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ICE CORE PROCESSING AT DOME F, ANTARCTICA

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Abstract: The Dome F Project is an integrated field and laboratory research effort on deep core drilling and analysis at Dome F, Antarctica. Ice core processing starts immediately after core recovery in the field to combine core drilling activities with core analysis procedures. Key factors in processing procedures include core logging, brittle zone handling, field measurements, sample preparation and core packing for transportation. Designing of a core processing line is quite important to maximize the benefit of the field activity and guide the following laboratory analysis. Functions and tasks of core processing are discussed and a core processing line for Dome F is proposed by taking various requirements and circumstances into consideration.

1. Introduction

Ice core processing in the field involves both core storage and core analysis (STAUFFER *et al.*, 1989). The depth scale for the core is determined in the field immediately after recovery and serves as a fundamental value to identify each core segment for subsequent core handling. This is called core-logging and is one of the most important tasks. The objectives of core analysis in the field are (1) to obtain general property information of the core as soon as possible as reference for the following laboratory investigations, and (2) to obtain fresh ice data to calibrate and/or examine time-dependent changes of the core such as volume relaxation alteration.

One of the most time consuming jobs is sample cutting for detailed core analysis in a laboratory. Sample preparation can be combined with a core processing line in the field if the cutting procedures are pre-planned.

Ice core processing at Dome F (Table 1) can be done by three persons. A 10 m length of the core is expected to be processed every day. The processing line should be constructed taking job priority into consideration.

Table 1. Glaciological data at Dome F, Antarctica

Drill site location:	77°22'S, 39°37'E
Elevation:	3807 m a.s.l.
Ice thickness:	2800–3000 m
Mean temperature:	–58°C (10 m snow temperature)
Accumulation rate:	3.2 cm in water equivalent/year
Distance from Syowa:	approximately 1000 km

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2. Core Storage

After the core segment is registered for the depth scale, bulk density, which is important information on the firnification depth region, is measured. Recording of core quality is essential for chemistry sampling. When core pieces sinter and leave tiny air-bubbles along the previous fractured surface, the contaminated part should be carefully removed before the measurement based on the quality record. Visual stratigraphy observation helps to identify the top direction of a core segment if the segment was rotated accidentally and the direction lost.

The processing table should be rigid and the surface should be flat and clean to avoid core breaking or bending accidents. Temperature should never be higher than –10°C. Below –20°C is desirable to maintain good core condition.

3. Field Measurement and Basic Analysis

Basic core analysis has been discussed by selected members of the National Institute of Polar Research and the Japanese Society of Snow and Ice. This includes stable isotope analysis, chemistry measurement and physical property study. The total amount for the basic analysis is estimated to be about 40% of core portion continuously along the depth. Electric conductivity measurement (ECM; HAMMER, 1980), dielectric property measurement (DEP; MOORE and PAREN, 1987) and stratigraphic recording by video camera have

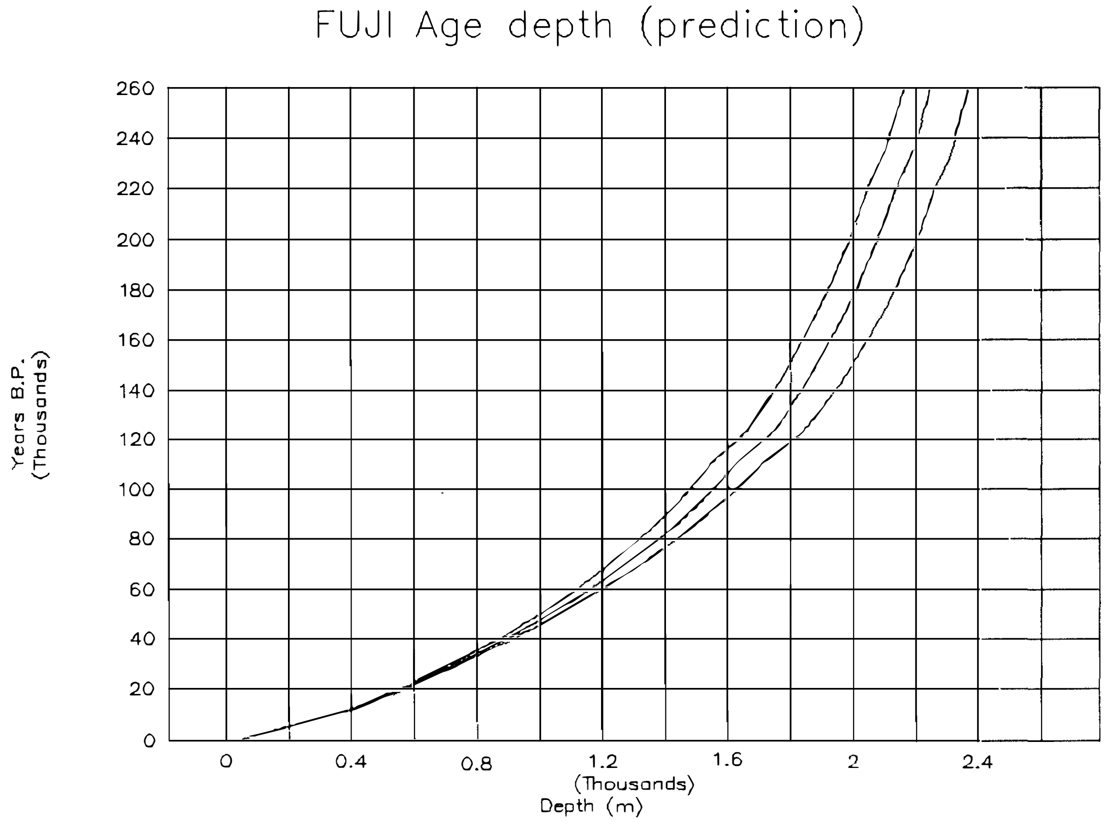

Fig. 1. A time scale calculated for the Dome F, Antarctica ice core (DAHL-JENSEN, unpublished).

been identified as fast and continuous measurements that can be done in the field. EC and pH are also measured on selected continuous/discrete melted samples in the field by considering the results of continuous measurements. Physical property study in the field includes observations of grain size/shape, *c*-axis orientation, air hydrate, and total air volume with a sampling interval of about 50 m.

4. Depth Age and Brittle Zone

A time scale for the Dome F ice core has been estimated by Dorthe DAHL-JENSEN (unpublished) as shown in Fig. 1. Three curves are obtained by using three different flow patterns at Dome F. The Holocene/Wisconsin boundary is located around a depth of 400 m. The Sangamon interglacial period is located around a depth of 1600 m. The annual layer thickness profile shown in Fig. 2 suggests that the thickness of Wisconsin age ice may be 1 to 2 cm if seasonal variation signals are formed at the snow surface and preserved in the ice sheet. This information should be taken into account for discrete sampling in the field.

An ice core is quite brittle immediately after recovery from a depth zone of high pressure air bubbles. Once air and ice are transformed into air hydrate, the ice core is very stable. Therefore, the brittle zone is usually located just above the transformation depth as indicated in Fig. 3 (SHOJI and LANGWAY, 1987). Another brittle zone may be located near

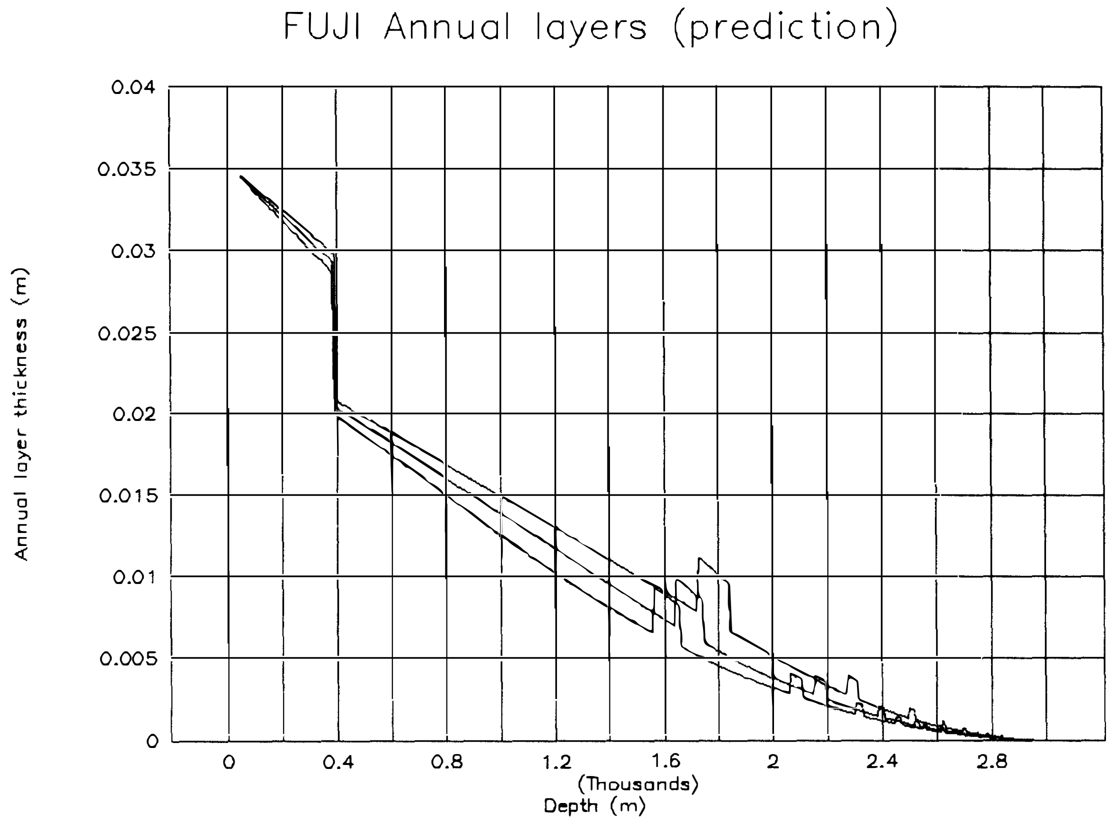

Fig. 2. An annual layer thickness profile calculated for the Dome F, Antarctica ice core (DAHL-JENSEN, unpublished).

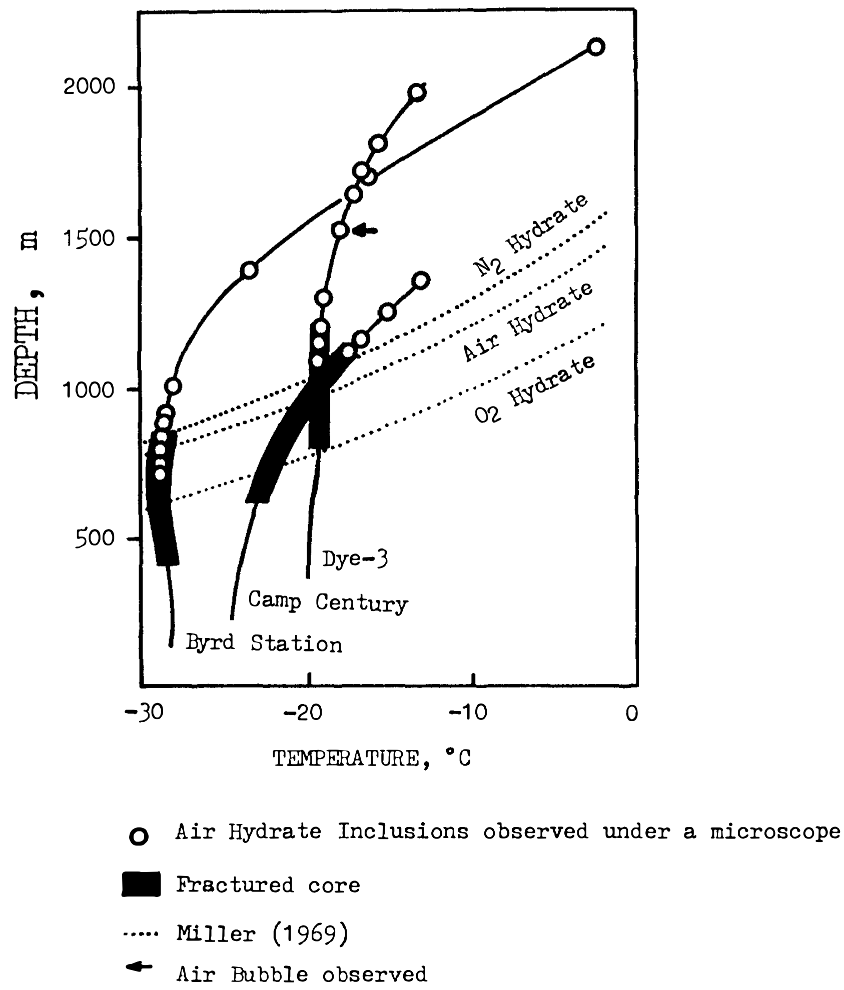

Fig. 3. Fractured core zones observed at Dye-3, Camp Century and Byrd Station (SHOJI and LANGWAY, 1987).

the bed of ice sheets if the bed temperature is relatively high and grain size is large as observed at Byrd Station, Antarctica and Dome GRIP, Greenland. At these places grain boundary separation has been observed in the outer half region of ice cores. As these boundary surfaces separate easily, sinter again and form tiny intergranular air bubbles, the outer half region is contaminated.

The transformation depth of air and ice into air hydrate was estimated to be about 400 m at Dome F by using Miller's equation (1969) as shown in Fig. 4. This means that the ice core may become increasingly brittle down to a depth of 400 m. However, core brittleness might last a few hundred meters more if the transformation is not completed.

5. Core Processing Procedure

The core processing procedure at Dome F has been considered, discussed and summarized as indicated in Fig. 5. After core retrieval, logging and bulk density measurements are made. One meter has been proposed as the length of segments into which the core should be cut for easy handling by one person. The core is cut lengthwise

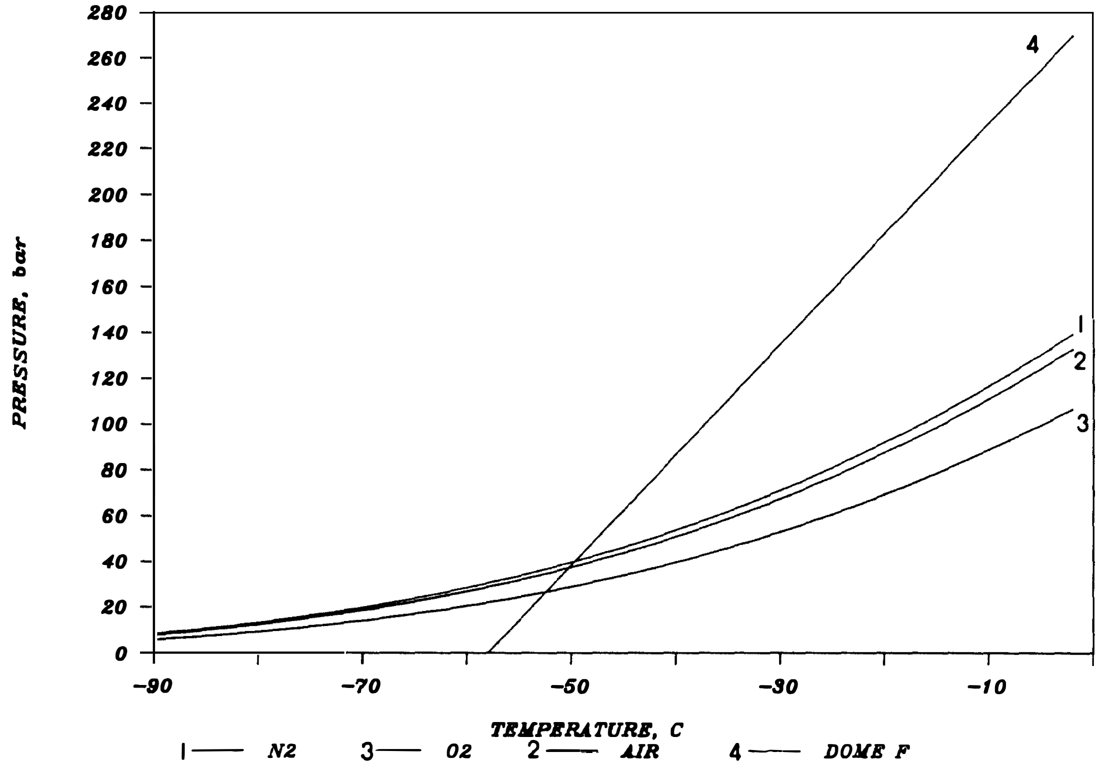

Fig. 4. Estimate of transformation depth from air and ice to air hydrate. Curves 1, 2 and 3 are dissociation pressure lines for nitrogen, air and oxygen hydrates, respectively (Miller, 1969). Curve 4 is an estimated pressure (depth)-temperature line at Dome F, Antarctica. Intercepts of Curve 4 with Curve 2 and 1 give initiation and completion pressures (depths) respectively for the transformation (Miller, 1969).

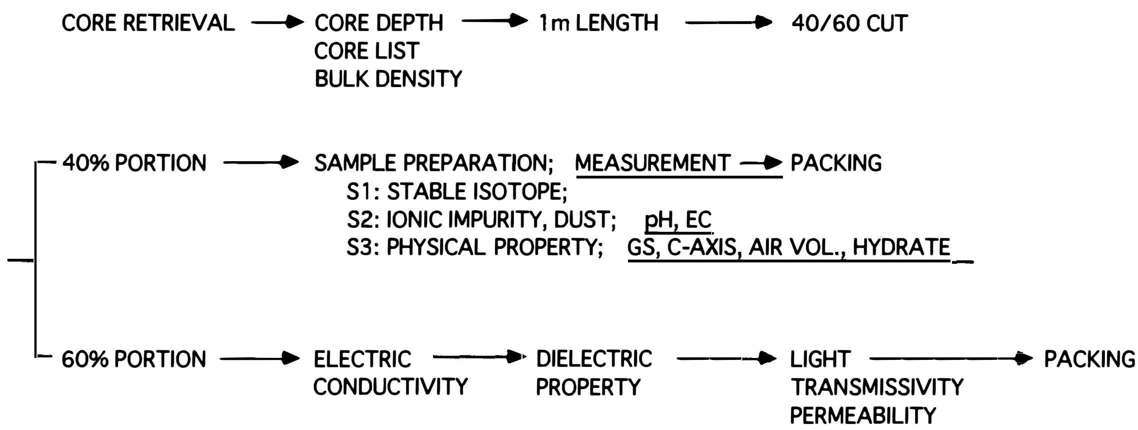

Fig. 5. A core processing procedure proposed for Dome F, Antarctica.

to separate the basic analysis portion (40%: S1+S2+S3) from the main core portion (60%: S4) as shown in Fig. 6. After separation by a horizontal band-saw, the surface is microtomed and electrical conductivity is measured by using the clean/flat surface. Then, other sample preparations and measurements are carried out as in Fig. 5.

A field trench laboratory has been designed as shown in Fig. 7. Table setting for core processing may be as shown in Fig. 8. Arrows show movements of core segments during

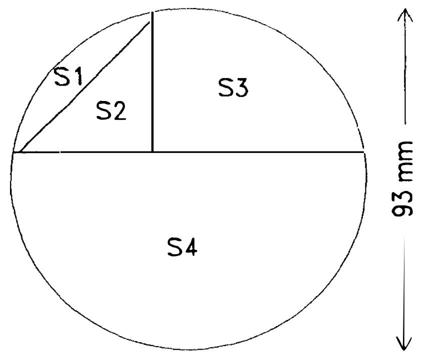

Fig. 6. A core cutting plan for the Dome F, Antarctic ice core. Samples S1, S2 and S3 are explained in Fig. 5. S4 is 60% portion, main core in Fig. 5.

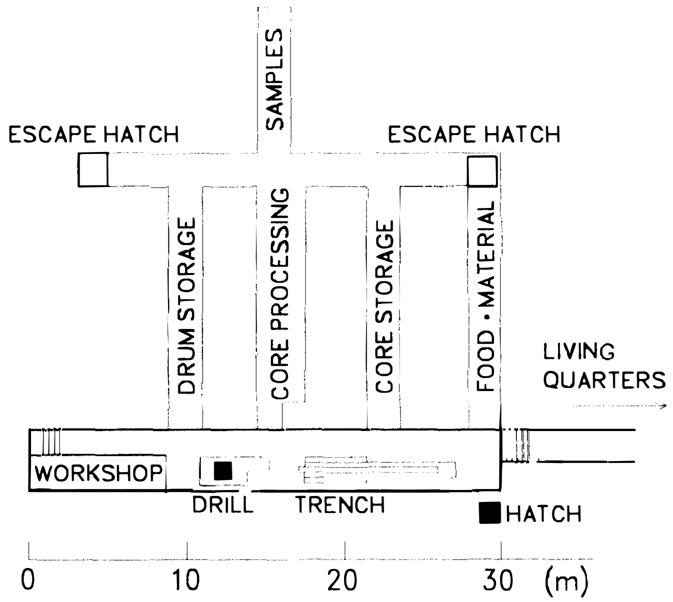

Fig. 7. Field trench laboratory proposed for core processing at Dome F, Antarctica.

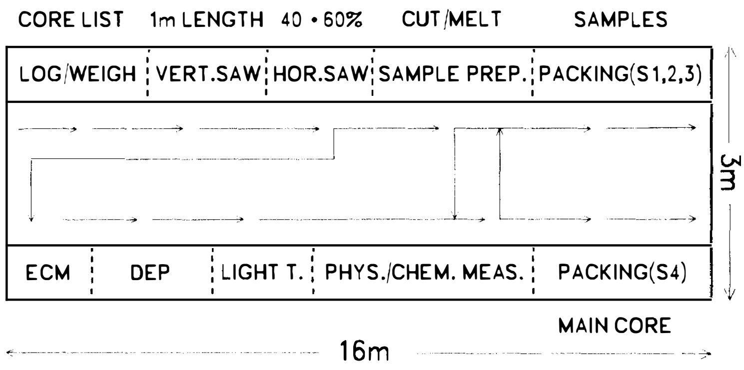

Fig. 8. A table setting plan for core processing at Dome F, Antarctica. Arrows show core segment movement for the processing procedure.

the processing procedure. Samples S1, S2 and S3 are stored separately from the main core S4 after packing as shown in Fig. 7.

Transportation of the 40% core portion (S1+S2+S3) has higher priority; the possibility of storing the main core portion (S4) in the field for one or two years is under consideration.

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