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Accumulation Rate at Site-J and Dye-2, Greenland

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Abstract

Shallow ice cores were drilled at Site-J, Greenland by Japanese Arctic Glaciological Expedition members in 1989. An accumulation rate value of 42 cm of ice/year for the core was obtained by utilizing Laki Eruption reference horizon in 1783 observed by ECM measurement on the core. A reference time scale calculated by simple summations of ammual accumulation layers agrees reasonably well with the results of ECM, EC and pH measurements for the volcanic event signals on the core.

1. Introduction

A team members of Japanese Arctic Glaciological Expedition (JAGE : PI, Dr. O. Watanabe) successfully obtained one 100 m-long and one 206 m-long ice cores at Site-J (66°51.9'N, 46°15.9'W), Greenland during the field activities in 1989. The prime objectives of the shallow ice core investigations are to acquire much fuller understanding of the near-surface characteristics of the ice sheet and to extract the information on the environmental condition changes whithin a few hundred years back in time (Watanabe and Fujii, 1990). A time scale of an ice core is generally determined by multi-parameter core studies and enables to examine local, regional and areal changes in the past environmental conditions by cross-correlating the obtained signals with those of other ice cores from various sites on the ice sheet. This report focuses on estimating an average accumulation rate (*i.e.* a reference time scale) for the Site-J ice core by taking the detailed study on the Dye-2 (66.48°N, 46.33°W) ice core into consideration.

2. Dye-2 ice core study

Dye-2 locates about 50 km south of Site-J. Elevation and 10 m-depth temperature at Dye-2 are 2100 m a.s.l. and −17.22 ℃ respectively, which are quite comparable to those of 2030 m a.s.l. and −16.3 ℃ at Site-J. A 100.20 m-long ice core was drilled at Dye -2 in 1977 and analysed by Geophysical Institute, University of Copenhagen. Detailed $\delta^{18}O$ analysis was made on the Dye-2 core with a procedure of 16 sampling per year based on the assumed accumulation rate of 36.5 cm of ice/year. The seasonal variation in the $\delta^{18}O$ profile obtained allowed to date the core back to 1742 A.D. at the bottom on a year-to-year basis. A high signal peak in ECM measurement as observed at a depth of 85.3 m of the same core, corresponding to Laki eruption in 1783. The total β activity measurement showed a clear signal increase at a depth of 12. 5 m, corresponding the start of 1955 A.D.. All the above measurements lead to an establishment of a reliable time scale for the Dye-2 core with an average value of annual layer thickness of 37.4 cm of ice/year. Annual layer thickness (ALT) generally decreases with depth due to the flow of ice mass. The thinning rate of ALT with depth, however, would be influenced by the upstream distribution of accumulation rate and/or ice thickness variations (Reeh *et al.*, 1985). The mean ALT for every 10 year interval of the Dye -2 core is shown in Fig.1. The variation in the profile shown is quite irregular and well exceeds 10 % of the average ALT value of 37.4 cm for the entire core. The mean ALT values for longer time spans counted backwards from 1970 A.D. to the past are shown in

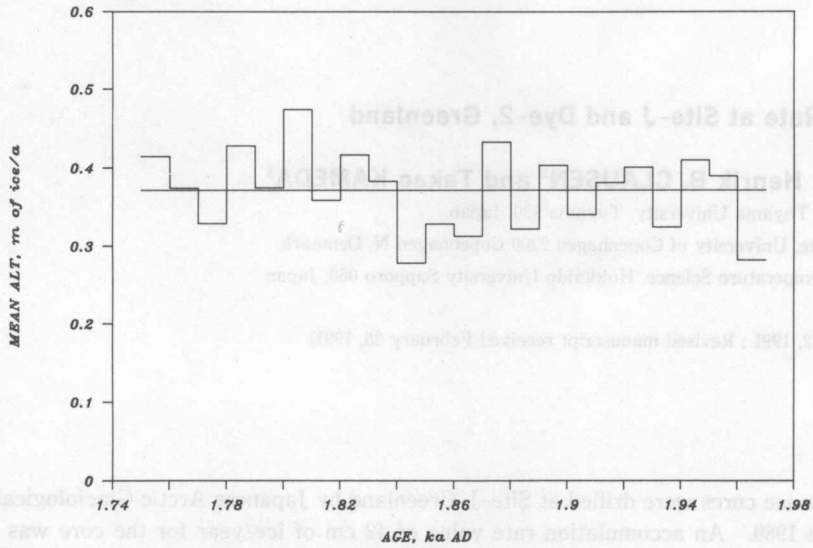

Fig. 1. Mean annual layer thickness (ALT) profile at Dye-2, Greenland (10 year average).

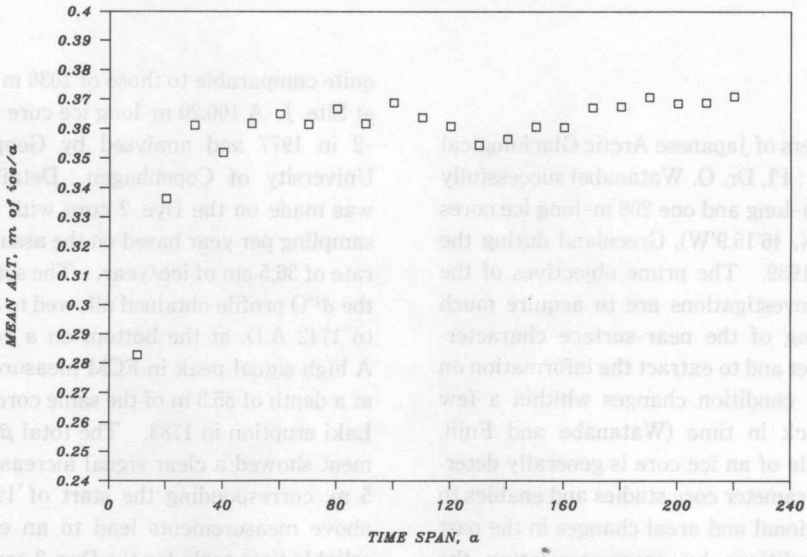

Fig. 2. Mean annual layer thickness (ALT) values obtained with various time spans on the Dye-2 ice core.

Fig.2, which suggests that more than a few tens of years are required to obtain a representative value of mean ALT around Dye-2 area. For the present day value of accumulation rate at Dye-2 location, the above value of the average ALT, 37.4 cm of ice/year is adapted (Clausen and Hammer, 1988). Depth-age relationships for the measured profile by $\delta^{18}O$ analysis and the calsulated profile by simple summation of 37.4 cm of ice per each year are shown in Fig.3. Differences for these two profiles are to be seen within a few meter of ice at several age levels.

3. Site-J ice core study

Two tentative time scales are available for the Site-J core from ECM measurements (Nishio, unpublished) and EC and pH measurements on melted samples (Fujii, unpublished). They both utilized reference horizons of volcanic events. Since their time scales differ by a few meters from each other at

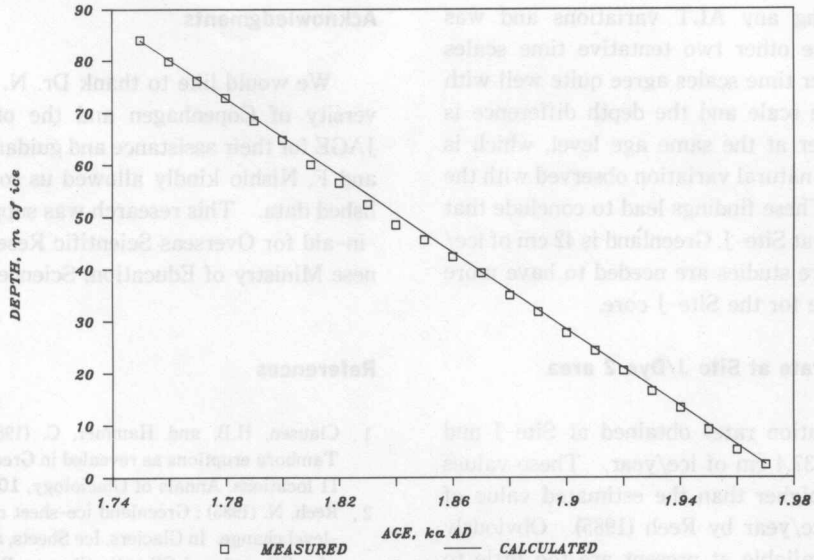

Fig. 3. Depth-age relationships of the Dye-2 ice core.

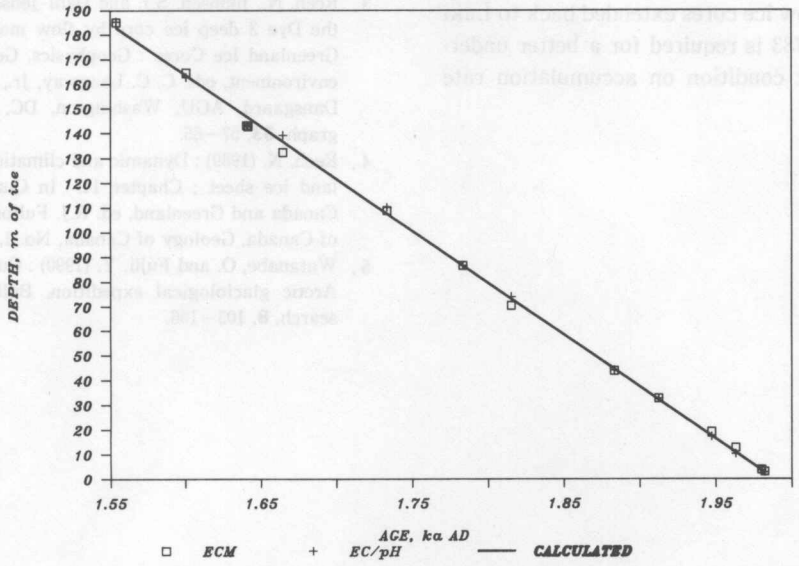

Fig. 4. Depth-age relationships of the Site-J ice core.

several age levels, an attempt was made to estimate an average ALT value for the accumulation rate at Site-J.

The simplest way to calculate the average ALT is to select a reference horizon with a known age of which the event should have occurred more than several tens of years before present. A distinct signal peak of ECM was observed at an ice equivalent depth of 86.673 m (Nishio, unpublished). Assuming that this peak position corresponds to Laki erruption event in 1783, an averaged ALT value of 42 cm of ice was obtained. The bottom depth of the Site-J core is about 10 % of the ice thickness in this region (Reeh, 1989). Therefore, we may expect about 10 % decrease in ALT within the core length due to the ice sheet flow. However, the ALT variation observed in the Dye-2 core suggests that the upstream effects are much larger than the general ALT thinning for the ice core. A reference time scale was calculated by using a constant accumulation rate of 42 cm of ice/year

without considering any ALT variations and was compared with the other two tentative time scales (Fig.4). Two other time scales agree quite well with the reference time scale and the depth difference is within a few meter at the same age level, which is comparable to the natural variation observed with the Dye-2 ice core. These findings lead to conclude that accumulation rate at Site-J, Greenland is 42 cm of ice/year. Further core studies are needed to have more detailed time scale for the Site-J core.

4. Accumulation rate at Site J/Dye 2 area

The accumulation rates obtained at Site-J and Dye-2 are 42 and 37.4 cm of ice/year. These values are significantly higher than the estimated value of about 33 cm of ice/year by Reeh (1985). Obviously measured data available at present are too little to construct more reliable map on accumulation rate distribution for this southwestern part of Greenland. A network of shallow ice cores extended back to Laki eruption event in 1783 is required for a better understanding of present condition on accumulation rate distribution.

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