NEW METHODS IN ICE CORE PROCESSING

by

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ABSTRACT

Core processing includes the inspection, registration, labelling and packing of ice cores as well as first measurements in the field. The methods of core processing applied during core drillings at Dye 3 and South Pole are presented. A modified version that will be applied in summer 1989 in Central Greenland is discussed in more detail. It includes the cutting and melting of subcores and the measurement of certain impurity concentrations (e.g. H_2O_2) continuously along the core in the field.

INTRODUCTION

It is evident that ice core processing belongs to any ice core drilling. It has to include at least the inspection, registration and labelling of the ice cores. An extended ice core processing in the field is especially needed if different laboratories are involved in the analyses of the ice cores later in the laboratory. The goals of an extended core processing are especially :

- to give a detailed documentation of the ice core which allows later to any core user to select the samples best suited for his analyses.

- to perform a preliminary dating already in the field which allows to preselect samples.

- to make analyses already in the field for components which might change during transportation and storage or which can be measured much more efficiently in the field.

A core processing that accomplishes at least partly these criteria, was applied during the deep core drilling at Dye 3 (1979-1981) and during the core drilling at South Pole by PICO 1983 and 1984. An extended core processing is also planned for the Eurocore drilling in Central Greenland in 1989. The operation of the core processing applied at Dye 3 and South Pole will shortly be presented before discussing the modified version of a core processing planned for Eurocore.

LAYOUT AND OPERATION

At Dye 3 the ice cores were inspected, measured, marked and recorded in a one to one scale on millimeter paper. The meter marks made on the ice core itself ensured that all investigators were using the same depth scale within a few millimeters. The core was then fixed in a frame and in a second step the core was splitted parallel to the core axis with a specially constructed band saw. The upper core segment (core diameter : 100 mm, height of segment : 32 mm) was used mainly for isotope analyses and dust concentration measurements. The samples for isotope analyses were cut to size and packed individually in the field. The dust measurements were also done to a large part already in the field (Hammer et al., 1985). The cutting surface of the remaining part was then planished by a microtome blade. In a third step the electrical conductivity was measured on the smooth and clean surface along the core (Hammer, 1980). The electrical conductivity results allowed to detect tracers of volcanic eruptions already in the field and together with the dust measurements, they allowed also to detect clearly the transition from the last glaciation to the Holocene. After the electrical conductivity measurements, the ice core was taken off the frame, cut in meter pieces, packed and labelled.

At South Pole station, ice cores from South Pole and from Siple Station were processed. The ice cores were first inpected, measured and marked. To obtain a flat and clean surface a very thin segment of the core was cut away with the bandsaw and discarded. The cutting surface was planished by a microtome blade. The smooth and clean surface was recorded in a third step continuously on video tape. Subsequently the electrical conductivity was measured on the same surface. The core was then splitted in two parts with an ordinary band saw and packed and labelled. The video recording was very useful as documentation of the ice cores. It is as informative as the recording by hand on millimeter paper, it is very easy to handle and can be copied and distributed to different core users. Core processing at Dye 3 and South Pole needed about 4 to 5 people to process 20 m ice core per day.

During Eurocore, an ice core drilling operation that will be performed in summer 1989 in Central Greenland, a core processing according to the layout shown in fig. 1 will be used. More analyses shall be performed already in the field. By the availability of new analytical techniques, which allow to measure very fast low impurity concentrations in small samples, it is well justified to measure several parameters already in the field. However, it has to be kept in mind, that each step for a one meter ice core has to be performed in less than about 30 minutes, in order not to slow down the whole core processing. Most of the new analytical methods are based on a modified flow injection technique, using a continuous flow of the melted sample. The question arises, whether one subcore should be extracted and melted in order to distribute the water to the different analytical instruments, or whether each analysis should be provided with a separate subcore and a separate melting device. We decided to use different subcores. The reasons as well as the method of cutting and melting the subcore will be discussed in the next chapter.

DIFFERENT COMPONENTS OF THE CORE PROCESSING LINE

Band saw :
We made a relatively great effort to construct a band saw which allows to split an ice core with a very flat and precise cut parallel to the core axis. The core is fixed in its frame to a stable bed-plate of a length of 3500 mm and a weight of 160 kg. The bandsaw is driven by a 0.5 kW electrical D.C. motor. Both wheels are counter-balanced. The saw blades are of the cross tooth system and have a thickness of 0.65 mm. The speed of the saw blade is variable. Best results were obtained with a velocity of about 4 m/s. The band saw moves automatically on a rail system along the bed-plate. The speed of advancement is also variable. For tests we used velocities between 8 and 20 mm/s. The band saw allows to cut a thin plate of only 8 mm thickness all along a one meter ice core.

Milling tool :

The cutting surface made with the band saw is flat but not clean and smooth enough to perform e.g. electrical conductivity measurements. Until present we used a microtome blade to planish the surface, but now we have constructed a milling device which gives a surface as clean and even smoother than with the microtome blade in less time. The milling cutter has a diameter of 160 mm. It contains 9 hard-metal cutters and rotates with 3 000 rpm. A layer of 1 mm at maximum can be milled away in one step. With an advancement of 8 mm/s or less, a smooth and clean surface is obtained.

Video recording

For the video recording we move the video camera (Sony V-8e) over the ice core which is illuminated from below. The polished cutting surface is recorder. The advancement velocity is 8 mm/s.

Preparation and melting of "subcores" :

It would be most efficient to separate one part of the ice core by a band- or circular saw, to melt this part continuously with a constant melting rate and to distribute the meltwater to the different analytical devices. The new analytical methods are fast and easy to operate, but occasionally there can occur interruptions in the analyses due to a failure in any of the analytical systems. Any interruption on one device would hold up all other measurements and therefore the whole core processing, or measurements for one component would be lost for a certain core length. We decided therefore to cut several subcores with a band saw and to use for each subcore an individual melting device. The principle of a simple melting device is shown in fig. 2. It is suitable for components which are not very susceptible to contamination. It has been applied successfully for continuous measurements of hydrogen peroxyde during a field operation at Dye 3 in summer 1988. A subcore with a rectangular cross section of about 8 x 10 mm^2 is cut with a band saw. The subcore is then continuously melted at a rate of 1 mm/s. The meltwater is pumped to a heated box where the concentration is measured continuously. The power needed to heat and melt the ice is 30 Watt, heat loss not included. The heating element consists of a teflon coated aluminium cylinder which can be heated up to 120 Watt. The heating power is electronically regulated in order to reach a rather constant melting rate. The melting rate is recorded by measuring the length of the remaining part of the subcore with a potentiometer circuit. Fig. 3 shows examples of H_2O_2 concentration profiles along two core sections of 1 meter each from the Dye 3 ice core. The analyses was performed immediately after core recovery. The results from two neighbouring subcores of the same depth interval show the excellent reproducibility of the method for H_2O_2.

However, for parameters like Ca++ and HCHO which are more susceptible to contamination, only the meltwater of the inner part of the subcore can be used. We are constructing therefore a special melting device for these components which allows to separate the meltwater from the surface of the subcore. The minimum subcore cross section required for this method is 15 x 20 mm^2.

There is an alternative to the melting of subcores. Hammer (1985) has used a kind of soldering iron to melt a small groove into the ice core itself. The meltwater is pumped away continuously. The method offers more flexibility, especially in case of fractured cores, since the melting track has not to follow necessarily a straight line. However, the method is laborious, especially if several continuous samples have to be extracted, and further we are afraid that this procedure could produce thermal cracks on the remaining core.

SOME REMARKS ON ANALYTICAL METHODS

As an example of a continuous flow analysis (CFA) the measurement of the H_2O_2 concentration shall be discussed. The meltwater is pumped off the melting device with a pumping rate exceeding the melting rate in order to separate small parcels of meltwater with air bubbles. The water is pumped through a heated tube into a thermostated box where all analytical instruments are placed. There, in a first step, the air segments are removed from the sample stream. The flow rate to the debubbler is about 6.4 ml/min, after the debubbler about 0.83 ml/min. Immediately after the debubbler a reagens solution is added with a rate of 0.45 ml/min to the meltwater. The reagens solution contains 0.03 M (mol/l) borate buffer (pH = 7.8), 2 10^{-3} M 4-ethylphenol and 3.6 mg/l peroxidase. Hydrogen peroxyde forms dimers of 4-ethylphenol, catalysed by the enzyme peroxidase. This dimer can be detected fluorometrically (absorption maximum : 310 nm, emission maximum : 400 nm). We have constructed a filter fluorimeter, using a cadmium lamp with a strong emission line at 326 nm as light source and with a photomultiplier as detector of the fluorescence light.

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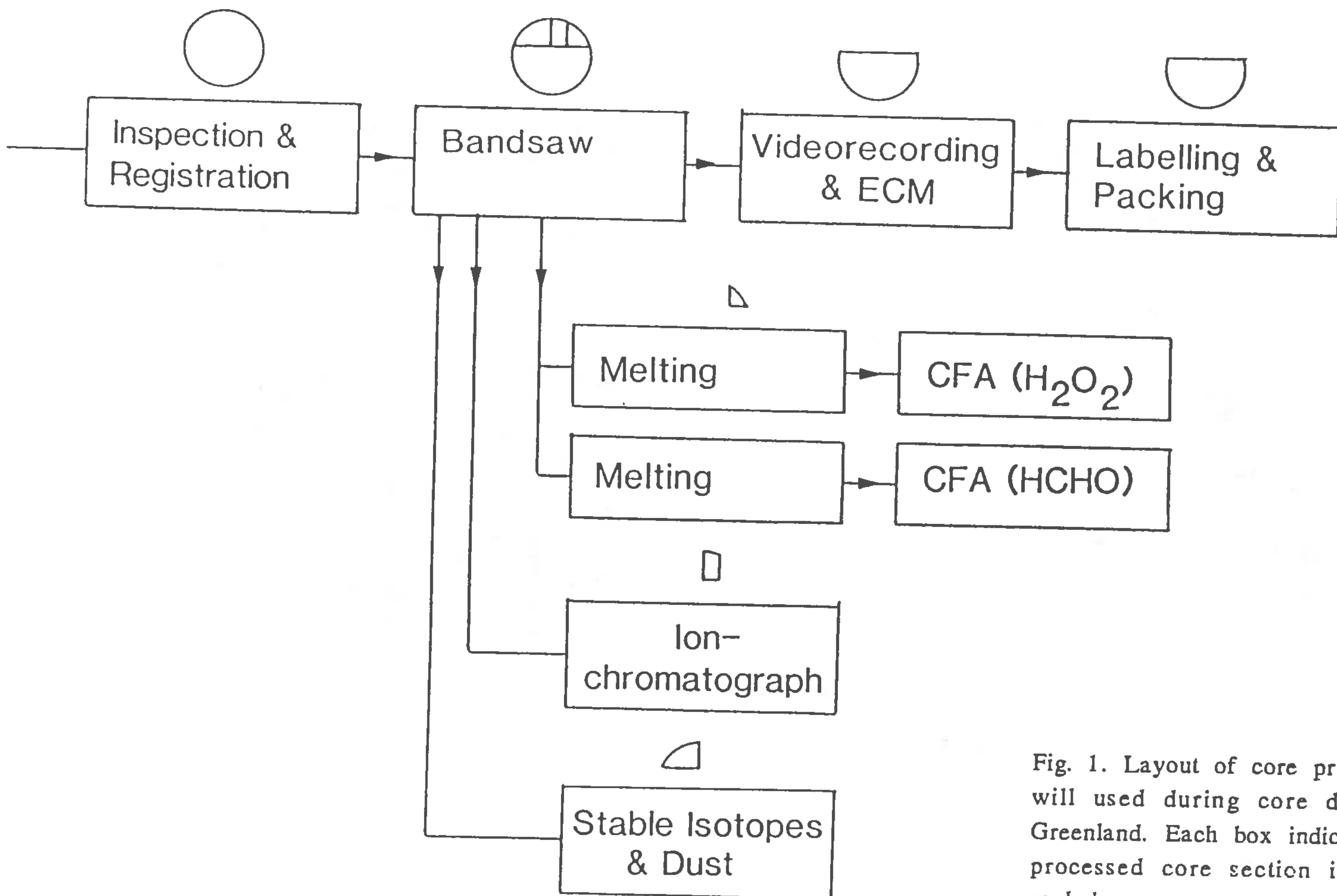

Fig. 1. Layout of core processing line which will used during core drilling in Central Greenland. Each box indicates one step. The processed core section is indicated above each box.

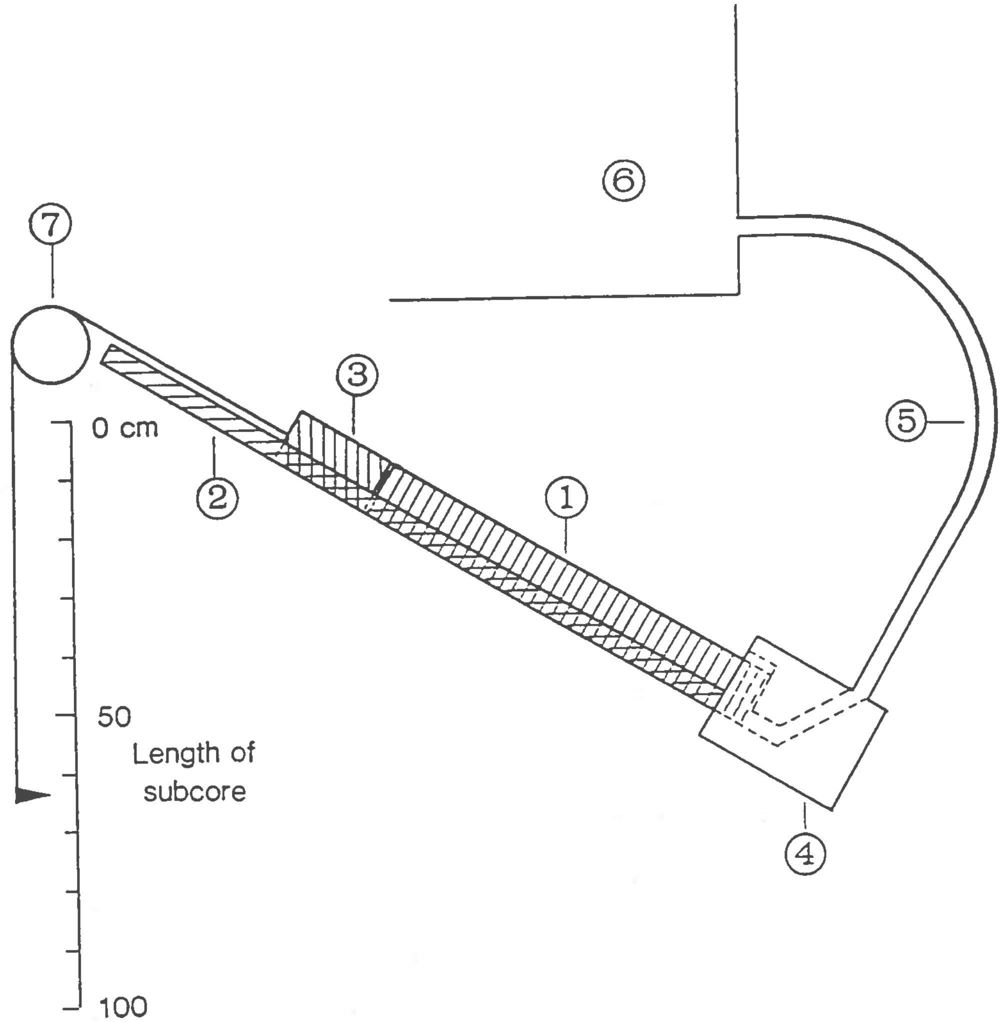

Fig. 2. Schematic of simple subcore melting device. The subcore (1) with a rectangular cross section of 8 x 10 mm^2 glides in a teflon coated channel (2). It is pressed with a weight (3) against a teflon coated aluminium cylinder (4) with an electronically regulated heater. The meltwater is pumped through a heated hose (5) to a thermostated box (6) where the concentration is measured. The melting rate is about 1 mm/s. The length of the remaining part of the subcore is measured with a potentiometer circuit (7).

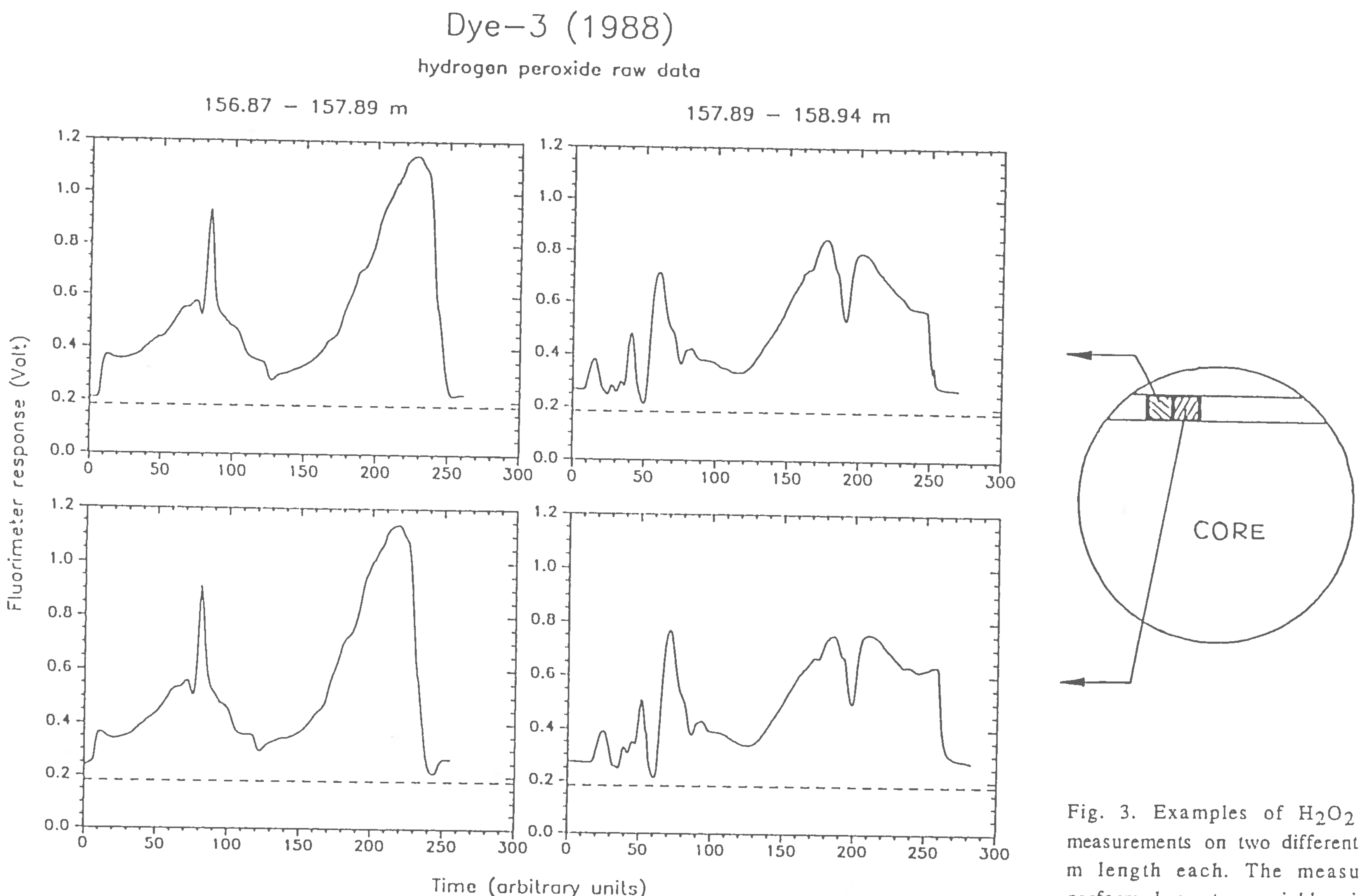

Fig. 3. Examples of H_2O_2 concentration measurements on two different ice cores of 1 m length each. The measurements were performed on two neighbouring subcores in order to test the reproducibility of the analysis.