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Field activities of the Japanese Arctic Glaciological Expedition to western Spitsbergen in 1991 and 1992 (JAGE 1991－1992)

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Abstract

In order to study on the cryosphere-atmosphere interactions and climatic change, glaciological and meteorological observations were carried out on the glaciers in the western part of Spitsbergen, Svalbard, in 1991 and 1992. Snow sampling and meteorological observations were carried out on Brøggerbreen and Isachsenfonna in the summer of 1991. Two shallow ice-core drillings, 83.9 m and 24.4 m in depth, were carried out on Snøfjellafonna (the ice field in the southern part of Eidsvollfjellet) in the summer of 1992. Although the drilling sites were located in the highest area of western Spitsbergen, features of melt-water refreezing were found in ice-cores, and one borehole was filled with water. Data processing and ice core analyses are in progress.

1. Introduction

The Arctic region is not only a heat sink of the earth, but a sink area of aerosols and other substances transported from middle latitudes. In the polar regions, the atmosphere subsides owing to the outflow of cold air on the surface, and is replaced by the air from the upper part of troposphere. Accordingly, substances originated from middle latitudes are transported to the polar regions and precipitate on the glacier surface, so that the historical change of substances in the atmosphere and paleoclimatic record can be read from glacier ice cores.

In western Spitsbergen of Svalbard, several glaciological investigations have been carried out since the Norwegian-Swedish Expedition to West Spitsbergen in 1934. The Norwegian-Swedish Expedition studied the stratification of snow and firn (Ahlmann, 1935a), ablation (Ahlmann, 1935b), temperature profile of firn (Sverdrup, 1935a), heat budget for ablation (Sverdrup, 1935b) and other subjects. Recently, Hagen and Liestøl (1990) investigated the mass balance of Brøggerbreen and discussed its relation to climate warming. According to these investigations, the glaciers in this region are temperate glaciers. Therefore, the existence of meltwater on the glaciers may affect stratification of firn and ice, which may give difficulty in the interpretation of the results of ice core analyses. We selected ice-core drilling sites at the highest area of western Spitsbergen where the effect of melting was thought to be the least. This report briefly describes field activities of the Japanese Arctic Glaciological Expedition in the western part of Spitsbergen in 1991 and 1992 (JAGE 1991－1992). Since 1987, JAGE has made glaciological investigations in the Arctic region, Greenland and Svalbard (Watanabe and Fujii, 1988, 1989).

2. Outline of field activities

To obtain a historical record of substances in the atmosphere and climatic change in the Arctic, ice-core samplings and meteorological observation were carried out on the glaciers around Ny-Ålesund, western Spitsbergen, in the summers of 1991 and 1992 (Fig. 1).

In the summer of 1991, the main research area was Brøggerbreen and preliminary observations were

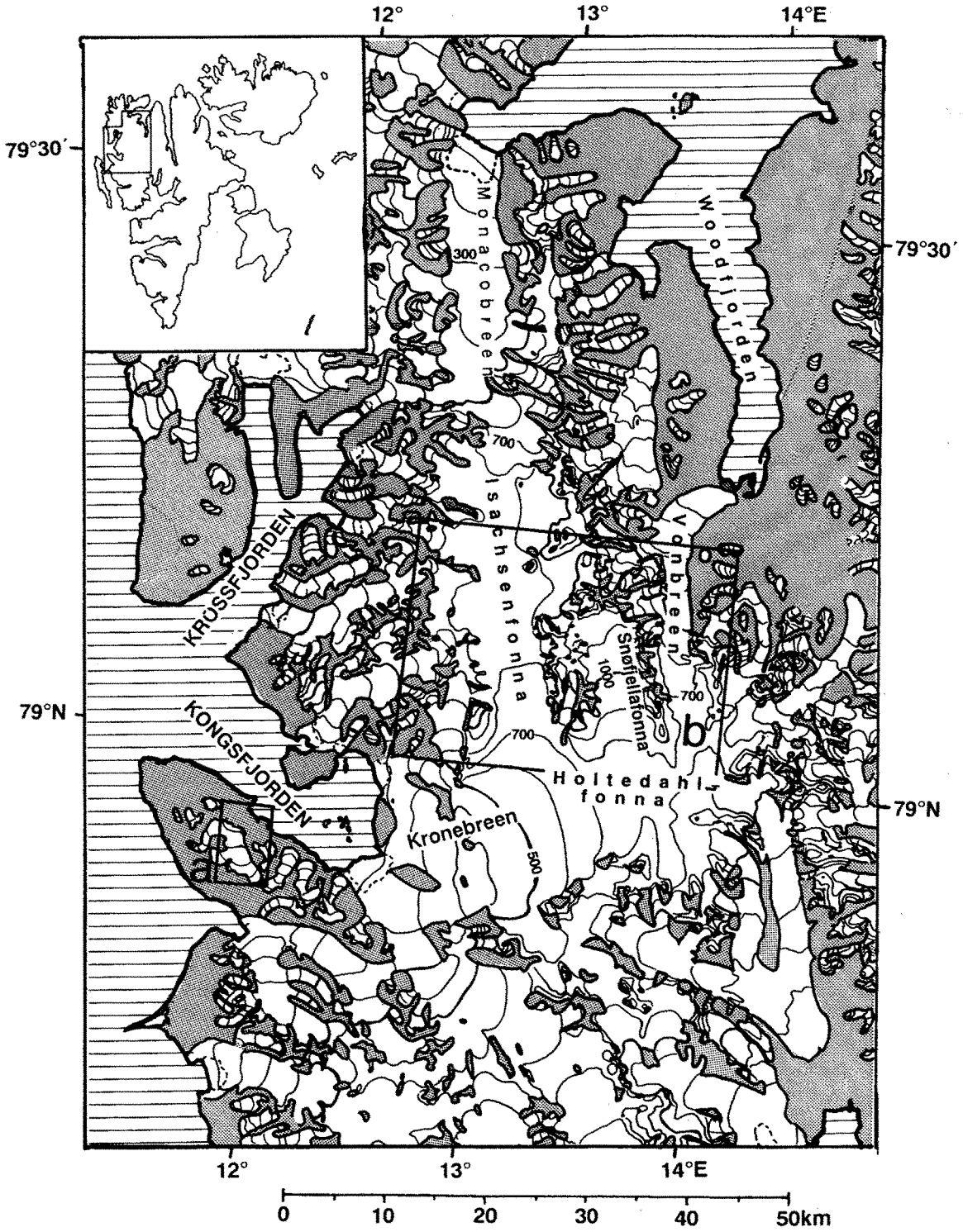

Fig. 1. Research areas of the Japanese Arctic Glaciological Expedition 1991 and 1992 in western Spitsbergen. (a) : Brøggerbreen (details in Fig. 2) ; (b) : Isachsenfonna and Snøfjellafonna (details in Fig. 4).

made on Isachsenfonna. The activities in 1991 were as follows :

a) observations of meteorological conditions relevant to the aerosol movement and settling on the glacier surface.

b) samplings of surface snow and ice for air and hydrogeochemical research.

c) observation of water movement in glacier to understand the firn and ice stratification and the vertical redistribution of substances in the snow and ice.

In the summer of 1992, the main research field of ice corings was Snøfjellafonna near Eidsvollfjellet, and other ice samplings were made on Brøggerbreen. The activities in 1992 were as follows :

d) shallow ice corings at high-altitude area in western Spitsbergen. The ice core stratigraphy and other physical properties provide information on the annual accumulation rate in this region, behavior of melt-water movement, formation mechanism of superimposed ice and other glaciological phenomena.

e) photographing glacier surface infrared images to study thermal morphology of glaciers and to aid analyses of satellite images of glaciers.

f) surface ice samplings for biological research of plankton and other biota on the glacier (Brøggerbreen).

g) analyses of ice cores and snow samples to study natural and anthropogenic climatic and environmental changes during the last few hundred years, including the seasonal and inter-annual variation of sea ice extent, and volcanic activities.

3. Research program in western Spitsbergen in 1991

In the summer of 1991, snow and ice samplings and meteorological observations were carried out on Brøggerbreen and a preliminary snow sampling was done on Isachsenfonna.

3.1. Research sites

a) Brøggerbreen

A small valley-glacier, Brøggerbreen (78°54'N, 11° 50'E), was selected for glaciological and meteorological observations (Fig. 2 and Fig. 3). It faces Kongsfjorden (Kings bay) and is close to Ny-Ålesund where scientific research stations of several countries, including Japan (National Institute of Polar Research (NIPR) maintains research facilities), are located. The reasons of selection are as follows :

(1) This is a typical maritime glacier in western Spitsbergen ; the annual snow accumulation is large.

(2) Long-term mass balance data and meteorological data are available ; since 1950 the mass balance of this glacier has been investigated by the Norsk Polarinstitutt (Hagen and Liestøl, 1990).

(3) The glacier terminus is only 3km from the Japanese Station in Ny-Ålesund.

b) Isachsenfonna

An ice field plateau, Isachsenfonna, was selected for preliminary snow sampling (Fig. 4). It is about 30 km NE of Ny-Ålesund and easily accessible by helicopter.

3.2. Research subjects

a) Meteorological conditions

To know the local change of heat balance on the surface of Brøggerbreen, an automatic weather station was set up at P1 on the terminal moraine of Brøggerbreen, another station was set at P2 on the glacier head, and 5 glaciological stations were occupied along a stream line of the glacier, as shown in Fig. 2. The observed elements are listed in Table 1.

b) Surface snow sampling

For chemical analyses, surface snow samples were taken at various glaciers.

c) Hydrological observation

Preliminary observations of percolation of water in glacier were made at 1m-deep bore-holes.

d) Infrared camera observation

Infrared images of Brøggerbreen were taken from the middle part of the glacier and from the Japanese Ny-Ålesund Station.

e) Pit work on Isachsenfonna

For selection of a coring site in 1992, preliminary glaciological observations were made at 2 m-deep pit.

3.3. Participants

Leader : Shun'ichi Kobayashi (Professor, Niigata University)

Members : Shuhei Takahashi (Professor, Kitami Institute of Technology), Hiroyuki Enomoto (Associate Professor, Kitami Institute of Technology), Kumiko Goto-Azuma

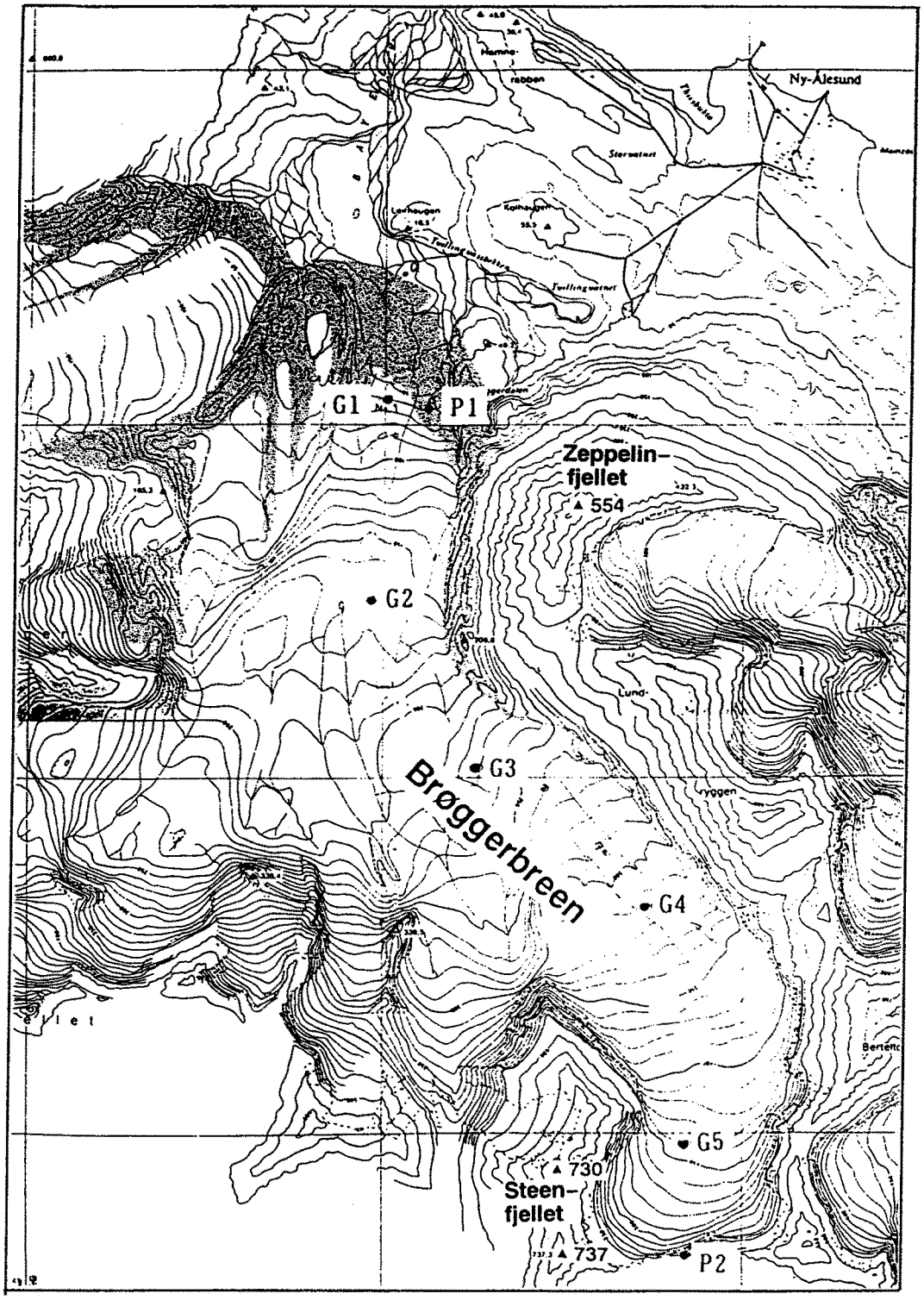

Fig. 2. Locations of observation points on Brøggerbreen in 1991. P1, P2 : automatic weather stations at the terminal moraine and at the glacier head respectively ; G1–G5 : observation points on the glacier.

(National Institute Post Doctoral Fellow, Nagaoka Institute of Snow and Ice Studies, National Institute for Earth Science and Disaster Prevention (NIED)).

4. Research program in western Spitsbergen in 1992

In the summer of 1992, shallow ice-corings were carried out at Snøfjellafonna, and surface ice samplings and meteorological observations were made on Brøggerbreen.

Fig. 3. Aerial view of Brøggerbreen.

4.1. Research sites

Snøfjellafonna is a high ice field in the upper part of Holtedalfonna in western Spitsbergen (Fig. 4 and

Table

Table 1. Observed elements on Brøggerbreen in the summer of 1991. T : air temperature, TS : snow temperature, TR : radiative temperature of glacier surface, WS : wind speed, WD : wind direction, RH : relative humidity, I : solar radiation, P : air pressure, M : melting rate.

Station	Altitude	Observed elements
P1	60m	T, WS, WD, RH, I, P
G1	60	M, T, TR, WS
G2	165	M
G3	230	M, T, TS, WS, RH
G4	315	M
G5	440	M, T, TS, TR, WS
P2	550	T, WS, WD

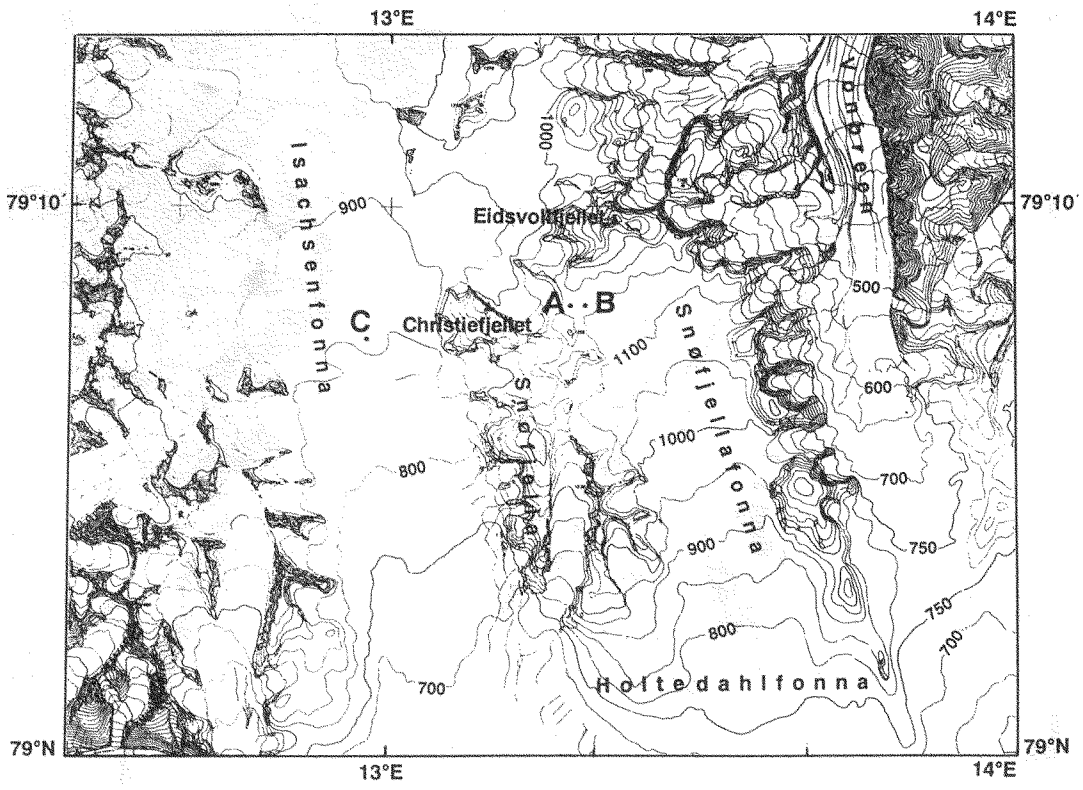

Fig. 4. Research sites on Isachsenfonna and on Snøfjellafonna. A, B : Site-A and -B for shallow ice coring on Snøfjellafonna in 1992 ; C : snow sampling site on Isachsenfonna in 1991.

Fig. 5). Coring sites were located on a col between Eidsvollfjellet (1451 m a.s.l.) and Christiefjellet (1245 m a.s.l.) as shown in Fig. 4. Site A (79°08'10"N, 13°17'30" E, 1190 m a.s.l.) was just on the col, and Site B (79°08' 10"N, 13°19'00"E, 1160 m a.s.l.) was on a flat place lower than Site A. The sites were selected by the following reasons :

(1) They are at high altitude which will lessen snow-melt and enable ice-core dating easy.
(2) This is a typical maritime ice-field in western Spitsbergen.
(3) Easy access from Ny-Ålesund by helicopter (about 40 km).

Figure 6 shows a plan of coring sites. At first the coring site was Site-B, but the drill machine met a water-table at a depth of about 20 m and the bore hole was filled with water. Since the electro-mechanical drill machine does not operate in the water, the coring site was moved to Site-A, about 500 m westward and 30 m higher than Site-B. The ice coring was done in a tent with 4.8 m×3.5 m in area and 2.3 m in height (Fig. 7 and Fig. 8). A trench with 5.5 m×2.3 m in area

Fig. 5. Aerial photo of Snøfjellafonna around research sites.

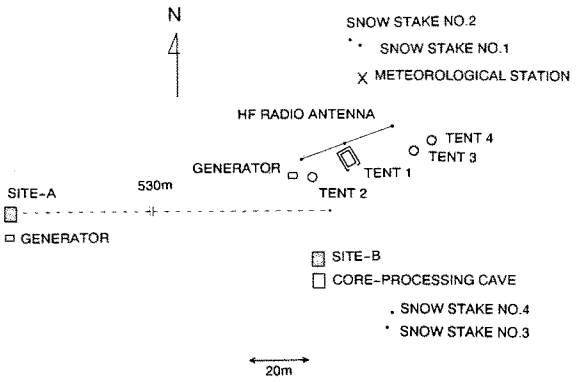

Fig. 6. Ice coring sites and camp facilities on Snøfjellafonna in 1992.

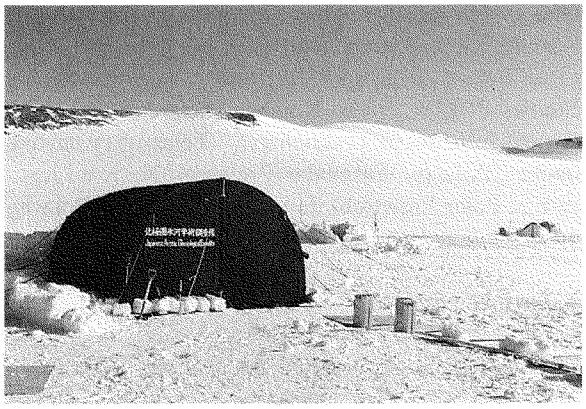

Fig. 7. Ice coring site at Site-B. The ice coring was operated in a tent with 4.8m x 3.5m in area and 2.3 m in height.

Fig. 8. Shallow ice coring with an electro-mechanical drill on Snøfjellafonna.

and 2.1 m in depth was dug and covered with a roof for core-processing (Fig. 9 and Fig. 10).

Description of Brøggerbreen is the same as in 3.1.

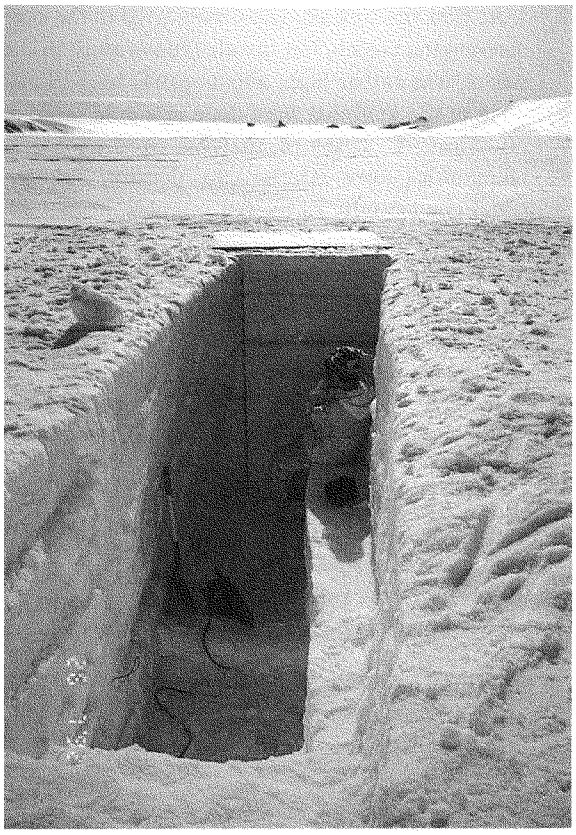

Fig. 9. Trench for core processing. Ice layers can be seen at intervals of several tens of centimetres.

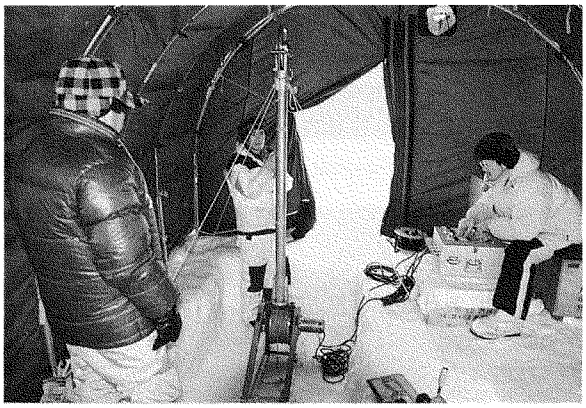

Fig. 10. In-situ ice core analyses in a core processing trench at Site-B.

4.2. Research subjects

a) Shallow ice coring

Two shallow ice cores, 83.92 m and 24.41 m in length and 78 mm in diameter, were obtained with an electro-mechanical drill.

b) In-situ core analyses

At first the core analyses were tried in the core-processing trench, but the air temperature in the trench was rather high, about −10°C to −1°C, so most of the analyses were done in a cold room in Ny-Ålesund. Items of analyses were photographing of ice cores, stratigraphy, density, and electrical conductivity of melted samples.

c) Borehole temperature
d) Pit work (refer to items of b))
e) Measurements of accumulation
f) Meteorological observations (Fig. 11)
g) Infrared camera observation (Fig. 12)
h) Sampling of 2.4 m long ice core (Brøggerbreen)
i) Sampling of surface sediments on glacier for biological analyses (Brøggerbreen)
j) Meteorological observations (Brøggerbreen)
Automatic weather stations set in August 1991 have been operated till August 1992.
k) Laboratory ice core analyses (Future work)
One-third portions of ice core samples were sent to Norsk Polarinstitutt for radioactive isotope analysis ; most of the other two-thirds were melted and transported to Japan for further laboratory analyses. Some ice cores were preserved in the cold room in Ny-Ålesund. The planned laboratory analyses are as follows : chemical composition (major ions), radioactive and stable isotope (^{3}H, ^{210}Pb, D, ^{18}O, etc.), organic compounds, gas composition of air bubbles, total gas content, biological inclusions, and mechanical properties of ice.

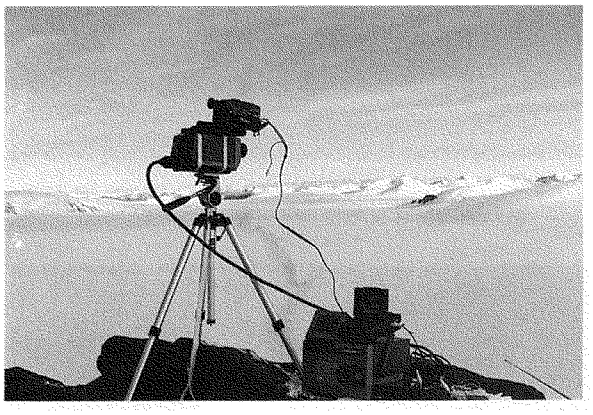

Fig. 11. Meteorological instruments at Site-B.

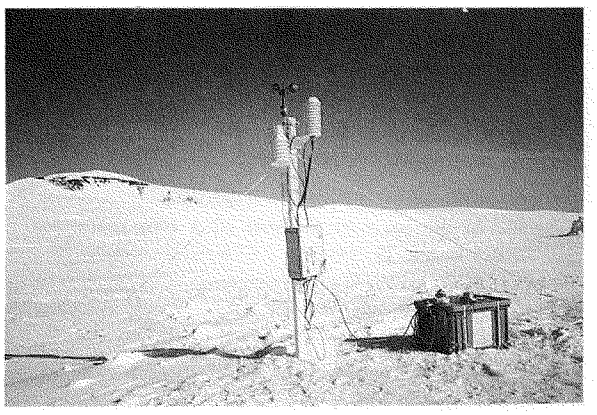

Fig. 12. Infrared camera observation on Snøfjellafonna in 1992.

4.3. Participants

Leader : Shuhei Takahashi (Professor, Kitami Institute of Technology). Members : Shiro Koshima (Associate professor, Tokyo Institute of Technology), Kumiko Goto-Azuma (National Institute Post Doctoral Fellow, Nagaoka Institute of Snow and Ice Studies, NIED), Takao Kameda (Research associate, Kitami Institute of Technology). Temporary participants : Okitsugu Watanabe (Professor, National Institute of Polar Research), Jon O. Hagen (Norsk Polarinstitutt).

5. Further studies

The glaciers of western Spitsbergen investigated in 1991−1992 were maritime temperate glaciers affected by the open sea on the west side of Spitsbergen. To study the role of polar regions in the global circulation of substances in the atmosphere, more extensive ice-core samplings are necessary. In the next several years, JAGE will investigate the glaciers in the other parts of Svalbard, such as the Høghetta ice field in northern Spitsbergen and Nordaustland which are likely less affected by maritime climate, as well as the Greenland ice sheet.

Preliminary scientific results of the expedition in 1991−1992 were presented at the 15th NIPR Symposium on Polar Meteorology and Glaciology held in July 1992 and at the general scientific assembly of the Japanese Society of Snow and Ice held in October 1992. Laboratory ice core analyses are in progress.

Acknowledgments

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References

1. Ahlmann, H., W. (1935a) : The stratification of the snow and firn on Isachsen's Plateau. Scientific results of the Norwegian-Swedish Spitsbergen Expedition in 1934, Part I. Geografiska Annaler, **17**, 29–42.
2. Ahlmann, H., W. (1935b) : Ablation measurements at the headquarters on Isachsen's Plateau. Scientific results of the Norwegian-Swedish Spitsbergen Expedition in 1934, Part II. Geografiska Annaler, **17**, 43–52.
3. Hagen, O., J. and Liestøl O. (1990) : Long-term glacier massbalance investigations in Svalbard, 1950–88. Annals of Glaciology, **14**, 102–106.
4. Sverdrup H. U. (1935a) : The temperature of the firn on Isachsen's Plateau, and general conclusions regarding the temperature of the glaciers on West-Spitsbergen. Scientific results of the Norwegian-Swedish Spitsbergen Expedition in 1934, Part III. Geografiska Annaler, **17**, 54–88.
5. Sverdrup H. U. (1935b) : The ablation on Isachsen's Plateau and on the Fourteenth of July Glacier in relation to radiation and meteorological conditions. Scientific results of the Norwegian-Swedish Spitsbergen Expedition in 1934, Part IV. Geografiska Annaler, **17**, 145–166.
6. Watanabe, O. and Fujii, Y. (1988) : Outline of the Japanese Arctic Glaciological Expedition 1987. Bulletin of Glacier Research, **6**, 47–50.
7. Watanabe, O. and Fujii, Y. (1990) : Outline of the Japanese Arctic Glaciological Expedition in 1989 (JAGE 1989). Bulletin of Glacier Research, **8**, 103–106.