B-4.4 Emission of Trace Gases from the Melting Permafrost in Tundra area of Siberia

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Permafrost area accounts for 20-30% of total land area, and so called ice-complex have been found to contain bubbles with high methane concentration (0.3-0.02%). The origin of methane in it has been found to be biogenic in warmer climate age. This methane is released as the result of global warming, but it is expected to be oxidized in the active layer if there exist above, which is the case in most of the area. However, at a cliff or through a fissure, it is released into the air directly.

Methane emission rate has been compared between Tundra and Taiga area. Methane emission from wetland in tundra was 20-80 mg/m2/day during August, 1993. The emission rate at different alas scattered in the range 2000-10 mg/m2/day depending on its type and places in it. [注1]

Key Wards Siberia, Tundra, Permafrost, CH4, Emission Rate

1.Introduction

Permafrost occupies 20-30% of total land area, and it is reported that high concentration of methane is contained in the bubble of the ice called ice wedge in permafrost, which is formed in the permafrost and it consist of almost pure ice without soil. This ice is not formed from the precipitated snow as it is found in Antarctica, but water in soil moved during the cycle of thawing and freezing. So the gas in it is not the old atmospheric air embedded but the origin is speculated to be the air and other gases dissolved in water. The source of methane is either the biogenic or thermochemical one. It is important to evaluate the total methane content in it, and the possible amount of them released to the atmosphere when permafrost melts under the warm climate condition in future, which may be a positive feedback to the global warming.

In tundra area, no trees can grew because of cold whether, and peat moss is the main habitant. The growth rate of peat is about 2mm in thickness. Although the growth rate of peat moss is slow because of low temperature, but the corruption of it is slow because of early winter and it is covered with water. Some of the carbon is emitted as either CO2 or CH4, and it is important to estimate the flux at the present condition and in a wormer climate.

2.Measurement of methane concentration in ice wedge

Ice complex, which is composed of ice with small amount of soil and frozen mixture of soil and ice, spreads over the lowland facing to Arctic Sea lowland, and at the lower reaches of

[注1] This report was summarized by G. Inoue from the reports by Dr.Fukuda et.al.and by Ms.Nakayama et.al. Institute of Low Temperature Science, Hokkaido University, and Dr.Nojiri et.al., NIES.

Lena River. At the cliff of ice complex, we can sample the ice from the bore ice wedge of the depth of 30-40m. The composition of ice wedge is much larger than the frozen soil in these places. The methane emitted from thawing permafrost is oxidized if it is covered by active layer, because the methane oxidizing micro-organism is active because of large supply of food. So, the largest emission is expected from the cliff where ice is facing to the atmosphere directly. It is important to measure the content of CH4 in this place.

The sampling of ice has been performed along the sea coast of Bykovsky Island near Tiksi city which locate at the mouth of Lena River. The sampling has been performed by Institute of Low Temperature Science of Hokkaido University, Permafrost Institute and Moscow State University in 1992 and 1993. Fig.1 shows the location.

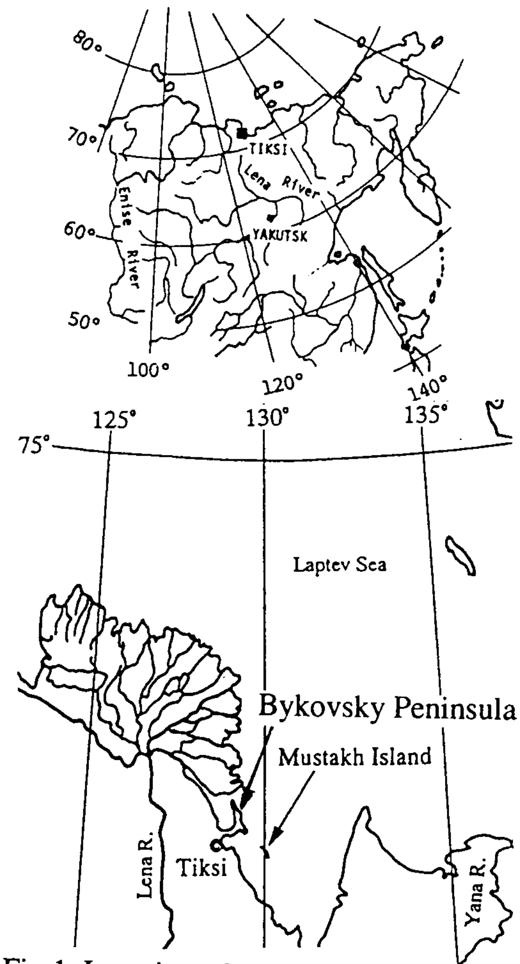

Fig.1 Location of research site

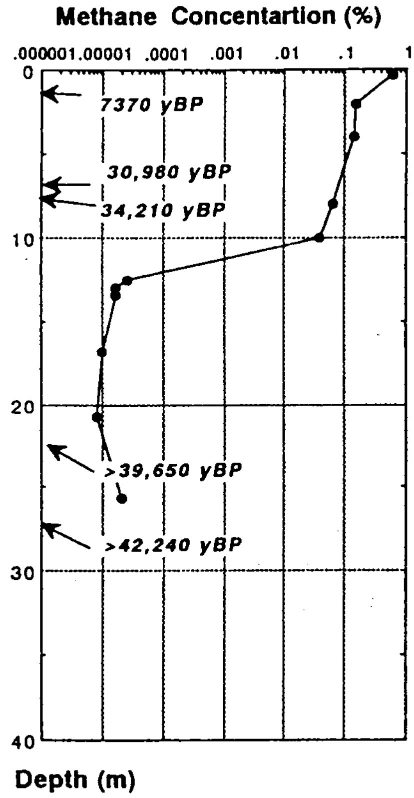

Fig.2 CH4 concentration in Ice Wedge at Bykovsky

Ice has been sampled from the bore ice wedge at the interval of 3m. The ice structure is in the shape of wedge and the inner and upper side is new. At the center of the ice wedge, a deep crack is formed in winter by the shrinking process, and the water from the surface penetrates into the crack and it is frozen. In this manner, the ice wedge increases its size. Along the trace of different age of ice, a lot of small ice bubble is observed, the size of which is about 2-3mm in diameter. Sample ice is melted in saturated NaCl solution to prevent the solvate of CH4 in water, and the gas component was collected in a small bottle for the later analysis in Japan. One of the result is shown in Fig.2.

3.Methane flux measurement by chamber method at Yakutsk

Two research fields have been chosen to compare the methane flux from permafrost area; one is from the wetland near Yakutsk, and the other is in Bykovsky Island; the former is in taiga area and the latter is in tundra area.

An alas was categorized into four regions based on environmental features; A:water area, B:floating-plant area, C:wetland area, and D:dry area. The methane fluxes, ground water levels and air temperatures were measured at each type area. The results of these measurements are presented in Table 1. The values of methane flux at type A were about 100-300 mgCH4/m2/day, (here after the unit is omitted) except RS2. These values are about ten times as large as diffusive fluxes at Lake Kasumigaura,Japan in summer. At type B, the flux values were 300-400 and is comparable with type A. The methane flux at type C were scattered from 180-1900, but there is a feature that the values at alases with large lakes were small (about 100-300) in contrast with large value (400-1000) for small lakes. At type D, the values of fluxes were 1-80.

The mats of floating-plant were developed along the shoreline of large lake, but the ratio of wetland area to the total open space in the forest including water surface is small. On the contrary, percentage of type B and C for the small lake is large. So it is concluded that the largest sources are the wetland area of small alas, and the water surface of large alas.

Table 1 Results of methane flux measurements at alases around Yakutsk

Site	Date	Type	CH4 flux 1)	GWL 2)	Air temp.	Lake size
KY	3 Aug.	D	38.1	30	21.2	
	9 Aug.	A	255.2			Large
		B	301.3		20.6	
		B	375.9		20.5	
		C	223.0	7	23.2	
		C	321.4	15	20.9	
		D	32.1	24	19.3	
LC	2 Aug.	A	3.1			
		A	39.7			Large
		C	9.0	3	21.9	
		C	11.8	1	15.4	
MG	11 Aug.	A	133.1			
		B	358.2		21.9	Large
		B	402.0		21.5	
		C	177.8	(7)	24.0	
		D	77.9	21	23.5	
RS1	30 Jul.	A	184.6			
		C	512.3	2		Small
		C	1022.5	2		
	13 Aug.	A	351.2			
		C	338.5	10	22.0	
		C	900.5	0	17.4	
		C	1921.7	5	17.6	
		D	53.2	38.5	21.0	
RS2	5 Aug.	A	829.8			
		C	475.9	(15)	17.9	Small
		C	671.9	(16)	17.3	
		C	1041.2	(8)	17.4	
		D	67.8	7	14.1	
SC	6 Aug.	B	109.6		21.9	
		C	232.8	0	24.2	Large
		D	0.0	-	24.3	

1) Unit is [mg CH_4 m^{-2} day^{-1}]
2) Groundwater Level, ( ) represents water depth

4.Methane flux measurement in Tundra Wetland, Mustakh Island

The measurements have been carried out on Mustach Island which is a long island with 7km in length and 0.5km in width. Mustakh Island is underlain by thick permafrost and has a very flat surface covered with tundra vegetation as sewage, moss and small shrub.

Methane fluxes were measured almost everyday at two fixed sites; one was a wet site covered with sewage (Site A) where ground water level (GWL) was near the surface, and the other was a moist site covered with moss (Site B) where GWL was about 20cm depth. Fig.3 indicates that the variation of methane flux at Site A was similar to that of mean daily ground temperature (MDGT). As compared the flux on 9 Aug. with that on 18 Aug., these flux values were on a same level although the latter MDGT was lower than the former. It is therefore likely that methane flux in tundra wetland is influenced not only the ground temperature but also thawed depth. If the methane flux was compared with the product of MDGT and thawed depth, the correlation coefficient is 0.7 (Fig.4).

As it is possible to calculate ground temperature profile and melting depth from meteorological data and thermal properties of soil with a numerical computation, it is suggested that the estimation of methane flux in tundra wetland is possible only from available meteorological data.

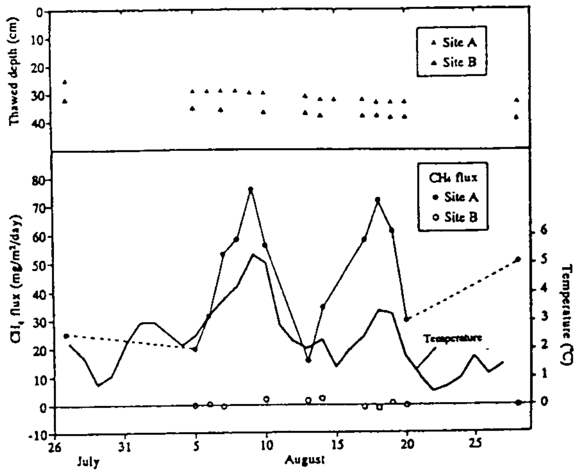

Fig.3 Methane flux, thawed depth and daily mean ground temperature in melting layer

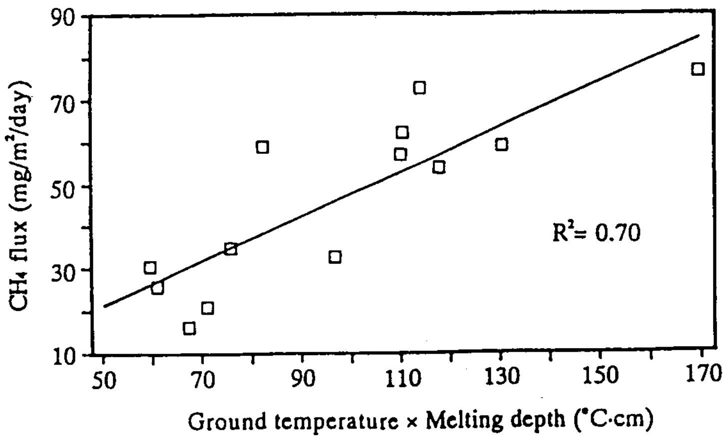

Fig.4 Relation between methane flux and the product of MDGT and melting depth. Solid line is the regression line