TRANSPORT OF WATER AND DYE TRACERS THROUGH SNOW

T. Wilhelm[1]
J. Rechenmacher[1]
Assoc. Prof. A. Denoth[1]

ABSTRACT

Experiments were done on the Stubai glacier area about 3000 m asl during July 1992. The experiments lasted one week. In order to be independend on the actual weather conditions natural melting and/or precipitation rates (rain on snow) were simulated. Repacked homogenous snow of a more or less uniform grain size of approximately 0.6 mm was used. Depending on the initial water saturation and the water input rate at the snow surface shock fronts were formed. Using a new measuring method it was possible to register continuously the liquid content directly within the snowpack. This opened the possibility to record shock fronts in time and space with a high resolution. Furthermore basic experimental studies with dye-tracers were done in order to get insight into the qualitativ behaviour of transport and adsorption of different tracers.

INTRODUCTION

The movement of water and dye tracers has already been studied both theoretically as experimentally throughout several years (Colbeck, 1977; Colbeck, 1971; Crell, 1979). The results of these experiments show that two parameters of the underlying theory are physically difficult to interpret. These parameters are n, the exponent in the exponential relation between the water flux and the saturation, and d, which is somehow related to the grain size of the snow. This was the motivation for further experiments in order to increase the data base. In addition a system to measure the water content within the snow pack was applied. For the first time it is therefore possible to continuously record the water flux at different depths within the snow pack. Furthermore qualitative studies of the movement of dye tracers were done. A principal difference between the used tracers could be observed.

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[1] Dept. of Experimental Physics, University of Innsbruck, Austria

EXPERIMENTAL SETUP

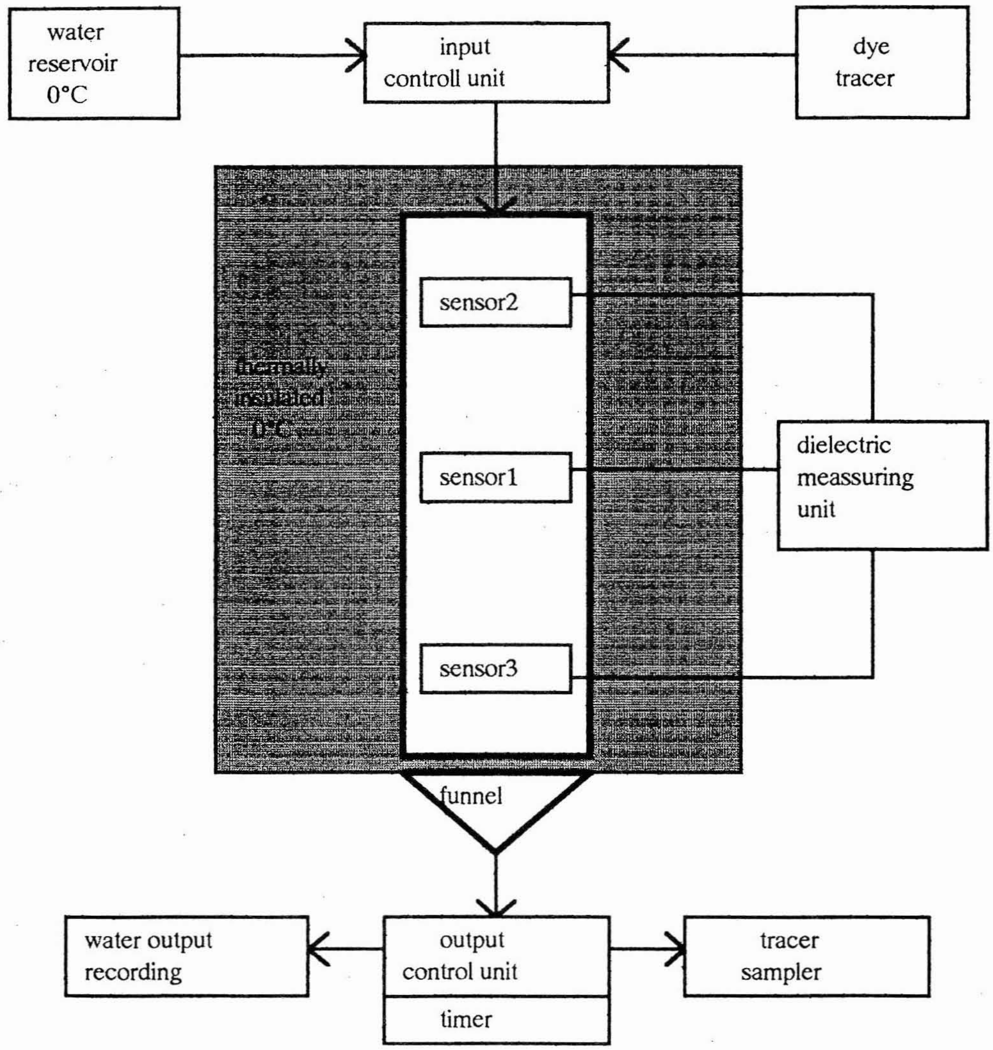

Figure 1 - blockdiagram of the experimental setup

Repacked more or less homogeneous snow is filled into an aluminum column of a size of 1.38 x 0.25 x 0.25 meter. A metall screen at the lower end of the column prevents the snow from running out. At the top water and dye tracers can be irrigated upon the snow (Figure 1. "Input controll unit"). At the bottom the water reaches through a funnel a magnetic valve. A time control unit (Figure 1. "Output control unit / timer") switches this valve between a continuous water output recording (see Figure 1.) and an automatic sampler for dye tracer probes (Figure 1. "Tracer sampler"). The dye tracer concentration of the collected probes is measured using a "Gilson Spektra/Glo" fluorometer. Capacitiv level meters and field proved plotters are used to measure and record the water in- and output continuously. Three capacitive sensors (Figure 1.

"Sensor 1-3") are placed vertically in the column at different depths when the column is filled. Attached to a processor controlled unit (Figure 1. "dielectric measuring unit") these sensors register the timely variations of the water content. For a description of the used aparture see (Denoth and Griessmaier, 1990).

FIELD SITUATION

For the experiments of July 1992 a two to three weeks old, wet snow with a mean grain size of approximately 0.6 mm was used. At the beginning of the experiment the snow density r, the grain size and the water content W were measured. To find out the water content the same capacitive measuring unit as described above was used. The grain size could be estimated with a calibrated magnifying glass.

After the column was filled the snow drained out until the saturation was approximately the same as the irreducible saturation. Several artificial water inputs of chosen input rate, lasting preselected times, followed. The input rates were chosen to simulate those produced by natural processes (radiation induced melting, light rainfall on snow). The water output was registerd during the whole week the experiment lasted. Most of the water inputs were interrupted to do a short dye tracer input. At the end of the experiment the front side of the aluminum column was opened. Vertical profiles of the snow density and the water content were measured. The grain size was estimated again.

PRELIMINARY RESULTS

From the recorded data it is possible to determine most of the parameters of the differential equation of the "Gravity flow theory". Using the numerical method of the characteristica (Tucker, 1977) the nonlinear equation was solved for several sets of the parameters n and d and compared with the recorded flux. The results are shown in Figure 2 and 3.

Figure 2. shows two water inputs (dashed lines) and the modelling of the water output (solid line) at a depth of 1.38 meter. The parameters n and d are the ones of the best fit with measured data

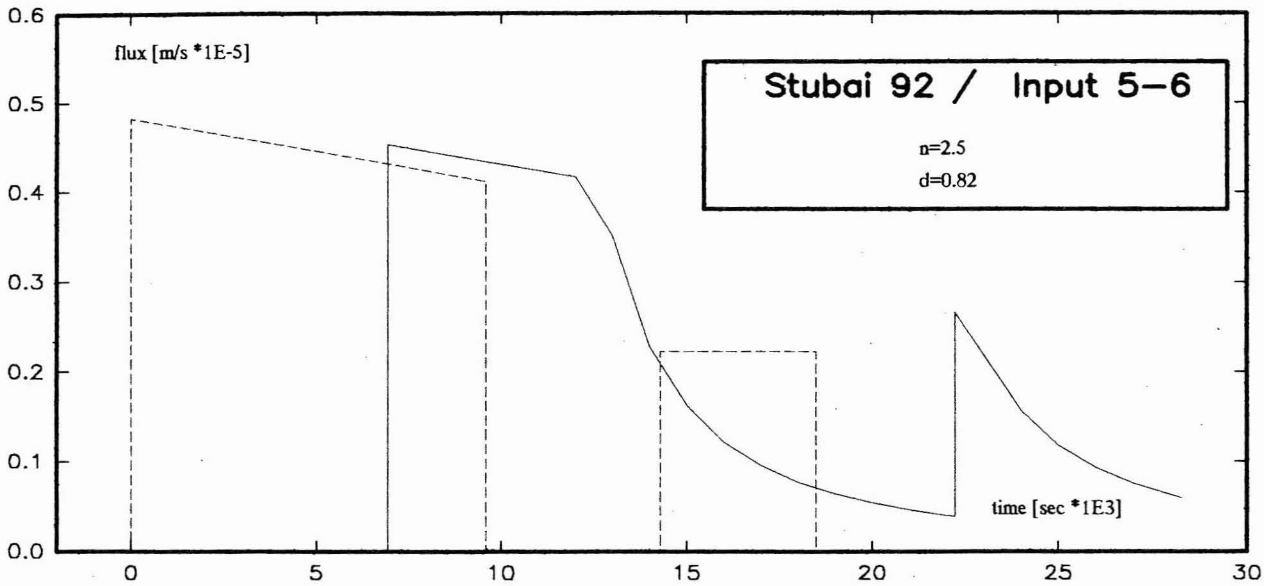

Figure 2 - Two water inputs and the according modelling of the output flux at a depth of 1.38 m

Figure 3.: The symbols D are some chosen data points of the continuous output recording of the water flux. In the interesting part of the plot, where the shock fronts appear, more points were taken. The solid line is the numerical solution of the differential equation of the "Gravity flow theory", where n and d were taken as fit parameters. This plot shows only the best fit (n=2.5 and d=0.82).

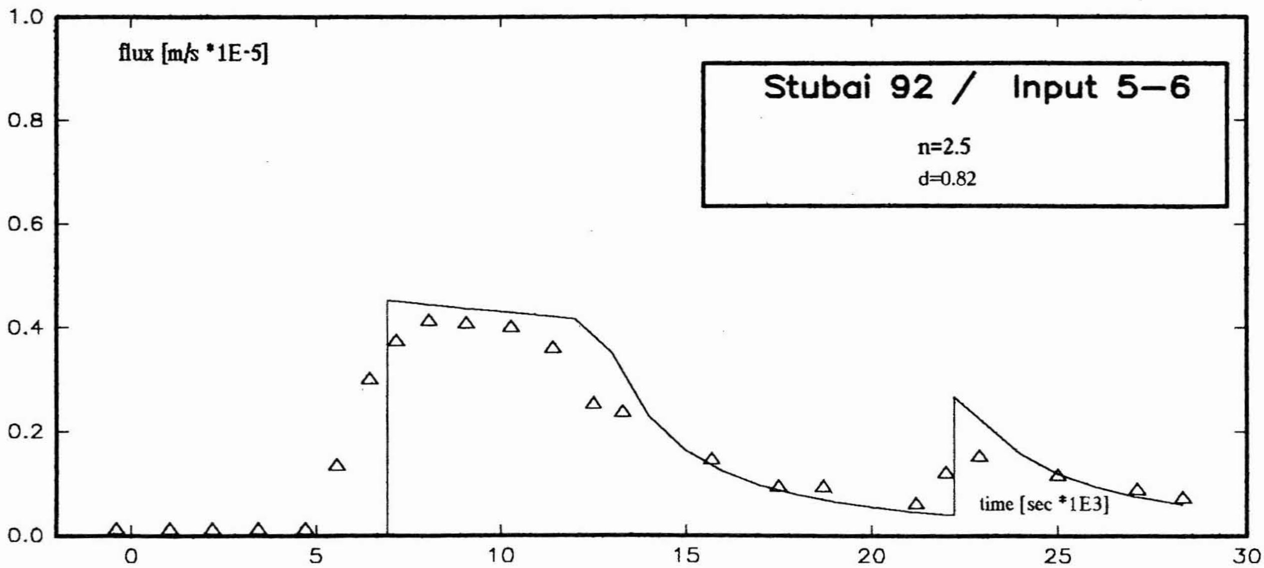

Figure 3 - Measured data points of the output flux and according modelling at a depth of 1.38m

Figure 4. shows the movement of a water wave within the snow column. These are some results of the new measurement system using the capacitive sensors and processor controlled unit.

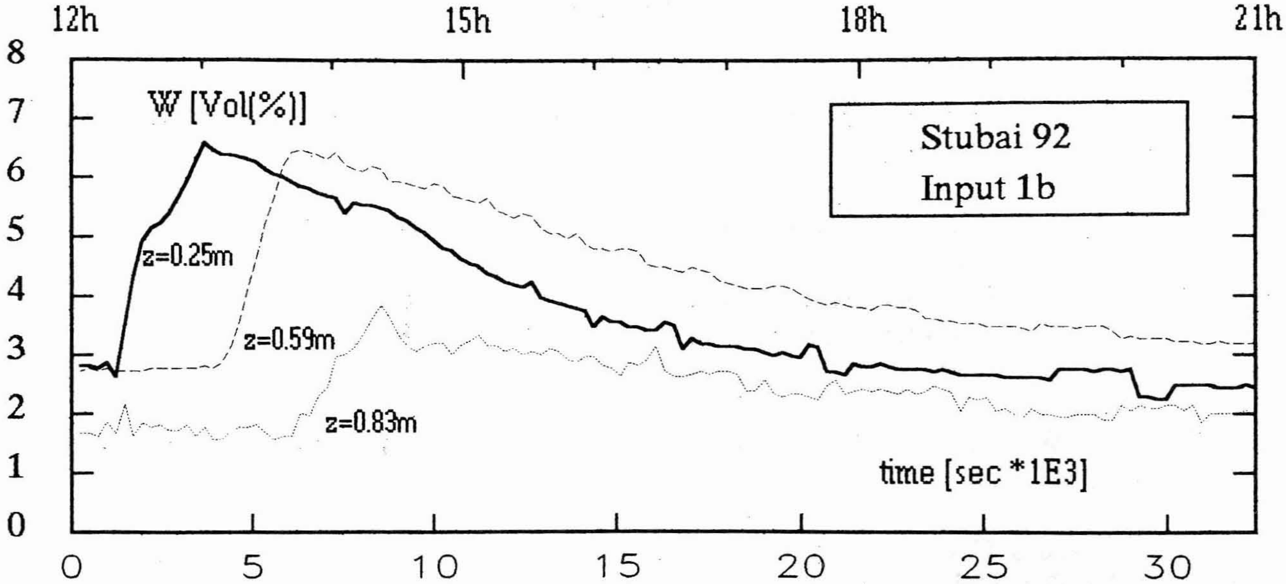

Figure 4 - timely variation of the water content at three different depths

Tracer results : From the two used dye tracers, Rhodamin B and Fluorescein, only Fluorescein is described by the theory of (Colbeck, 1977). Rhodamin is strongly adsorbed. It is therfore very important to chose carefully what dye tracers one uses.

OUTLOOK

A correlation analysis between the structur related parameters of the theory (n, d, the irreducable saturation Si and the porosity f) should be done. Also more dye tracers should be tested. Therefore the data base for both, the tracers and the water flux, needs to be improved significantly.
Using a photographic method a more accurate picture of the grain geometries can be found. It is hoped to deduce the parameter d from these photographic analysis.

ACKNOWLEDGEMENT

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