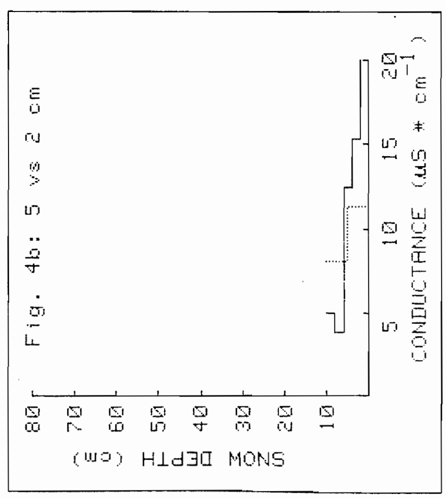
Fig. 4b: 5 vs 2 cm
SNOW DEPTH (cm)
CONDUCTANCE (µS * cm-1)

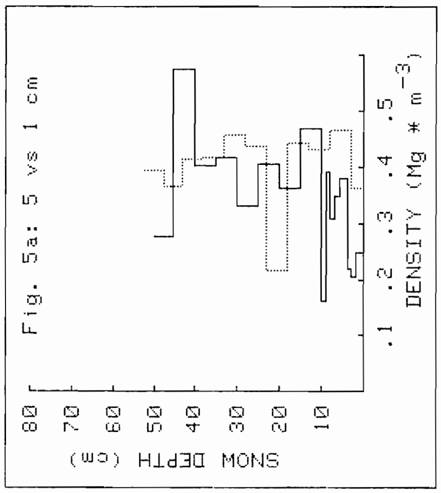
Fig. 5a: 5 vs 1 cm
SNOW DEPTH (cm)
DENSITY (Mg * m-3)

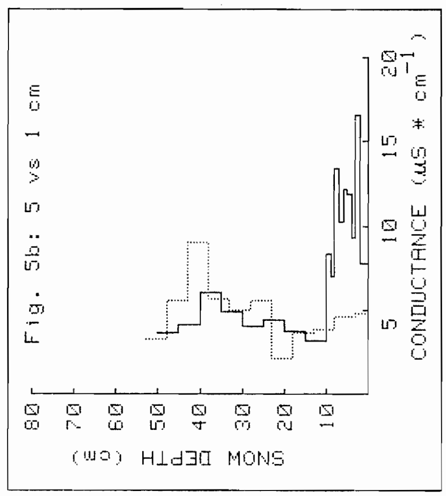
Fig. 5b: 5 vs 1 cm
SNOW DEPTH (cm)
CONDUCTANCE (µS * cm-1)

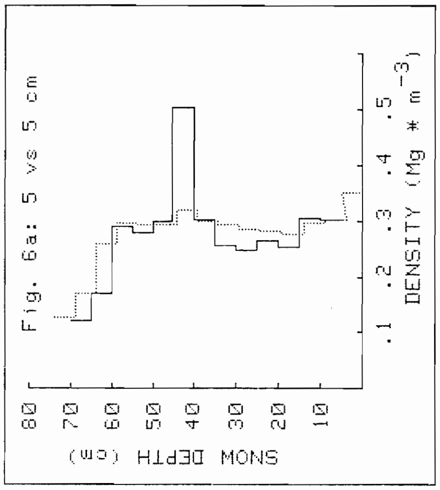
Fig. 6a: 5 vs 5 cm
SNOW DEPTH (cm)
DENSITY (Mg * m-3)

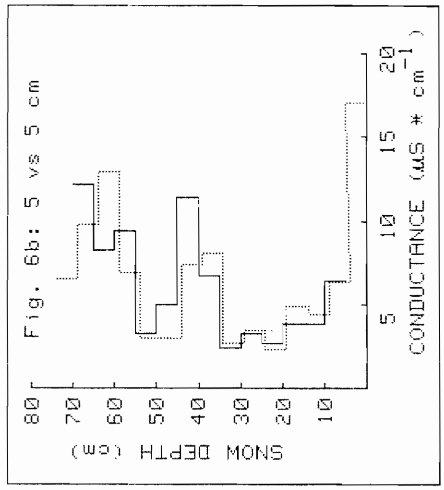
Fig. 6b: 5 vs 5 cm
SNOW DEPTH (cm)
CONDUCTANCE (µS * cm-1)