Proc. NIPR Symp. Polar Meteorol. Glaciol., 5, 150–155, 1992

ICE LAYER OBSERVATIONS IN THE G6 ANTARCTIC ICE CORE

Hitoshi SHOJI[1], Kazunao MURATA[1] and Yoshiyuki FUJII[2]

[1]*Faculty of Science, Toyama University, 3190, Gofuku, Toyama 930*
[2]*National Institute of Polar Research, 9–10, Kaga 1-chome, Itabashi-ku, Tokyo 173*

Abstract: Ice crust layer studies were carried out on a 100 m-long ice core from G6, Antarctica. Light table observations were conducted to measure the depth, thickness, orientation and shape of each ice layer. The results were analyzed for the depth variations to obtain information on past ice sheet surface conditions. No indication was obtained of any distinctive change in snow surface conditions for the last several hundred years at the G6 site.

1. Introduction

Ice crust layer observations were conducted to obtain information on past ice sheet surface conditions by using the G6 Antarctic ice core drilled by members of the Japanese Antarctic Research Expedition (JARE-27) in 1986. The 100 m-long (10 cm in diameter) ice core was augered by using an electro-mechanical shallow drill.

G6 site (73°07′S, 39°46′E, 3005 m a. s. l.) is located on a katabatic wind slope of Mizuho Plateau where glazed surface formation takes place (FUJII and KUSUNOKI, 1982). The 10 m temperature at G6 is −43.1°C (Antarctica: East Queen Maud Land, Enderby Land Glaciological Folio, Sheet 7, Tokyo, National Institute of Polar Research). The average snow accumulation rate is 15.9 cm of snow/year (NISHIO *et al.*, 1988) which corresponds to an accumulation rate of 6.6 cm of ice/year using the bulk density of 380 kg/m^3 at 0.5 m-depth. The bulk density profile of the core (SHOJI and FUJII, 1991) gives the best-fit to the firnification equation (HERRON and LANGWAY, 1980) if an accumulation rate of 9 cm of ice/year is assumed. Grain size measurements give an accumulation rate of 12 cm of ice/year (NISHIZAWA, unpublished). These findings suggest 9±3 cm of ice/year as a possible value of the accumulation rate at G6.

The depth, thickness, orientation and shape of each ice layer were measured on a light table with accuracies of 1 mm, 0.1 mm and 1 degree respectively for the first three measurements. All experiments were made in a cold laboratory at −10°C.

2. Results and Discussion

2.1. *Ice layer depth distribution*

A total of 1181 ice layers were observed along the whole core length from 0.5 to 99.85 m depth. The sum of all layer thicknesses is 882 mm which corresponds to

1.2% of the total core length of 73.8 m in ice equivalent. The layer thickness distribution (Fig. 1) has an average value of 0.7 mm.

The average interval between layers was calculated to 6.3 cm of ice which is within the range of possible accumulation rate values mentioned in a previous section. In addition, the intervals averaged for every 5 m of ice increment stay almost constant

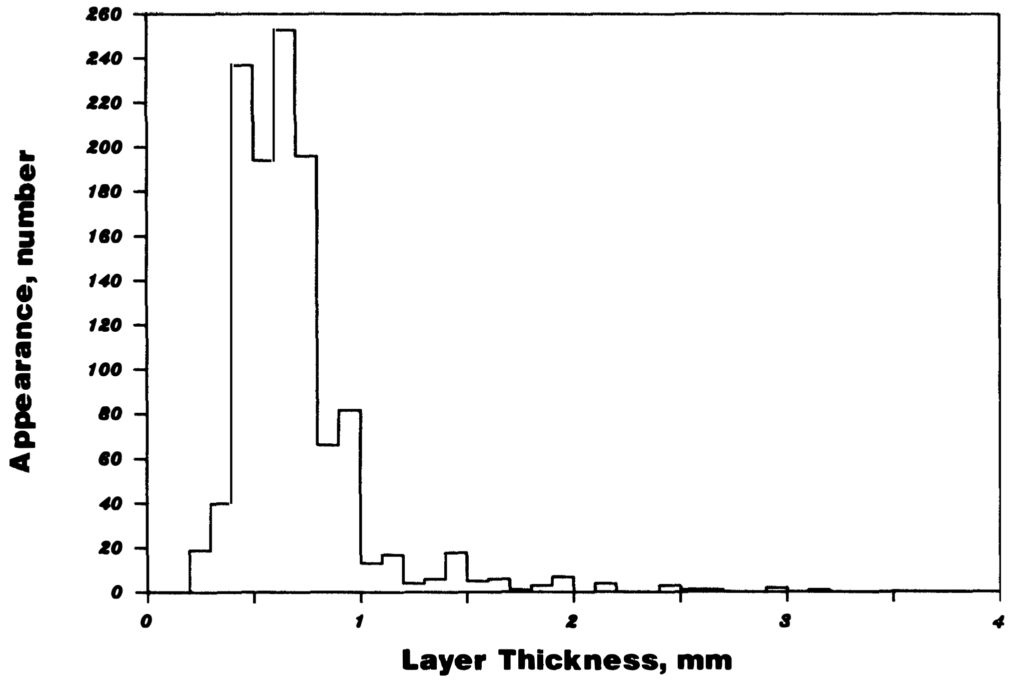

Fig. 1. Thickness distribution of ice crust layers observed in the G6 Antarctic ice core. The average thickness is 0.7 mm.

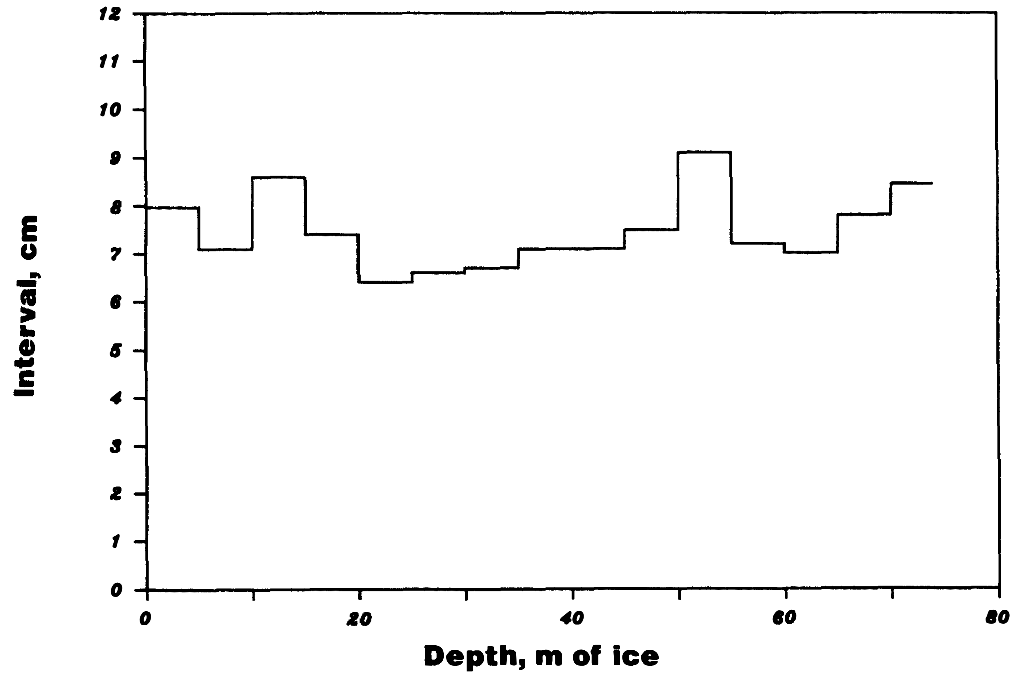

Fig. 2. Interval profile of ice crust layers observed in the G6 Antarctic ice core.

with depth as shown in Fig. 2. To examine the regularity of ice layer appearance with depth more thoroughly, the interval distribution was obtained for the entire core length (Fig. 3). If the accumulation rate is constant and each ice layer forms during a different summer, the profile should have a peak around an interval length of 6 cm.

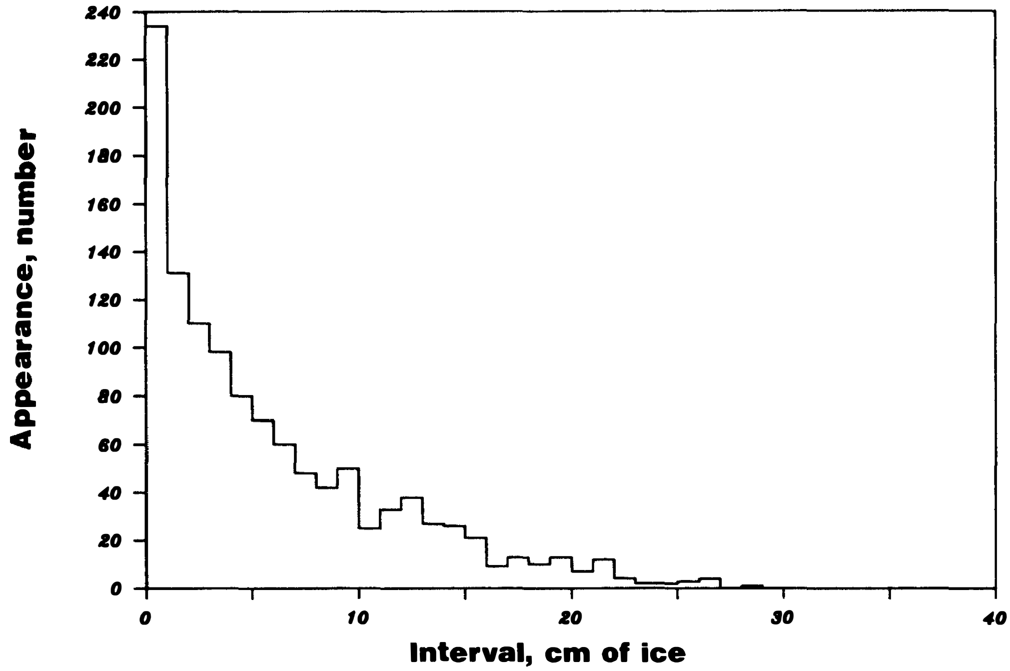

Fig. 3. Interval distribution of ice crust layers observed in the G6 Antarctic ice core.

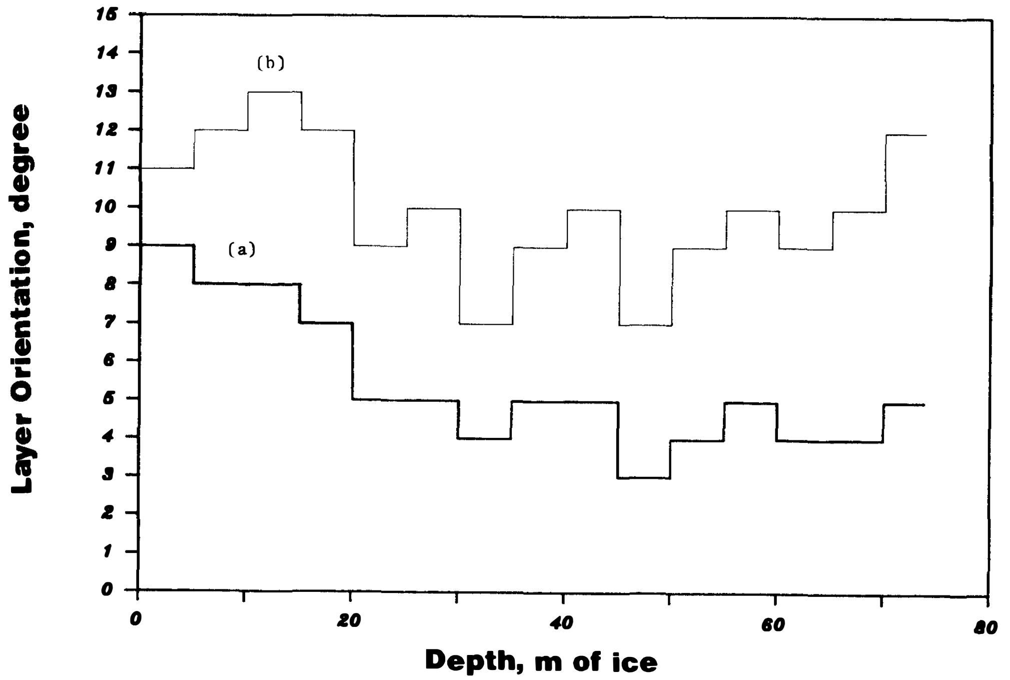

Fig. 4. Orientation profile of ice crust layers observed in the G6 Antarctic ice core. The "orientation" is the angle between the core axis and normal to the ice layer plane. Lines (a) and (b) are the measured and density-corrected profiles respectively.

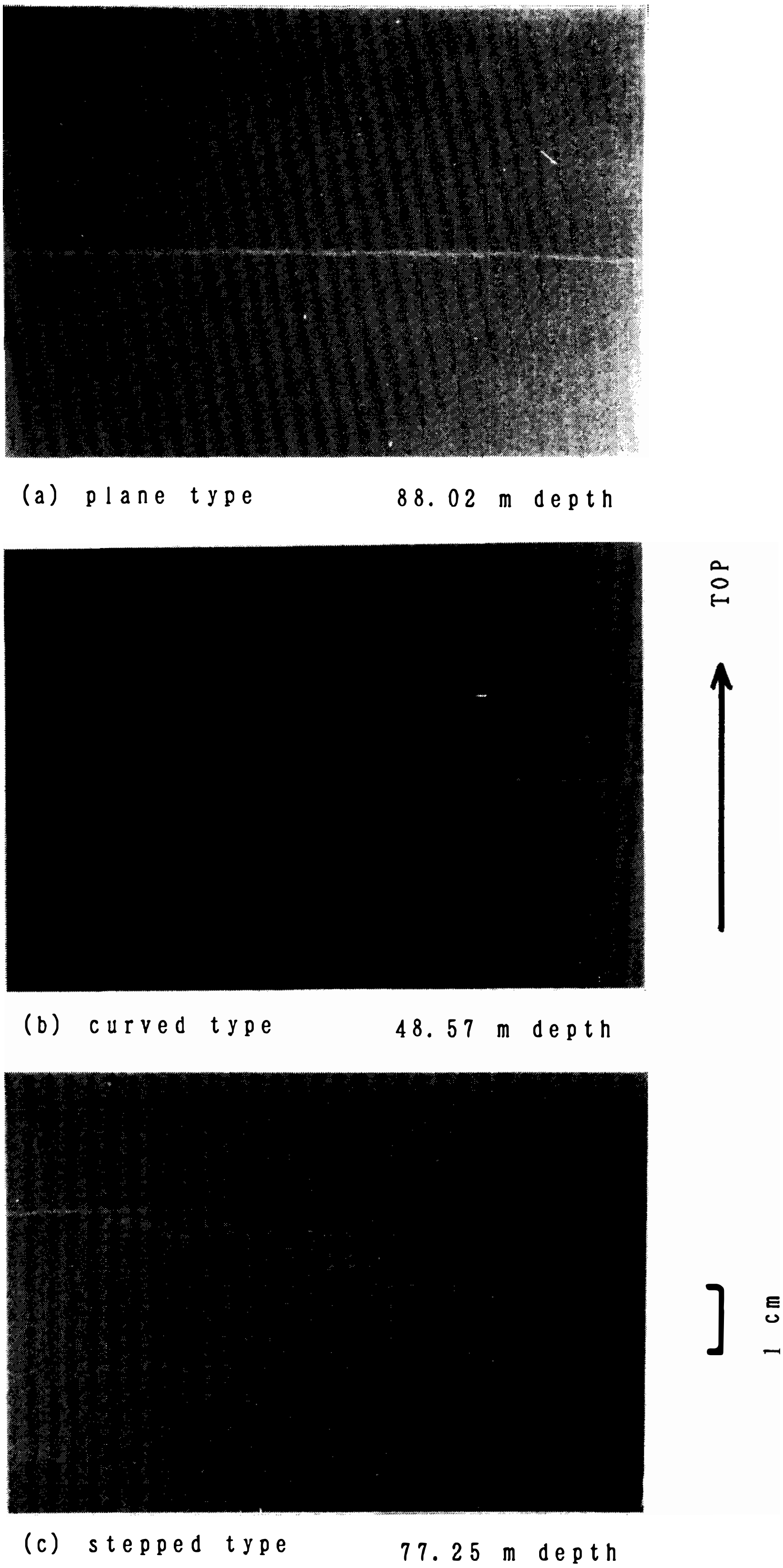

Fig. 5. Classification of ice crust layers observed in the G6 Antarctic ice core: (a) plane type, (b) curved type and (c) stepped type.

The interval profile obtained shows no such trend, indicating that ice layer formation occurred quite randomly and/or erosion including sublimation at the surface disturbed the layer sequence completely. This agrees with present day field observations that surface deposition/erosion events take place quite irregularly both in time and location at the glazed surface area (FUJII and KUSUNOKI, 1982).

2.2. *Ice layer orientation*

The orientation of each ice layer was examined by measuring the angle θ between the core axis and the plane normal to each ice layer. The orientation profile obtained indicates that the angle θ decreases with depth as shown by line (a) in Fig. 4. One should note that the ice layer can tilt with depth due to the densification of snow/firn above and below the layer, although the horizontal extension of snow/firn by flow has only a negligible effect on the rotation.

When snow/firn is densified from the initial density ρ_1 to a density ρ_2, the angle θ_2 after the rotation will be give by the following equation,

$$\tan\theta_2=(\rho_1\tan\theta_1)/\rho_2\ ,$$

where θ_1 is the initial angle. Each angle θ measured was corrected to its surface value by using the above equation with a surface density of ρ_1=380 kg/m^3. The corrected θ profile (line (b) in Fig. 4) shows an almost constant level of 10°, suggesting almost constant conditions for the orientation formation of ice crust layers near the surface in the past on a statistical basis.

2.3. *Ice layer type classification*

Shapes of ice layers were classified into three types: plane, curved and stepped

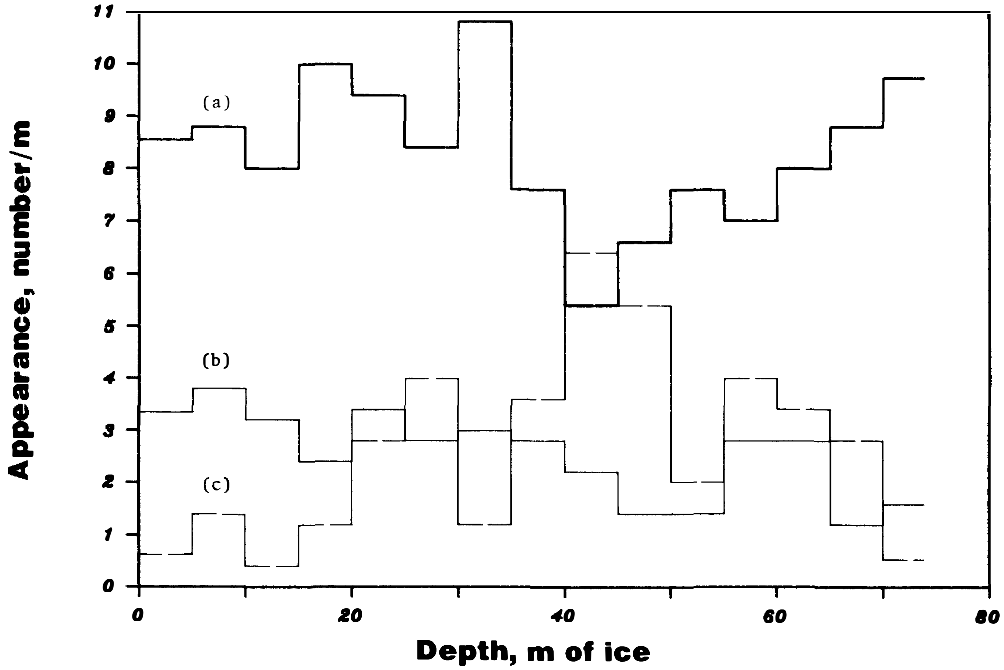

Fig. 6. Depth profiles of three types of layers observed in the G6 Antarctic ice core; (a) plane type, (b) curved type and (c) stepped type.

(Fig. 5). Each of them exists in single or multiple layered form. The overall appearance rates of plane, curved and stepped layers are 61, 19 and 20% respectively. The stepped layer is less abundant compared with the other two in the core although the stepped layer feature was easily recognized at the glazed surface area during the field traverse, especially during the early stage of crust layer formation near the surface (FUJII, unpublished). Three profiles of the frequency of appearance are shown in Fig. 6. The appearance levels of plane and curved layers are almost constant with depth, although small perturbations exist. The stepped layer distribution has a broad peak around a depth of 40 m in ice equivalent, which corresponds to an estimated age of 330 to 660 years B. P. Perhaps there were some unknown surface conditions that were favorable to the preservation of the stepped ice layers at the place and age of the snow deposition.

3. Conclusions

The surface conditions for snow deposition and erosion at G6, Antarctica seem to have stayed almost constant for more than several hundred years. Some slight change in the surface environment might have occurred at the snow deposition place around 330 to 660 years B. P. which resulted in the preservation of more stepped layers in the ice core. No other distinctive change was observed in the distribution profiles of ice layer orientation, type and appearance in the G6 core.

Acknowledgments

The authors thank Prof. O. WATANABE, National Institute of Polar Research for invaluable discussions on the glazed surface condition. They also thank JARE-27 members for conducting ice core drilling at G6, Antarctica.

References

FUJII, Y. and KUSUNOKI, K. (1982): The role of sublimation and condensation in the formation of ice sheets surface at Mizuho Station, Antarctica. J. Geophys. Res., **87**, 4293–4300.

HERRON, M. M. and LANGWAY, C. C., JR. (1980): Firn densification: An empirical model. J. Glaciol., **25**, 373–385.

NISHIO, F., OHMAE, H. and OSADA, K. (1988): Glaciological research program in East Queen Maud Land, East Antarctica, Part 7, 1986. JARE Data Rep., **137** (Glaciology 16), 49 p.

SHOJI, H. and FUJII, Y. (1991): Preliminary study of the G6, Antarctic ice core (abstract). Proc. NIPR Symp. Polar Meteorol. Glaciol., **4**, 135.

(Received November 6, 1990; Revised manuscript received October 19, 1991)