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Outline of Japan-Russia joint Glaciological Research on Sofiyskiy Glacier, Russian Altai Mountains in 2000 and 2001

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Abstract

This paper focuses on field activity by the "Japan-Russia Joint Glaciological Research on Sofiyskiy Glacier, Russian Altai Mountains" carried out during 15-24 July 2000 and 6-17 July 2001. The purpose of this investigation was to reconstruct climate and environment records in the past few decades through ice core study. Three ice cores 25.1 m, 12.3 m and 9 m deep were recovered and two pits of 3 and 4.5 m deep were made on the accumulation area of Sofiyskiy Glacier (49°47′10″N, 87°43′48″E; 3435 m a.s.l.). The deepest 25.1 m core will preserve the environmental record during the last 10 to 20 years. Ice core samples were cut and melted at the research site, and transported to Japan for more detailed analyses, such as oxygen isotopes, microparticles, pH, anions, cations and bacteria content. Cores consisted of firn and ice layers. It was found that the borehole temperature was 0°C from the surface to 8m depth and also from 16m to 25m depth. The temperature between 8 and 16 m was negative with the minimum at 10 m depth (−0.1°C for the 2000 borehole and −0.3°C for the 2001 borehole). Meteorological observations were also carried out. After the investigation on Sofiyskiy Glacier in 2001, reconnaissance survey of glaciers near the Russia-China-Mongolia border region was carried out and surface snow was sampled at two sites.

1. Introduction

Glaciological investigations were carried out on the accumulation area of Sofiyskiy Glacier, Russian Altai Mountains during 15-24 July 2000 and 6-17 July 2001 as a Japan-Russia joint research project. The purpose of this investigation was to reconstruct climate and environment records in the past through ice core study. Recent climate warming has been remarkable in Siberia (e.g. Chapman and Walsh, 1993; Weller, 1998), and the ice core from Sofiyskiy Glacier located on the southern fringe of the Siberian plain is expected to provide information on climate and environment changes in the past few decades.

We obtained ice cores to depths of 12.3, 25.1 and 9 m and made 3 and 4.5 m deep pits in 2000 and 2001. Some of the analytical results of the 12.3 m core (stratigraphy, grain size and density), borehole temperature, stratigraphy for the 3 m deep pit and meteorological observations have already been published (Fujii *et al.*, 2000). Detailed analyses of melted samples obtained are done for oxygen isotopes, microparticles, pH, anions, cations and bacteria content. This report outlines the field activities on Sofiyskiy Glacier in 2000 and 2001, and describes results of reconnaissance survey of glaciers near the Russia-China-Mongolia border region in July 2001.

2. Location of the ice coring site

Figure 1 shows the location of the ice coring sites in 2000 and 2001 on Sofiyskiy Glacier. We started our

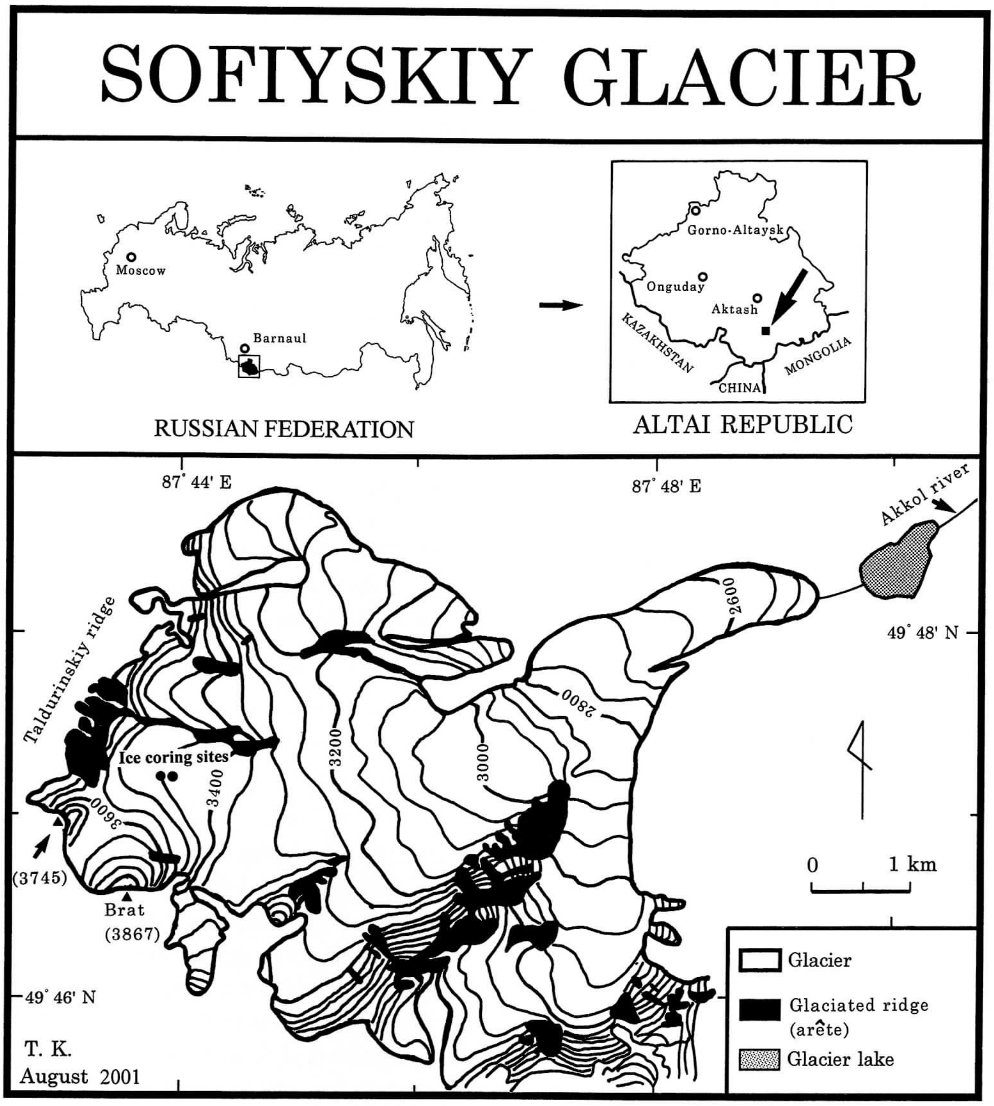

Fig. 1. The locations of the ice coring sites in the 2000 and 2001 field seasons. The solid circle on the left indicates the coring site in 2000 and that on the right in 2001. The distance between the sites is 90m.

flight from Aktash, Altai Republic, where is the closest helicopter site to Sofiyskiy Glacier. A helicopter Mi-8 MTV was used for the flight. The GPS location of the ice coring site in 2000 was 49°47′41″N, 87°43′43″E and 3,454 m a.s.l., however, this site corresponds to 49°47′10″N, 87°43′43″E and 3,450m a.s.l. on the map published by ROSKARTOGRAFIYA (1/200, 000; 1996) in Russia. The reason for the difference is uncertain. The coring site (Borehole-1) in 2001 was 90 m east from and 15 m lower than that in 2000. The location of the Borehole-1 on the map is estimated to be 49°47′10″N, 87°43′48″E and 3,435 m a.s.l. Figure 2 shows Sofiyskiy Glacier from ablation area to accumulation area. This picture was taken on July 15, 2000. Lateral moraine was clearly observed along the ablation area of the glacier. The coring site and Brat (3,867 m a.s.l.) are shown in Fig. 2. Figure 3 shows the camp site in 2001, including the two ice coring sites (Boreholes-1 and -2), core processing trench, 4.5m deep pit, meteorological station, tents, and the direction and the distance from the meteorological station to the borehole in 2000. A camp site map for the 2000 season is published in Fujii *et al.* (2000).

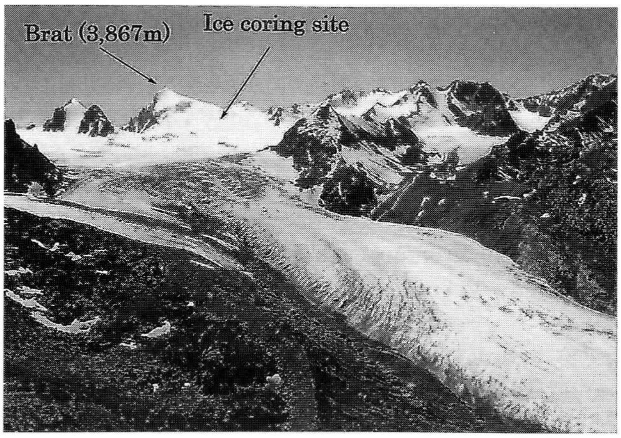

Fig. 2. Sofiskiy Glacier from ablation area to accumulation area (July 15, 2000). Ice coring site and Brat (3,867 m a.s.l.) are shown.

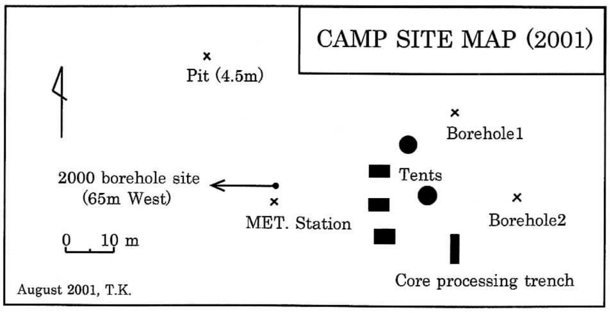

Fig. 3. Camp site map in 2001 field season.

The ice thickness at the coring site in 2000 was estimated to be 210 m by radio echo sounding (Frank Pattyn and Wim Van Huele, personal communication); however, the ice thickness map for the whole Sofiyskiy Glacier shows only 100 m of ice thickness at the site (Narozhniy *et al*, 2002). The reason for the difference is uncertain.

3. Ice coring, core processing and borehole temperatures

Table 1 shows research activities on Sofiyskiy Glacier in 2000 and 2001. We used a hand auger for the ice coring in 2000 and 2001, and an electro-mechanical drill in 2001. The hand auger was mainly operated by S. M. Arkhipov and I. A. Ponomarev in both years, and that with an electro-mechanical drill by three engineers of St. Petersburg State Mining University. We obtained a 12.3 m ice core in 2000, and 25.1 m and 9 m ice cores in 2001 with a hand auger. However, the electro-mechanical drill, which transports cutting chips by air sucking, did not work since the firn temperature at shallow depth was 0°C and the cutting chips were wet. The deepest 25.1m core will preserve the environmental record during the last 10 to 20 years. The hand auger and electro-mechanical drill were manufactured by Department of Technology and Technique of Hole Drilling, St. Petersburg State Mining University.

Cores consisted of firn and ice layers. The core stratigraphy was recorded *in situ* on chart sheets in real scale. The cores were cut at 10 cm intervals in 2000 and 20 cm intervals in 2001 in the core processing trench. The ice samples for the 2000 season were melted in plastic bags, and the water samples were stored in polyethylene bottles. These samples were sent to Japan for detailed analysis. The melt water from cores in 2001 was poured into a polysulfone filter holder (Advantec Co. Ltd, Japan; KP-47U) with a bell jar (Advantec Co. Ltd., VT-500). The water was then filtered with a 47 mm hydrophilic PTFE filter ("Omnipore membrane filter" by Millipore Co. Ltd.; pore size of 0.2μm) by using an electric vacuum pump (Advantec Co. Ltd., EP-01) or a hand vacuum pump (Advantec Co. Ltd., HP-01), and stored in a pre-cleaned polyethylene bottle. The vacuum process was used for accelerating the filtering. The sample bottles and filters were sent to Japan for detailed analysis. Figure 4 shows ice core analysis being done in the core processing trench in 2001. Snow stratigraphy of 3m pit in 2000 season was published in Fujii *et al*. (2000).

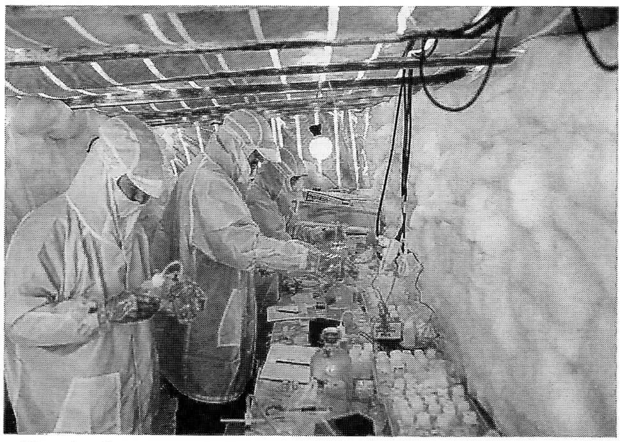

Fig. 4. Ice core analysis in the core processing trench in 2001.

Table 1. Research activities on Sofiyskiy Glacier in 2000 and 2001.

Year	2000	2001
Ice coring depth by hand auger	12.3 m	25.1 m and 9 m
Ice core analyses	· In situ measurements of stratigraphy, grain size and density · Preparation of melt water samples for chemical analyses	· In situ measurements of stratigraphy and density · Preparation of melt water samples for chemical, biological and volcanological analyses
Borehole temperature	· 1 m interval, from the surface to 12.3 m in depth	· 0.5 to 2 m interval, from the surface to 25.1m in depth
Snow pit observation	· 3 m in depth	· 4.5 m in depth · surface snow sampling at the ablation area
Meteorological observation	Ta, Ws, Wd, P, Hs, CA and CT at 3 times per day (9LT, 15LT and 21LT)	Ta, Ws, Wd, P, Rd at every one hour, and Hs, CA and CT at 3 times per day

Ta: air temperature, Ws: wind speed, Wd: wind direction, P: atmospheric pressure,
Rd: solar radiation, Hs: height of surface snow, CA: Cloud amount, CT: Cloud type

Figure 5 shows borehole temperatures for the 2000 and 2001 (Borehole-1) coring sites. A thermistor sensor (Model BYE-64, Technol. Seven, Co. Ltd., Japan) and a portable digital multimeter were used for the measurements as shown in Kameda *et al.* (1993). The thermistor sensor was allowed to come to equilibrium over at least 2 hours to obtain reliable values. It was found that the borehole temperature was 0.0°C from the surface to 8 m depth and take the minimum temperature at 10 m depth, which was −0.1°C for the borehole in 2000 and −0.3°C for the Borehole-1 in 2001, respectively. The temperature gradually increased with depth from 10 m depth, and became 0.0°C again below about 16m in depth for Borehole-1. This thermal condition was probably formed by cold temperature conduction in winter and melt water percolation from the surface in summer. In other words, during winter the firn temperature from the surface to about 16 m depth becomes negative due to cold temperature conduction, while during summer melt water percolates from the surface, and the firn temperature rises to 0°C. When we observed the borehole temperature in the middle of July, melt water had reached 8m in depth. It is uncertain whether the negative temperature remains during the whole year or vanishes at the end of the melting season in August.

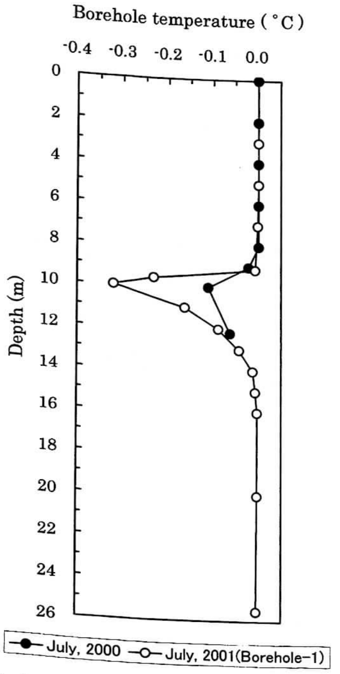

Fig. 5. Borehole temperatures in 2000 and 2001 (Borehole -1).

4. Meteorological observations

Figure 6 shows air temperature, wind speed, weather condition and snow height variation at the camp from 15 to 24 July 2000. Air temperature was measured by a thermistor sensor at 1.5m height, and wind speed was obtained as the mean of values guessed from experience by three observers (Kameda, Fujii and Nishio). So the wind speed data in Fig. 6 are only for reference. The weather during the 2000 season was mostly clear with wind speed of 3 to 4 m s^{-1}. Snow height variation was measured using a stake installed in the surface snow. After the surface snow height increased from 15 to 17 July due to snow accumulation (+52 mm), the height decreased from 17 to 24 July due to snow melting and sublimation (a total of 157 mm of snow was lost). Thus, the surface mass balance from 15 to 24 July was −48.3 mm in water eq. (an average surface snow density of 460 kg m^{-3} from 0 to 100 mm in depth was used).

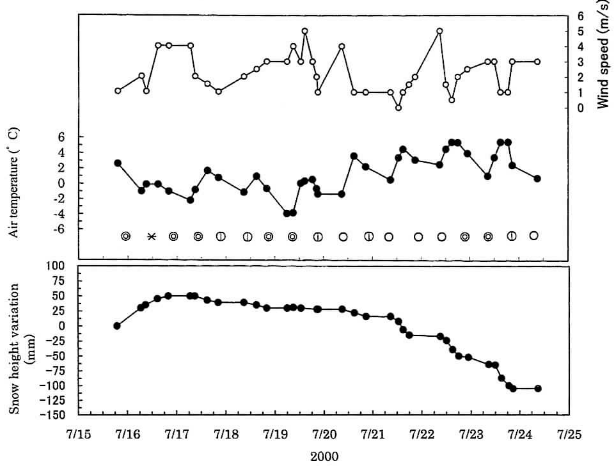

Fig. 6. Meteorological conditions and surface height variation on Sofiyskiy Glacier from 15 to 24 July 2000.

Figure 7 shows air temperature, relative humidity, wind speed and snow height variation from July 7 to 17, 2001. Air temperature, relative humidity and

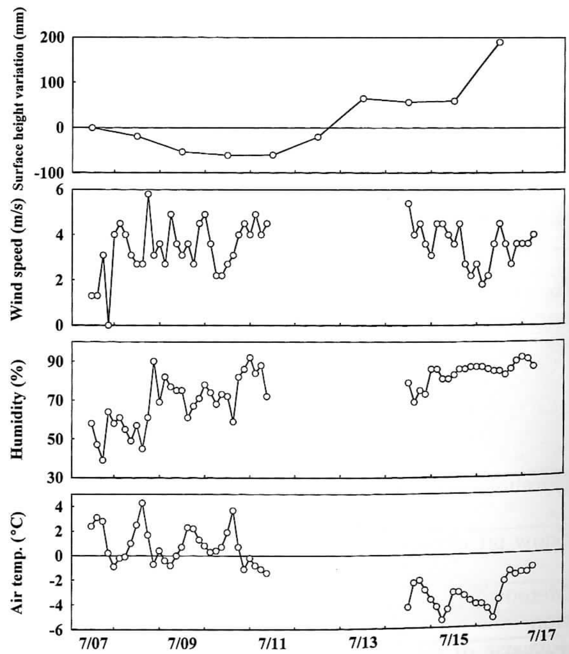

Fig. 7. Meteorological conditions and surface height variation on Sofiyskiy Glacier from 7 to 17 July 2001.

wind speed were measured with an automatic weather station (Davis Instruments: Weather Monitor II) every hour. The weather during the 2001 season was always cloudy or snow. Surface snow height decreased due to sublimation and melting from 7 to 11 July, but increased due to snow accumulation from 11 to 17 July. Net accumulation from 7 to 17 July was 190mm in snow. If we assume that the density of new snow on the surface is 300 kg m^{-3}, surface mass balance during the ten days was +57 mm in water eq.

5. Reconnaissance survey of glaciers near the Russia-China-Mongolia border region

A reconnaissance survey of glaciers near the Russia-China-Mongolia border region was carried out on July 17, 2001. A mountain range forms the border; Mt. Nirambal (4,374 m a.s.l.) in China is the highest mountain in this region. Purposes of the survey included surveying the surface snow conditions of glaciers near the border area, and finding a suitable site for ice coring in the future. The five Japanese in 2001 field season, S.M. Arkhipov, A.V. Logvinov (Polar Routes, LTD) and a Russian serviceman from Aktash frontier guard base joined the flight.

Figure 8 shows the landing sites: Site 1 (49°10′30″ N, 87°52′10″E; 3,500 m a.s.l.) and Site 2 (49°10′10″N, 87° 48′25″E, 3,620 m a.s.l.). These sites were selected because they are located at high elevation and their surface topography is relatively flat. However, mountain ridges are close to both sites, and the widths of the flat areas were only about 200 m (Site 1) and 300 m (Site 2). We landed on Site 1 and Site 2 at 18:30 and 19:00, respectively and spent about 15 minutes at each site for snow pit studies. Figure 9 shows surface snow sampling at Site 1.

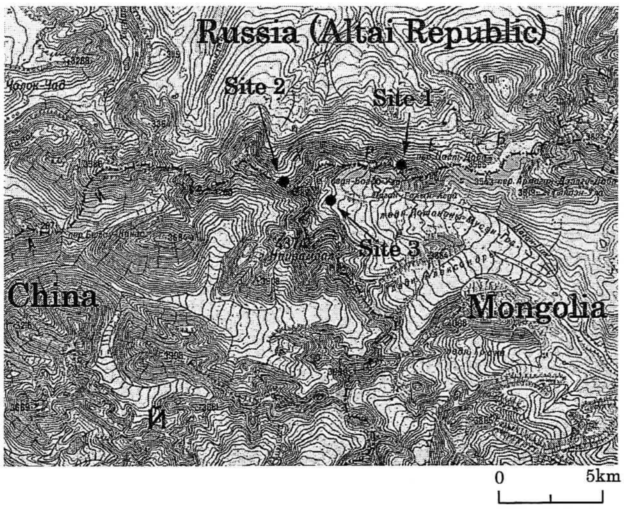

Fig. 8. Landing sites (Site 1 and Site 2) during the reconnaissance survey near the Russia-China-Mongolia border region in July 2001. Site 3 is relatively flat and wide area in accumulation area of Potanina Glacier in Mongolia. This site may be suitable for future ice coring site.

Fig. 9. Surface snow sampling at Site 1.

Figure 10 shows snow stratigraphy at Site 1 and Site 2. The solid layers and open circles indicate ice layers and wet snow, respectively (Colbeck *et al*., 1990). The surface layer at Site 1 was composed of 20cm thick wet snow layer from the surface and superimposed ice beneath. The snow layer from 15 to 20cm in depth was soaked by melt water. Small black particles (ϕ0.1 - 0.5mm) were observed in superimposed ice from 30 to 40cm depth. The surface snow layer at Site 2 was composed of wet snow and 30 to 50 mm thick ice layers. The snow temperature at Site 2 from the surface to 95cm was 0.0°C. Snow samples for chemical analysis were collected from the surface to 40cm in depth (Site 1) and from the surface to 100cm in depth (Site 2). These samples will be analyzed in Japan.

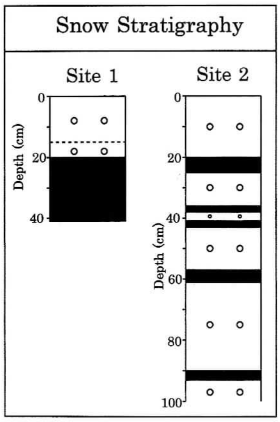

Fig. 10. Snow stratigraphy at Site 1 and Site 2. The solid layers and open circles indicate ice layers and wet snow, respectively.

It was found that the glaciers near the border on the Russian side are relatively small and steep, so it is difficult to find a suitable site for ice coring. On the other hand, Potanina Glacier in Mongolia has a relatively flat and wide accumulation area (*ca*.800m × 600m, surface slope along the flow line is about 8°) with an average elevation of 3800 m a.s.l. (Site 3: 49°10′ N, 87°50′E). Site 3 may be suitable for future ice coring site.

Table 2. Principal investigator and field members in 2000 and 2001.

	Name	Affiliation, city
Principal Investigator	Yoshiyuki Fujii	National Institute of Polar Research, Tokyo
Field members in 2000	Yoshiyuki Fujii	National Institute of Polar Research, Tokyo
	Fumihiko Nishio	Chiba University, Chiba
	Takao Kameda	Kitami Institute of Technology, Kitami
	Lev M. Savatyugin	Arctic and Antarctic Research Institute, St. Petersburg
	Serguei M. Arkhipov	Institute of Geography, Russian Academy of Sciences, Moscow
	Ivan A. Ponomarev	Faculty of Geography, Altai State University, Barnaul
Field members in 2001	Keisuke Suzuki	Shinshu University, Matsumoto
	Takao Kameda	Kitami Institute of Technology, Kitami
	Mika Kohno	National Institute of Polar Research, Tokyo
	Fumio Nakazawa	Nagoya University, Nagoya
	Jun Uetake	Tokyo Institute of Technology, Tokyo
	Serguei M. Arkhipov	Institute of Geography, Russian Academy of Sciences, Moscow
	Ivan A. Ponomarev	Faculty of Geography, Altai State University, Barnaul
	Alexander V. Krasilev	St. Petersburg State Mining University, St. Petersburg
	Valeriy M. Shashkin	St. Petersburg State Mining University, St. Petersburg
	Andrey N. Dmitriyev	St. Petersburg State Mining University, St. Petersburg
	Lev M. Kaplun	Hospital No. 36 of Kronstadt, Kronstadt, St. Petersburg
	Andrey E. Korygin	Ecoshelf, St. Petersburg,

6. Participants

Principal investigator of this project and field members in 2000 and 2001 seasons are listed in Table 2.

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