Mem. Natl Inst. Polar Res., Spec. Issue, 54, 253–260, 2001

Report

Activities of the Japanese Arctic Glaciological Expedition in 1999 (JAGE 1999)

Hideaki Motoyama[1], Okitsugu Watanabe[1], Kumiko Goto-Azuma[1], Makoto Igarashi[1], Morihiro Miyahara[2], Tomoharu Nagasaki[3], Lars Karlöf[4] and Elisabeth Isaksson[4]

[1]*National Institute of Polar Research, Kaga 1-chome, Itabashi-ku, Tokyo 173-8515*
[2]*Nihon Link Co., Ltd, 2-7-32 Yodogawa, Miyazaki 880-0907*
[3]*Niigata University, Igarashi Ninomachi, Niigata 950-2102*
[4]*Norwegian Polar Institute, N-9296 Tromsø, Norway*

Abstract: To reconstruct climatic and environmental changes in Svalbard in the past several hundred years, an ice core was drilled on the summit of Austfonna ice cap, Svalbard (79°50′N, 24°00′E, 750 m a.s.l.) to a depth of 289 m in May 1999 by a Japan–Norway cooperative project. Ice core stratigraphy measurement, digital camera recording of the ice core, and measurements of bulk density and electrical conductivity of ice (ECM) were conducted *in situ*. Snow pit observations were carried out at three different sites. Fresh falling snow, drifting snow and surface hoar were sampled.

1. Introduction

The prime objective of the Japanese Arctic Glaciological Expedition (JAGE) is to study the climatic and environmental changes for the last few hundred years using ice cores from various areas of the Arctic cryosphere. Several shallow ice cores have been retrieved from Svalbard glaciers (Table 1). Previous research activities have already been outlined by Watanabe and Fujii (1998, 1990), Watanabe *et al.* (1993), Watanabe (1996), Watanabe *et al.* (2000) and Kamiyama *et al.* (2001). This research focuses on Japanese glaciological research activities on the top of Austfonna, Nordaustlandet, Svalbard in 1999.

2. Location of the ice coring site and its glaciological conditions

Austdomen, on the Austfonna ice cap (79°50′N, 24°00′E, 750 m a.s.l.), was selected for the ice coring site. It is 3 km north of the 1998 last ice coring site (Fig. 1: Watanabe *et al.*, 2000). The glaciological conditions were reported by Watanabe *et al.* (2000). The total area of the Austfonna ice cap is 8450 km^2 and the ice depth reaches 570 m. In order to determine the present regime and the hydrothermal state of the glacier, and to reconstruct past glacioclimatic conditions, radio echo sounding of the ice thickness, and thermal drilling of the glacier on the ice divide, were conducted in 1984, 1985 and 1987 on the Austfonna ice cap by Soviet scientists. Researchers observed that the ice on the divide of Austfonna was 550–570 m thick, and they obtained a 567 m ice core which covered the surface to the bed

Table 1. Ice coring in Svalbard by JAGE. Drilling period, position, 10 m ice temperature and surface ice density are summarized.

Date	Drilling sites	Latitude, longitude	Altitude (m a.s.l.)	Drilling depth (m)	10 m ice temp. (°C)	Ice density (kg/m^3)	
						0–10 m	10–20 m
May–June 1987	Høghetta Ice Dome	79°17′N, 16°50′E	1200	85.61 (bedrock)	−11.0	(ice)	(ice)
July–Aug. 1992	Snøfjellafonna	79°08′N, 13°18′E	1190	83.92	−2.8	565	775
		79°08′N, 13°19′E	1160	24.41			
June–July 1993	Åsgårdfonna	79°27′N, 16°43′E	1140	185.3, 49	−6.8	808	881
Sep. 1994	Brøggerbreen	78°52′N, 11°55′E	550	10	(0)	812	
May–June 1995	Vestfonna	79°58′N, 21°01′E	600	210	−3.7	639	839
Mar.–Apr. 1998	Austfonna	79°48′N, 24°00′E	750	118.62	−1.0	601	876
Apr.–May 1999	Austfonna	79°50′N, 24°00′E	750	289.075	−2.8	649	840

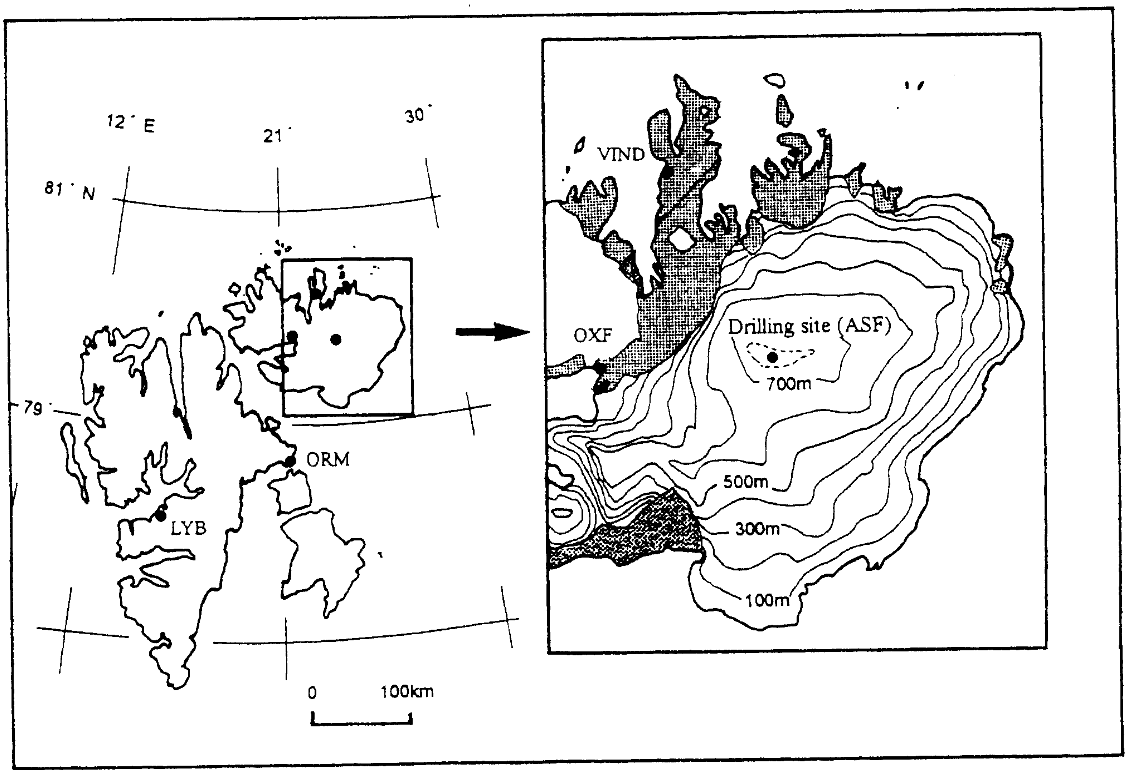


Fig. 1. Ice coring site on Austfonna, Svalbard. Dots indicate ice-free area (Watanabe et al., 2000).

rock. Some results have been published (Arkhipov *et al.*, 1987, Zagorodonov and Arkhipov, 1990).

3. Logistics

Our project (JAGE) and the ICEMASS project, whose purpose is to clarify the mass balance in the arctic cryosphere, were conducted at the same location and during the same season. In consideration of cost and weather risk, transportation of both sets of equipment was carried out in cooperation. The first incoming team (ICEMASS) and the last outgoing team (JAGE) used several flights of twin otter airplanes with skis (maximum pay load 1000 kg) for transportation of the main equipment. Two helicopter flights (maximum pay load 570 kg) were used for transportation of people in and out. The weight of the total incoming equipment (JAGE) including passengers was 4470 kg; the outgoing weight including the ice core was 4800 kg. Part of the outgoing equipment was temporarily deposited on the glacier because of bad weather, and was transported by a ship of Norwegian Polar Institute.

The ice coring site on the top of the ice cap was determined based on topographical observations by ICEMASS. We arrived there on April 25, 1999 and set up the camp

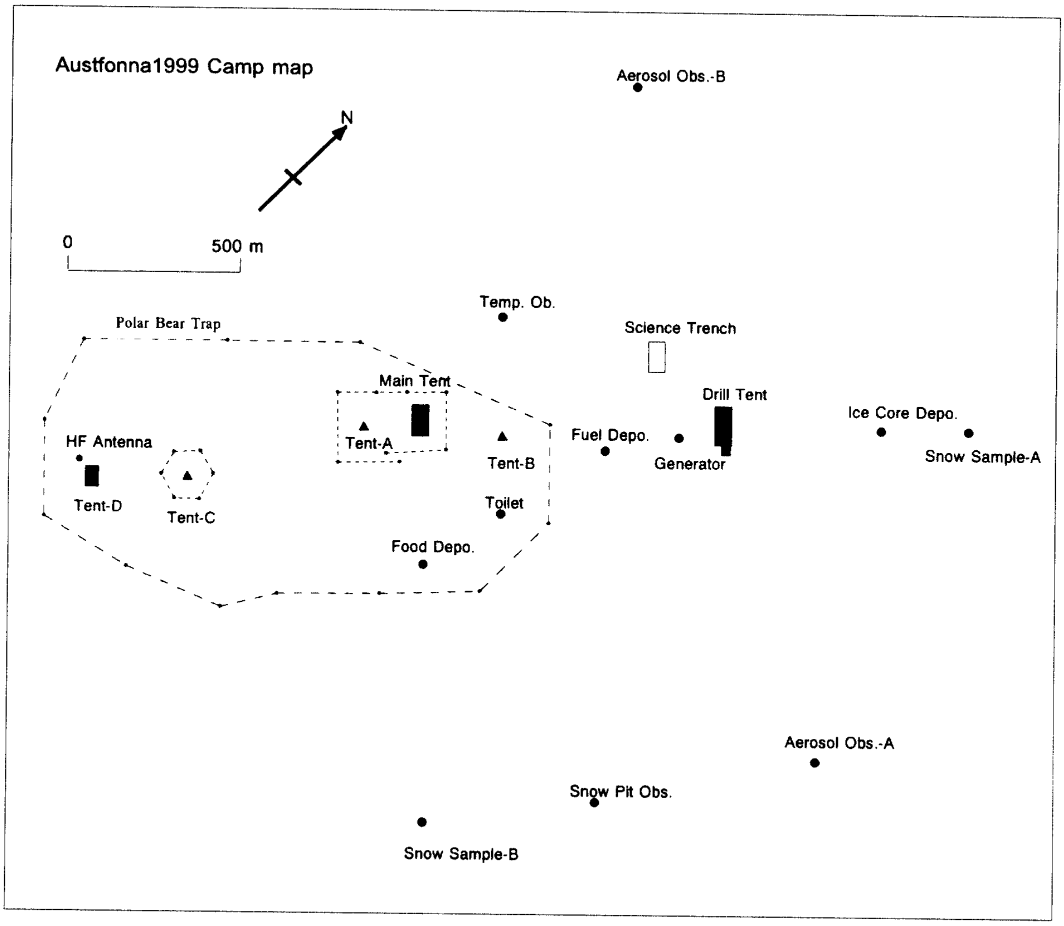
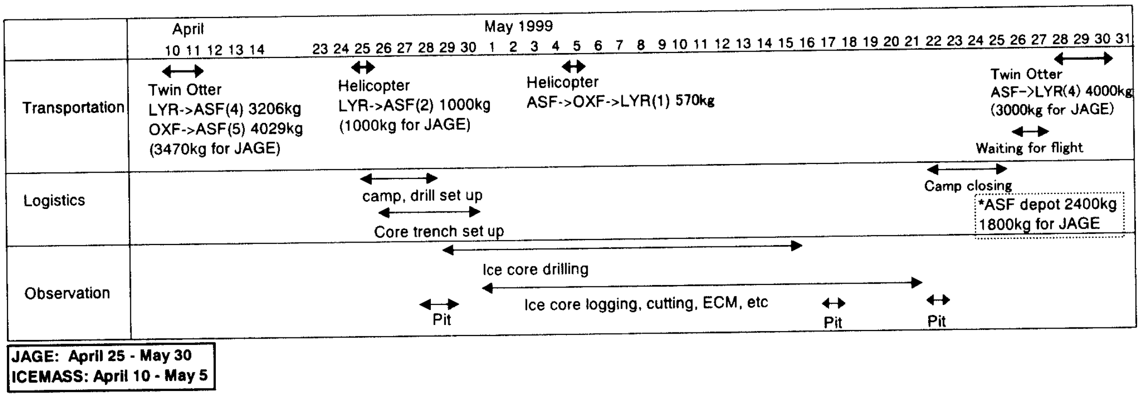


Fig. 2. Camp location map.

*Table 2. Schedule of flights and operations. LYR: Longyearbyen, ASF: Austfonna (drilling site), OXF: Oxfordhalvoya (drilling equipment and fuel deposit site), ( ): number of flights. *Depot equipment on ASF was transported to LYR in July 1999.*



equipment, drilling equipment and an ice core processing trench. The ice core drilling began on April 29. The outline of the camp is shown in Fig. 2. The drilling tent was damaged by a heavy snow storm in 1998, so we reinforced the tent and changed the practice period to a later date. The schedule of flights and operations is shown in Table. 2.

4. Ice coring, ice core processing

We used a shallow ice drill (D-2 type, Geo Tecs Co. Ltd, Japan, Takahashi, 1996) and an intermediate depth winch (W-4 type, Geo Tecs Co. Ltd.) as was also used in 1998. The progress of ice coring is shown in Fig. 3. The final drilling depth was 289.075 m. Various drill parts were modified, including the cutter, heel, core catcher, core barrel, winch power, anti-torque device and chip-ice separator. Characteristics of the ice core drilling are shown in Fig. 4. Coring length and drilling speed became stable below depths of 73 m and 59 m, respectively, as shown in Fig. 4a. The ice cutting pitch was changed for these depths. The average coring length for the whole depth was 76.1 cm/run, and drilling speed was 23 cm/min. Ice core quality became brittle deeper than 135 m, so the number of core pieces per each run were increased as shown in Fig. 4b. Consumption energy for drilling was stable, averaging 415 W.

Ice cores were processed in a snow trench. Room temperature was below zero Celsius throughout the season. The ice core processing is summarized in Table 3. The ice core stratigraphy measurement, digital camera recording of ice core, and measurements of bulk density and electrical conductivity of ice (ECM) were done *in situ*. The ice samples were melted and filled in pre-cleaned 50 m*l* bottles. The pH and electrical conductivity (EC) of the melt water were measured *in situ*. The ice core samples were transported to the Norwegian Polar Institute in Tromsø, Norway; water samples were transported to Japan in a cooled condition. A chemical analysis was performed at the laboratory of the National Institute of Polar Research. The analysis included the major soluble ions Cl, NO_3, SO_4, Na, K, Mg and Ca; stable oxygen isotope ratio and radioactivity (tritium).

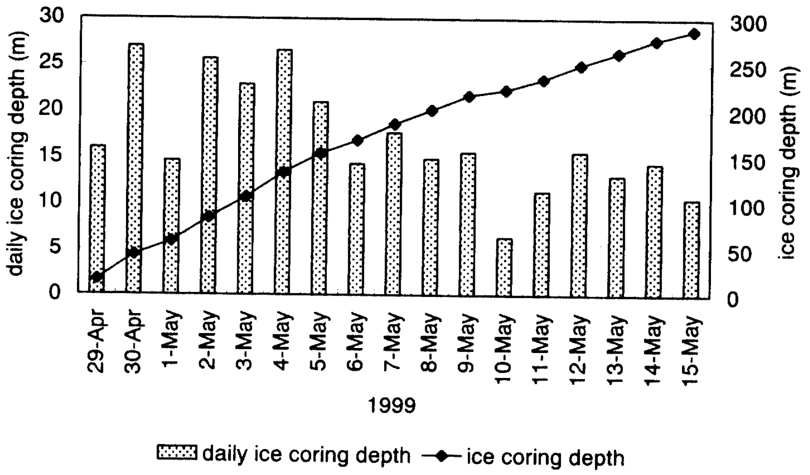


Fig. 3. Progress of ice coring.

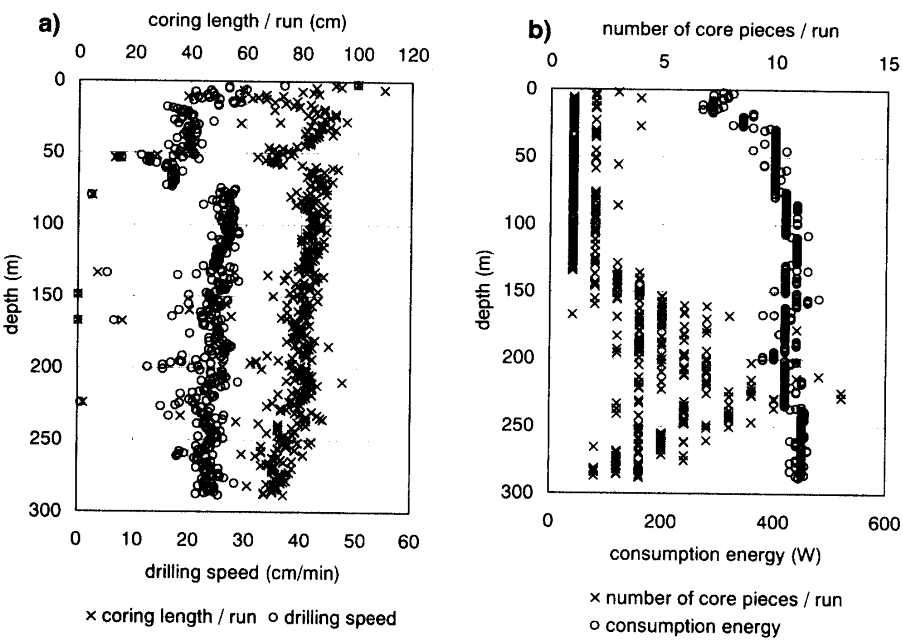


Fig. 4. Characteristics of ice core drilling. a) coring length per run or drilling speed versus ice coring depth. b) number of core pieces per run or consumption energy for drilling versus ice coring depth.

5. Glaciological and meteorological observations

Borehole temperatures were measured at depths of 5, 10, 15, 20, 40, 80, 120, 160, 200, 240, and 288 m. Snow pit observations were carried out; two near the drilling sites and one 2 km northward. The fresh falling snow and drifting snow were sampled in a timely manner. The frost accumulating around the surface of the tent ropes and the surface hoar

Table 3. Ice core processing.

temporary preservation ice core (90- 70 cm in length)

↓

transport to core processing trench

↓

density measurement

core length, core diameter, weight of the core

↓

core logging

fitting of top and bottom core

core stratigraphy: cutting position, boundary layer, quality of ice/snow (ice/bubble diameter and its density, degree of depth hoar, distinction of firn/superimposed ice)

marking of cutting position (within 50cm) and core direction

image recording by digital video camera

↓

core cutting and packing

A: ECM -> packing (keep freeze)

B: packing (keep freeze)

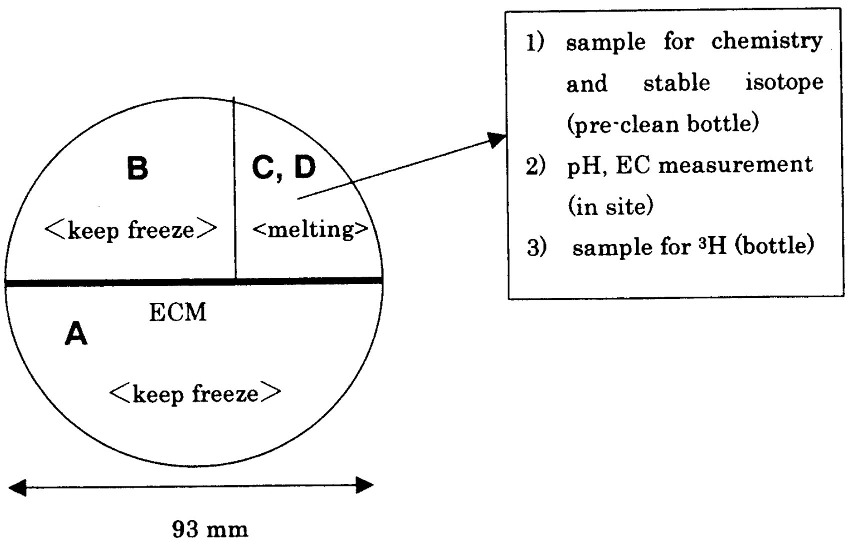
C: cleaning -> melting -> in bottle (keep freeze)

D: cleaning -> melting -> pH, electrical conductivity measurements

↓

transportation of samples to Tromsø Norway and Tokyo, Japan.

cutting plan



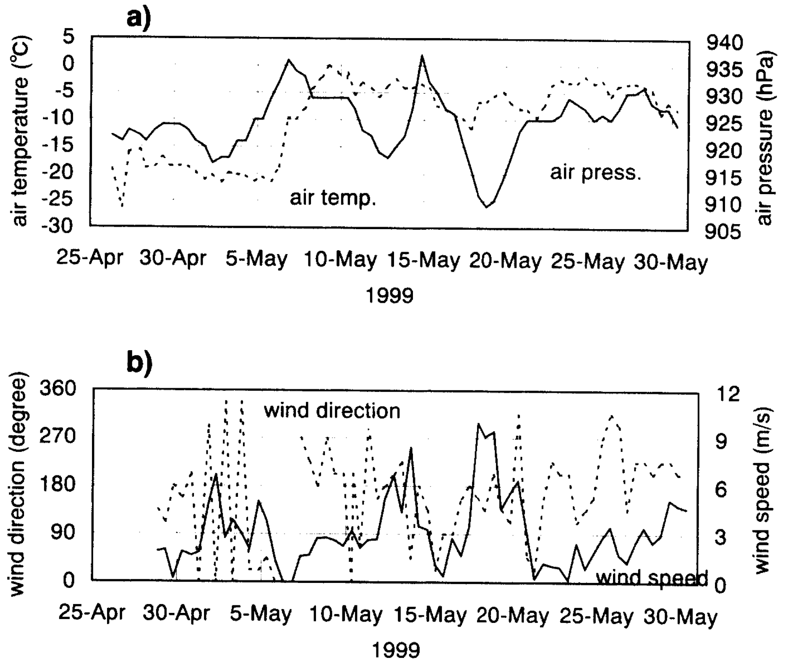


Fig. 5. Meteorological observations: a) air temperature and air pressure, b) wind speed and wind direction. Observations were conducted twice a day.

on the snow were sampled on occasion. The air up to 1 m above the snow surface was filtered using a cassette type collector with 4 filters. The aerosols were caught first by a 0.2 μm filter, and secondly the gas constituents in the air were caught by three alkaline filters. Air temperature (by portable thermometer), wind direction and wind speed (by portable anemometer), air pressure (by semiconductor type gauge), weather, cloud amount and type, and visibility were observed twice a day. Drifting and falling snow were sampled. Continuous air temperature and snow temperature near the snow surface were observed by automatic data recorders. The weather conditions are shown in Fig. 5. It is obvious that after May 7 the season quickly progressed into summer.

6. Participants

Principal Investigator in 1999 project:

Okitsugu Watanabe (National Institute of Polar Research)

Norwegian counterparts:

Elisabeth Isaksson (Norwegian Polar Institute)

Jon Ove Hagen (University of Oslo)

Field members

Field Leader: Hideaki Motoyama (National Institute of Polar Research)

Members: Makoto Igarashi (National Institute of Polar Research)

Tomoharu Nagasaki (Niigata University)

Morihiro Miyahara (Nihon Link Co. Ltd)

Tetsuhide Yamasaki (Independent polar explorer)

Lars Karlof (Norwegian Polar Institute)
Collaborator of the field operation:
Kumiko Goto-Azuma (National Institute of Polar Research)

Acknowledgments

We would like to express our sincere gratitude to Dr. Jon Ove Hagen and the ICEMASS group. The logistic section of the Norwegian Polar Institute in Longyearbyen supported our daily radio contact and flight schedule. This research was supported by a grant from the International Scientific Research Program of the Ministry of Education, Science, Sports and Culture (No. 10041130, PI O. Watanabe).

References

Arkhipov, S.A. and 11 colleagues (1987): Soviet glaciological investigations on Austfonna, Nordaustlandet, Svalbard in 1984–1985. Polar Geogr. Geol., **11**(1), 25–49.
Kamiyama, K., Motoyama, H. and Watanabe, O. (2001): Field observations of the Japanese Arctic Glaciological Expeditions in Svalbard from 1993 to 1995. Mem. Natl Inst. Polar Res., Spec. Issue, **54**, 243–251.
Takahashi, A. (1996): Development of a new shallow ice core drill. Seppyo (J. Jpn. Soc. Snow Ice), **58**, 29–37 (in Japanese).
Watanabe, O. (1996): Japanese glaciological activities in the Arctic region. Mem. Natl Inst. Polar Res., Spec. Issue, **51**, 329–336.
Watanabe, O. and Fujii, Y. (1988): Outline of the Japanese Arctic Glaciological Expedition in 1987. Bull. Glacier Res., **6**, 47–50.
Watanabe, O. and Fujii, Y. (1990): Outline of the Japanese Arctic Glaciological Expedition in 1989 (JAGE 1989). Bull. Glacier Res., **8**, 103–106.
Watanabe, O., Takahashi, S. and Kobayashi, S. (1993): Outline of the Japanese Arctic Glaciological Expedition (JAGE) in 1991–1992. Bull. Glacier Res., **11**, 63–67.
Watanabe, O., Kamiyama, K., Kameda, T., Takahashi, S. and Isaksson, E. (2000): Activities of the Japanese Arctic Glaciological Expedition in 1998 (JAGE 1998). Bull. Glacier Res., **17**, 31–35.
Zagorodnov, V. and Arkhipov, S. (1990): Studies of structure, composition and temperature regime of sheet glaciers of Svalbard and Severnaya Zemlya: method and outcomes. Bull. Glacier Res., **8**, 19–28.

(Received May 17, 2000; Revised manuscript accepted July 6, 2000)