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Glaciological features of Koryto Glacier in the Kronotsky Peninsula, Kamchatka, Russia

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Abstract

Glaciological as well as meteorological features of Koryto Glacier at Kronotsky Peninsula, eastern Kamchatka, were studied in the summer of 1996. The glacier lays in the altitudes between 320 m and 1180 m, and is classified as a temperate glacier. Shallow corings at several altitudes on the glacier in July indicate that the balance increases linearly with increasing altitude in the accumulation area of the glacier. More than 600 cm of the balance from the end of summer in 1995 was found at the highest part of the glacier in July, 1996. The ablation rate less depends on altitude in the accumulation area, although there was significant difference in ablation rates between bare ice at the terminus and clean snow above the transient snow line. Valley-wall effect on ablation rate was found only near the terminus of the glacier. Degree day factors were calculated at two different altitudes : 0.72 (cm $°C^{-1}$ day^{-1}) at the altitude of 545 m and 0.55 (cm $°C^{-1}$ day^{-1}) at the altitude of 1005 m. Simple estimation of mass balance during the balance year of 1995–1996 suggests that the extremely high positive specific net balance of the year can be ascribed to the heavy snowfall in the winter of 1995–1996.

1. Introduction

In spite of many years of intensive studies by Russian scientists, glaciers in Kamchatka have long been one of the most unknown features for glaciologists outside Russia. Indeed, a brief description of the glaciers in Kamchatka by Horvath (1975) was the only one information we could access before 1991. The glaciers in Kamchatka have particularly been interested in by Japanese glaciologists since they are the nearest glaciers to Japan where only perennial snow patches are found. Comparison of cryospheric conditions between Japan and Kamchatka has been considered to be essential for further understanding of the nature of snow patches in Japan (Higuchi *et al.*, 1979).

To study glaciers and hydrologic cycle in Kamchatka is also important in order to clarify the climate system and its stability around the Northern Pacific. It was reported by Jones (1988) that the climate shifted in this region around 1977 to a cooling over the North Pacific and a warming over Alaska in surface temperature. Trenberth (1990) interpreted this phenomena as the deeper and eastward-shifted Aleutian low which advected warmer and moister air into Alaska and colder air over the North Pacific. Indeed, the frequency of surface cyclones in the northeastern parts of the Pacific increased after 1977 due to the stronger tendency of cyclones to migrate eastward to the Gulf of Alaska (Ueno, 1993). Because the eastern coast of Kamchatka is one of the place where Meso-β scale cyclones frequently develop throughout the year (Umemoto, 1991), the eastward shift of surface cyclones after 1977 must have influenced on the precipitation, and accumulation of the glaciers in Kamchatka.

We started a joint Russo-Japanese glaciological research on Kamchatka glaciers in 1996, aiming at clarifying the glacial system and its variation in the peninsula (Kobayashi *et al.*, 1997). In this paper, we will report a preliminary glaciological work at a glacier in the Kronotsky Peninsula, eastern Kamchatka, where mass balance of the glacier is considered to depend strongly on the activity of Aleutian low.

2. Regional settings

Kronotsky Peninsula (54°45'N, 161°40'E) is located at the east coast of Kamchatka as a prominent massif intruding into the Pacific (Fig. 1a). The peninsula consists of Tertiary volcanoes which have relatively flat summits and steep U-shaped valleys down below. The altitude of the peninsula seldom exceeds 1000 m, and the summit parts alone attain to an altitude as high as 1300 m.

There are 32 glaciers in this region (Fig. 1b ; Vinogradov, 1968), most of which have clean appearance as compared with other glaciers in Kamchatka where the surface of glaciers are usually covered with debris or volcanic detritus. The glaciers in this region lay at the lowest altitudes in Kamchatka, some of which flowing down to the altitude of 250 m.

The Koryto Glacier is the third largest glacier in this region : the largest is Bunina Glacier (10.5 km^2) and the second is Left Tyushevsky Glacier (10.2 km^2). The Koryto Glacier has the area of 8.9 km^2 and it extends from 1200 m to 250 m a.s.l. toward northwest exposure (Vinogradov, 1968). There is a relatively large accumulation area, while the glacier tongue is narrow (Fig. 2). The surface of the glacier is free of debris, and lacks any icefall or intensive crevassed area. Hypsographic curve of the glacier shows its steep snout and its flat firn basin (Fig. 3). The equilibrium line altitude (ELA) was reported to be 780 m in the balance year of 1981/1982 (IAHS (ICSI)-UNEP-UNESCO, 1988).

Glaciological works on Koryto Glacier were conducted both in 1970/1971 and 1981/1982 balance years (Vinogradov and Khodakov, 1973 ; IAHS (ICSI)-UNEP-UNESCO, 1988). The former estimated a winter balance in the accumulation area to be 3250−3800 mm and a summer balance in the same area to be 2550−2600 mm by measuring the balance both in spring and end of summer in 1971. The calculated specific net balance in the balance year of 1970/1971 was +580mm. In the year of 1981/1982, in contrast, a specific winter balance of 3490 mm was exceeded by a specific summer balance of −3774 mm, and resulted in the specific net balance of −284 mm. The terminus of the Koryto Glacier retreated for 80 m from 1971 to

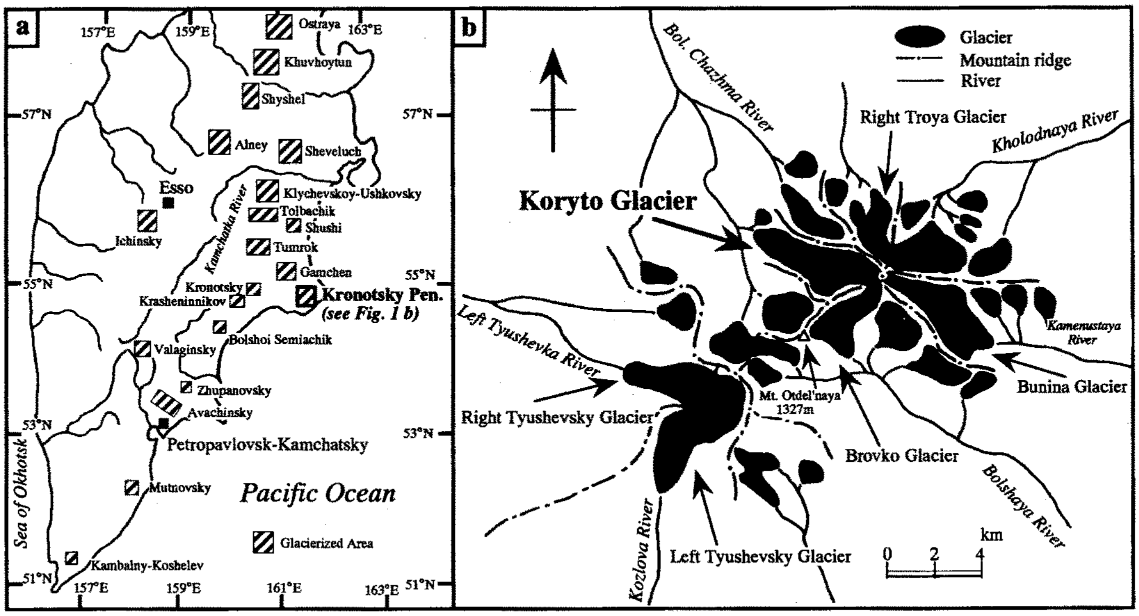

Fig. 1 Map of study area including distribution of present-day glaciers in Kamchatka (1a) and the distribution of glaciers in Kronotsky Peninsula (1b). Data source is Vinogradov (1968).

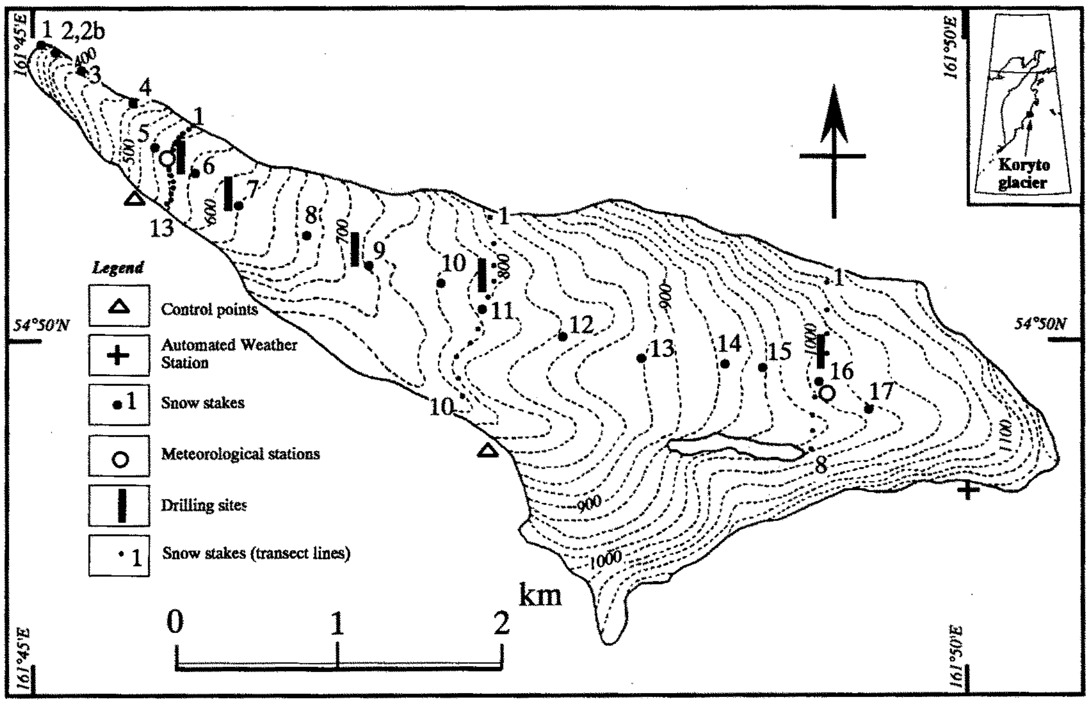

Fig. 2 Contour map of Koryto Glacier. Locations of several observation points are plotted by symbols.

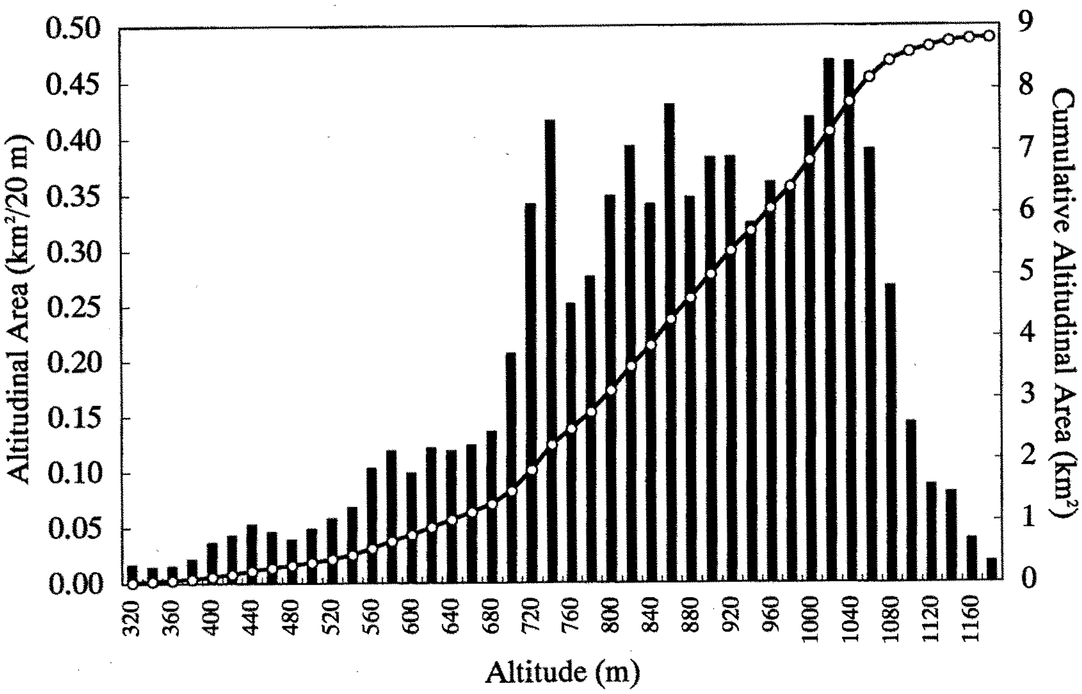

Fig. 3 Hypsographic curve of Koryto Glacier. It is characterized by an extensive accumulation area and a narrow tongue.

1982 (IAHS (ICSI)-UNEP-UNESCO, 1988). The retreating trend from 1971 to 1982 is consistent with a summation of estimated specific net balances from 1939 to 1971 as to be −14 m (Vinogradov and Khodakov, 1973).

This project is the first intensive measurement of mass balance of the glacier since the work in 1982.

3. Observation

Distribution of mass balance and summer ablation was studied in the Koryto Glacier this year. In conjunction with these measurements, a flow of Koryto Glacier (Yamaguchi *et al.*, 1997) together with meteorological and hydrological features (Kodama *et al.*, 1997) were observed simultaneously. The observation was conducted from July 8 to 20 in 1996.

In the beginning of July, there existed a plenty of snow deposited during the winter of 1995/1996. Our research base camp was established just below the present snout of Koryto Glacier, which lays at an altitude of 320 m, a slightly higher than that in 1982 when it was at 280 m a.s.l. (IAHS (ICSI)-UNEP-UNESCO, 1988). The glacier ice was exposed at the terminus only between 320 m and 480 m in altitude due to the sufficient winter snow.

Mass balance of the glacier was studied by measuring a distribution of both the balance and daily melting rates at several altitudes on the glacier. The balances at points of the glacier were estimated by drilling shallow firn cores down to a depth of previous summer surface which was clearly marked by a thin dirt layer or a dirt ice body. The coring was performed using the PICO lightweight coring auger (Koci and Kuivinen, 1984). The cutters of the auger were changed to a wider type manufactured by Geo Tecs Co. Ltd. The operation of drilling down to a depth of more than 10 m was supported by an original tripod system.

Five cores were obtained in the accumulation area of the glacier (Fig. 2). The cores obtained at Nos. 7, 11, and 16 were used for continuous analysis of stratigraphy and measurement of wet density. The cores taken from No. 16 were subsequently divided into pieces of approximately 10 cm, and melted to pack in polyethylene bottles for the isotopic analyses. The cores from Nos. 5 and 9 were used to estimate the balances at the altitudes.

Ablation of the glacier was measured by the stake method. The stakes were distributed spatially on 18 sites on the glacier, and zonally, they were installed along three transections ; 13 sites at the lower line (No. 5), 10 sites at the middle line (No. 11) and 8 sites at the upper line (No. 16), respectively (Fig. 2). Changes of relative heights between the top of stakes and snow surfaces were recorded at least once every day, and water equivalent ablation was calculated by measuring surface snow densities at each point. Snow stakes along the three transections were measured for a few times only, therefore, zonal features of the ablation will be discussed using total amount of ablation during the observed period.

We established two temporal meteorological stations on the glacier : one at the altitude of 545 m (No. 5), and the other at 1005 m (No. 16) (Fig. 2). Air temperature (℃), relative humidity (%), wind speed (m s^{-1}), wind direction (°), global radiation (W m^{-2}), snow surface temperature (℃) and atmospheric pressure (hPa) were measured every 30 minutes (Kodama *et al.*, 1997). In this report, we use the air temperature only to show the relationship between air temperature and ablation. Detailed meteorological features will be discussed in Kodama *et al.* (1997).

4. Results

4.1. Accumulation of Koryto Glacier

Fig. 4 shows the stratigraphies of the firn cores retrieved at both Nos. 16 and 11. Temperature at any points of the cores was at the pressure melting point, thus, the glacier is considered to be temperate. The firn of the cores is composed of rounded granular snow partly interbedded by thin ice layers.

The No. 16 core is composed mainly of firn down to the depth of 21.96 m. Density near the surface is 550 kg m^{-3}, and increases with increasing depth to 750 kg m^{-3} at the depth of 21 m (Fig. 5). There exist uniform layers of granular snow from the surface to the depth of 10.54 m where the first dirt layer was found. The dirt layer was visible, and found to contain a small amount of sand particles. The dirt layer is considered to be the summer surface in 1995. Thus, the amount of firn from the surface to this layer is determined as a balance at this point from the end of summer 1995 to the day of coring.

There is a distinct black volcanic ash layer at the depth of 11.95 m. It was confirmed by NOAA satellite in October 1, 1994 that a volcanic ash of Klychevskaya, an active volcano located approximately 155 km to the north-north-west of the glacier, covered the

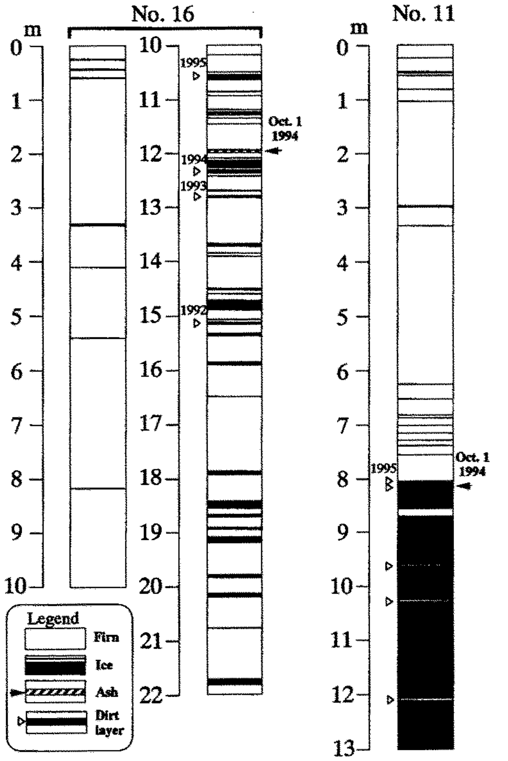

Fig. 4 Stratigraphies of shallow cores retrieved at the sites nos. 16 (1005 m a.s.l.) and 11(785 m a.s.l.).

Kronotsky Peninsula, therefore, the ash layer is marking the day. There are three different dirt horizons below the ash layer, each of which might be dated to the summer surfaces of 1994, 1993 and 1992, respectively. We could not find any visible dirt layer below the lowest dirt layer assigned to 1992.

The No. 11 core consists of a uniform firn underlain by a massive ice below 8.05 m. Density profile also shows a clear jump of the values around 8.05 m (Fig. 5). The physical properties of the firn are completely same as that in No.16 core, while the massive ice is composed of bubbly white-colored ice. There exists a dirt horizon of 1995 summer surface around the boundary. The ash horizon of October 1, 1994, at this core, is found at the depth of 8.12 m where the ash and a dirt layer is mixed together. At the deeper part, there are three dirt horizons at the depths of 9.59, 10.26 and 12.08 m.

It is controversial whether the massive ice body found in No. 11-core is an ice flowed from the upper part or an ice frozen in situ. The altitude of the drilling site of No. 11 is approximately 785 m which is very close to the equilibrium line at 780 m in 1982. The specific net balance in 1981/1982 was −284 mm, a slightly negative value, therefore, usual ELA of the glacier is considered to be located somewhat lower

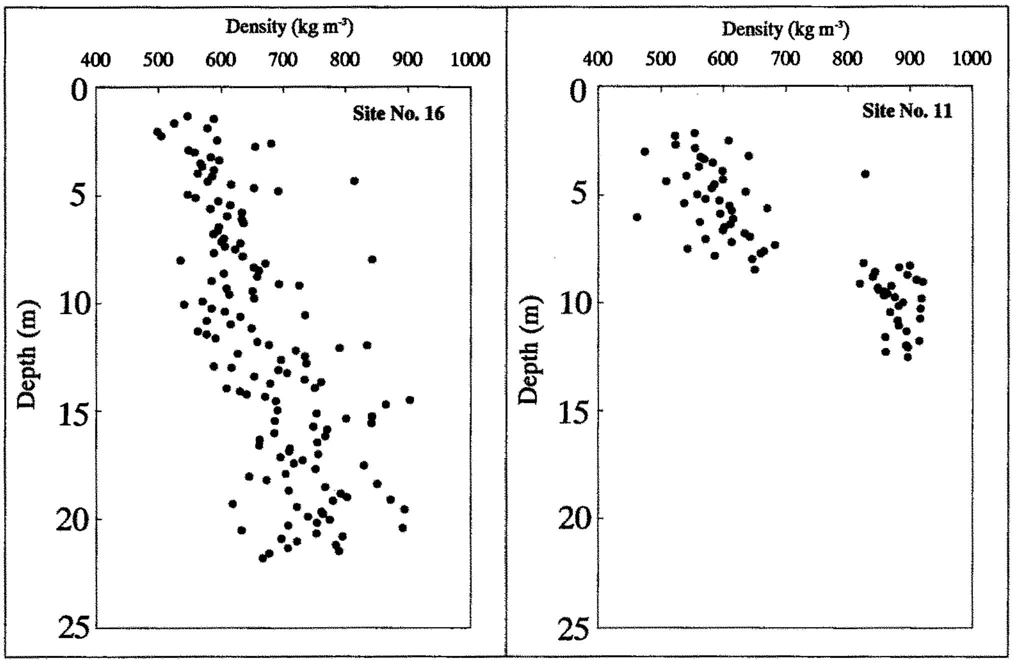

Fig. 5 Vertical profiles of wet densities of cores at sites nos. 16 and 11 of Koryto Glacier.

than 780 m. In addition to this, there is a firn at a depth between 8.57 and 8.71 m of No. 11 core. This may suggest that the massive ice layer below the depth of 8.05 m could be an ice layer formed in situ by seasonal freezing of firn. If it is true, the dirt horizons in this core may correspond to the summer surfaces of 1995, 1994, 1993, 1992 and 1991, respectively.

Fig. 6 shows an altitudinal gradient of balances from the end of summer in 1995 to July 1996 in the accumulation area of the glacier. It was derived by five cores' data mentioned above. A transient snow line was located in the field as the boundary between the bare ice and the winter snow. The balance gradient can be expressed as a simple linear equation (solid line), if we do not consider the altitude just above the snow line ;

$$b_j = 0.62\ z - 3.73 \qquad \cdots\cdots(1)$$

where b_j is the value of the balance (cm in water) from the end of summer in 1995 to July 1996, while z is the altitude (m) of the points. The equation can not be applied to the area just above the transient snow line, because the gradient in this region is much steeper than that of the upper part of the glaciers. It may be explained by a intensive ablation around the snow line, and/or less accumulation in the area where the surface slope begins to be steeper downward.

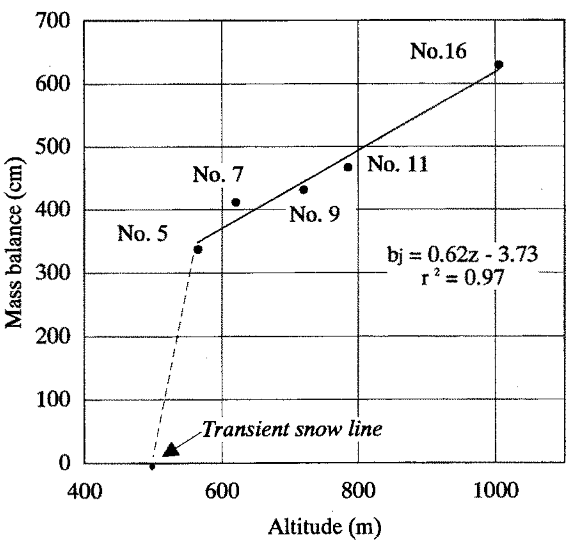

Fig. 6 Mass balance gradient in the accumulation area of Koryto Glacier from the end of summer in 1995 to July, 1996.

4.2. *Ablation of Koryto Glacier*

Ablation at the glacier surface was measured at 18 points with different altitudes from 320 m at the terminus to 1015 m at the highest point of the accumulation area (Table 1). In addition, three transections of stakes were set in order to measure a valley wall -effect on surface ablation : the lower, the middle and the upper lines were set across No. 5, No. 11 and No. 16, respectively.

Fig. 7 shows a daily march of cumulative change in glacier surface level (cm in height) from July 8 to 19.

Table 1. Information of the snow-stake sites on Koryto Glacier

Stake No.	Altitude (m)	Slope direction (°)	Slope angle (°)	Surface condition
1	320	338	15	Dirt ice
2	370	338	19	Dirt ice
2b	370	338	19	Snow
3	420	293	13	Dirt ice
4	480	315	10	Dirt snow
5	545	293	1	Snow
6	585	0	2	Snow
7	620	248	4	Snow
8	670	–	0	Snow
9	720	225	12	Snow
10	765	270	6	Snow
11	785	225	7	Snow
12	825	203	9	Snow
13	870	270	9	Snow
14	930	315	9	Snow
15	955	338	13	Snow
16	1005	–	0	Snow
17	1015	–	0	Snow

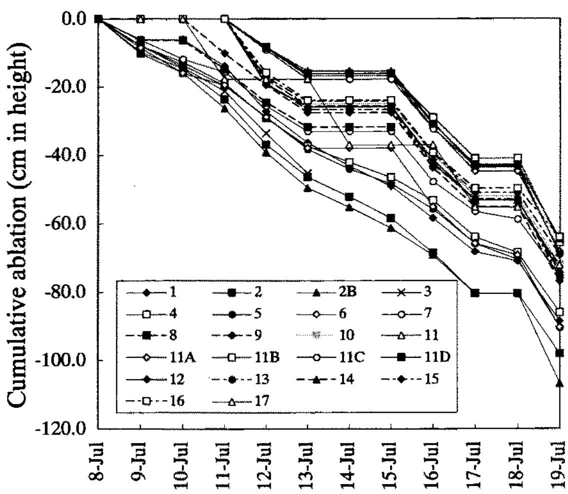

Fig. 7 Daily march of cumulative change in the glacier surface level (cm in height) at different altitudes of Koryto Glacier.

There was no snowfall during the observation period. All the sites showed a consistent decrease in the surface level, although the amount is different from one place to the others. In the ablation area, total of the surface lowering was approximately 100 cm, while in the accumulation area, it was about 70 cm during 11 days.

Table 2 shows the average ablation rates (cm in water e.q. per day) at the glacier surface of the three transections. In each transection, the ablation rates were obtained from algebraic means of total ablation during July 9−17 (lower line), July 11−17 (middle line) and July 9−19 (upper line). The sites were arranged by ascending number from the right to the left banks of the glacier at each transection. In the lower line, one can see the rates near the banks are slightly higher than the middle of the valley except for site No. 7. In contrast, the melting rates are almost constant along the transection in the middle line. In the upper transection, the right bank showed a slightly higher values than the left bank.

Table 2. Ablation rates (cm/d) along three transections on the Koryto Glacier. Site No. is arranged from right to left banks by ascending number.

	Lower line (No. 5)	Middle line (No. 11)	Upper line (No. 16)
Site No.	cm/d	cm/d	cm/d
1	4.8	3.8	3.8
2	3.5	3.3	4.1
3	4.1	3.6	3.9
4	3.4	3.5	3.8
5	3.6	3.7	4.7
6	3.2	3.1	3.5
7	4.1	3.7	3.3
8	—	3.6	3.6
9	3.3	3.7	
10	3.9	3.3	
11	4.5		
12	4.4		
13	4.1		

Next, we will show an altitudinal distribution of the ablation from July 12 to 19 (Fig. 8). Cumulative ablation was obtained using total surface lowering (cm) from July 12 to 19, multiplied by the snow/ice densities (g cm^{-3}) at each point. The transient snow line was located at the altitude of 480 m on the glacier. The cumulative ablation below the transient snow line is especially high, except for the case of No. 2B, where the stake was set on a patch of firn just beside No. 2 where glacier ice was exposed. This indicates that the intensive ablation below the firn line is due partly

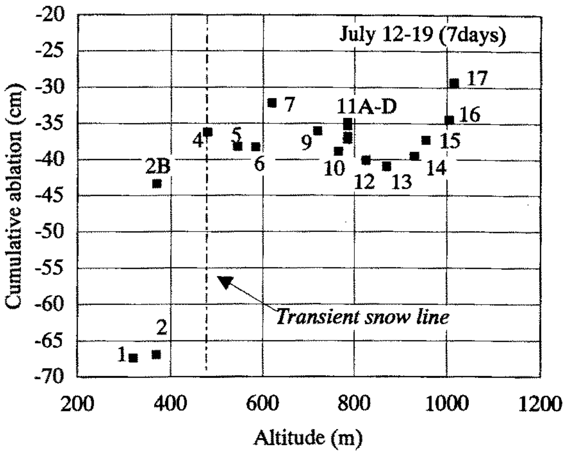

Fig. 8 Altitudinal gradient of cumulative ablation (cm : July 12−19) on Koryto Glacier.

to the difference of surface condition : albedo, roughness and so on.

In the accumulation area, it is likely that the amount of ablation is independent of altitude. If one look the figure carefully, however, the ablation decreases with increasing altitude, as usual way, above 800 m. This suggests a possibility that the ablation at the altitude between the transient snow line and 800 m could be reduced with some local reason. One possible explanation could be a local cloud condition : it was often observed during our observation that lower and middle parts of the glacier were covered with stratus cloud, while the uppermost part was cloud free. This cloud condition probably influenced the incoming short wave radiation, and then ablation. Air temperatures observed at nos. 5 and 16 also showed that there were several occasions of air temperature inversion between the two sites. This problem is further discussed in Kodama *et al.* (1997) from various meteorological observations.

Our observation is limited to 13 days in July, therefore, it is necessary to estimate an annual ablation using some assumptions. Estimation of ablation by using air temperature is often done in applied glaciology. We will introduce an ablation coefficient from the observed air temperature and ablation data at No. 5 (545 m : July 8 to 19) and No. 16 (1005 m : July 9 to 17) . We may neglect evaporation from the glacier surface during the summer time because latent heat flux during our observation period was always positive (condensation) (Kodama *et al.*, 1997). Therefore, we assume the surface melting equals the surface ablation.

The relationship between accumulated hourly melting index, a sum of positive hourly air temperature, ΣT_h^+(°Ch) and accumulated amount of snowmelt, Σm (mm) is shown in Fig. 9. The accumulated amount of snowmelt Σm is proportional to ΣT_h^+, which is expressed as ;

$$\Sigma m = 0.30 \Sigma T_h^+ \quad \text{(Site No. 5 : 545m)} \cdots\cdots(2)$$

$$\Sigma m = 0.23 \Sigma T_h^+ \quad \text{(Site No. 16 : 1005m)} \cdots\cdots(3).$$

The coefficients are called the degree hour factor (mm °C^{-1}h^{-1}), and values from 0.2 to 0.3 are reported for seasonal snow in Japan (Kojima *et al.*, 1983). The values obtained on the glacier were almost consistent with the values for the melting season in Hokkaido, Japan. If we calculate the degree day factor f (cm °C^{-1}day^{-1}), a rather popular coefficient than the degree hour factor, the equations (2) and (3) will be converted to ;

$$M = 0.72\,\Theta_a \quad \text{(Site No. 5 : 545m)} \cdots\cdots(4)$$

$$M = 0.55\,\Theta_a \quad \text{(Site No. 16: 1005m)} \cdots\cdots(5).$$

where M is an amount of daily snowmelt (cm day^{-1}), and Θ_a is a daily mean air temperature (°C). Calculated degree day factors f of 0.72 (No. 5) and 0.55 (No. 16) are similar to those reported for the snow melt in perennial snow patches in Japan (Arai and Sekine, 1973).

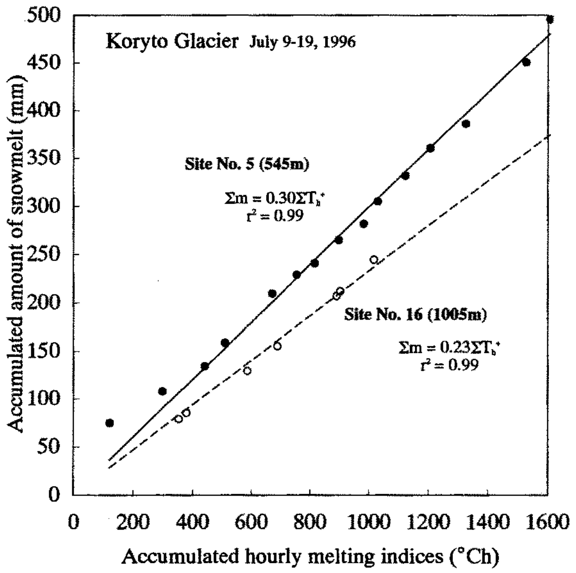

Fig. 9 Relationship between the accumulated amount of snowmelt (mm) and the accumulated hourly melting indices (°Ch).

5. Discussion : mass balance of Koryto Glacier

Mass balance of the Koryto Glacier during the balance year of 1995/1996 is estimated from the data collected in the field. Although the year has not finished yet, the estimation help us to understand the mass exchange of Koryto Glacier to some extent.
Net balance b_n (m) of the Koryto Glacier can be expressed as ;

$$b_n = \int_{t_1}^{t_m} (\dot{c} + \dot{a})dt + \int_{t_m}^{t_j} (\dot{c} + \dot{a})dt + \int_{t_j}^{t_2} (\dot{c} + \dot{a})dt \cdots(6).$$

where t_1, t_m, t_j, and t_2 are the time at the end of the summer ablation season in 1995, the time of intervening maximum of balance, the time of coring in this study, and the time at the end of summer ablation season in 1996, respectively. The term c and a indicate accumulation and ablation rates, respectively. Koryto Glacier is a temperate glacier situated at the very low altitude, therefore, it may be possible for the first approximation to assume that ablation occurs only between t_m and t_2, while accumulation does between t_1 and t_m. Then, eq. (6) can be simplified as ;

$$b_n = \int_{t_1}^{t_m} \dot{c}\,dt + \int_{t_m}^{t_j} \dot{a}\,dt + \int_{t_j}^{t_2} \dot{a}\,dt \quad \cdots\cdots(7).$$

For simplicity, term t_1 is defined by the summer surface marked by a dirt layer in the cores, while t_m is assigned to the end of April, and t_2 is to the end of October on the basis of average monthly air temperature θ_m observed at Kronoky Meteorological Observatory (approx. 0 m a.s.l.) at the coast of southern part of the Peninsula during recent four years (Table 3). Here, air temperature at Koryto Glacier was estimated using air temperature lapse rate of -6 °C km^{-1} as usual. The value of -6 °C km^{-1} may not be necessarily appropriate during the whole summer season as already exampled by the occasional air

Table 3. Summer monthly average air temperature (°C) at Kronoky Meteorological Observatory from 1991 to 1994.

	May	Jun.	Jul.	Aug.	Sep.	Oct.
1991	3.2	6.3	9.7	11.5	7.9	4.7
1992	2.6	8.1	9.9	10.1	6.8	2.4
1993	2.9	6.6	10.6	11.7	8.9	3.7
1994	2.7	7.4	11.0	12.5	9.1	5.1
Mean	2.9	7.1	10.3	11.5	8.2	4.0

temperature inversion on the glacier. However, we used the value for the first approximation. If we calculate a monthly air temperature at the terminus of the glacier (320 m), positive air temperatures are encountered from May to October, while at the highest point of the glacier (1200 m), they are from July to September. This means that ablation may occur from May to October at the terminus and from July to September at the highest part. In contrast, the accumulation may occur from November to April at the terminus and from October to June at the highest part, deducing from the estimated air temperatures. The accumulation at the highest part is, however, not large on May, June and October because of lesser number of cyclones. Thus, we assume that accumulation occurs from November to April only throughout the glacier, while ablation does when the air temperature is positive. The time of coring t_j was fixed to July 12 around which the coring operations were conducted on the glacier.

Let us assume that the total ablation a_t (m) of the balance year 1995/1996 will be equivalent with integration of daily ablation rate at each altitude, calculated with degreeday factors f multiplied by average daily air temperature θ_a at that altitude, during the ablation period $t_m - t_2$;

$$a_t = \int_{t_m}^{t_2} \dot{a}\, dt = -\sum_{t_m}^{t_2} f \cdot \frac{1}{100} \cdot \theta_a \quad \cdots\cdots (8).$$

$f = 0.72 \text{ if } z < 780$ m,

$f = 0.55 \text{ if } z \geq 780$ m

The altitude z of 780 m was arbitrary selected as an altitude dividing the two values of observed degree-day factors f. It is a well known feature that the ablation rate depends on surface albedo of glacier as already shown by the case of the altitudinal change in ablation for the short period (Fig. 8). The albedo effect was, however, not explicitly considered by just giving two different values of f for the two regions.

Total accumulation c_t (m) was estimated from the positive balance obtained from firn core data (Fig. 6 : eq. (1)) and ablation between t_m and t_j (73 days) as follows ;

$$c_t = \int_{t_1}^{t_m} \dot{c}\, dt = \frac{1}{100}\{(0.62z - 3.73) + (\sum_{t_m}^{t_j} 73 f \cdot \theta a)\} \quad \cdots\cdots (9).$$

$f = 0.72 \text{ if } z < 780$ m,

$f = 0.55 \text{ if } z \geq 780$ m

Fig. 10 shows the altitudinal distribution of the estimated mass balance terms c_t, a_t, and $b_n (= c_t + a_t)$ of Koryto Glacier in the balance year of 1995/1996. ELA can be expected to exist at an altitude of 590 m. Specific net balance $\bar{b}_n$ is calculated to be +3.03 m for the year of 1996/1995. This is an extremely high positive value as compared with previous observed values of +0.58 m (1970/1971) and −0.28 m (1981/1982). If the average air temperature from 1991 to 1994 is considered to be normal, the extremely high positive balance can be ascribed to the sufficient accumulation observed in 1995/1996.

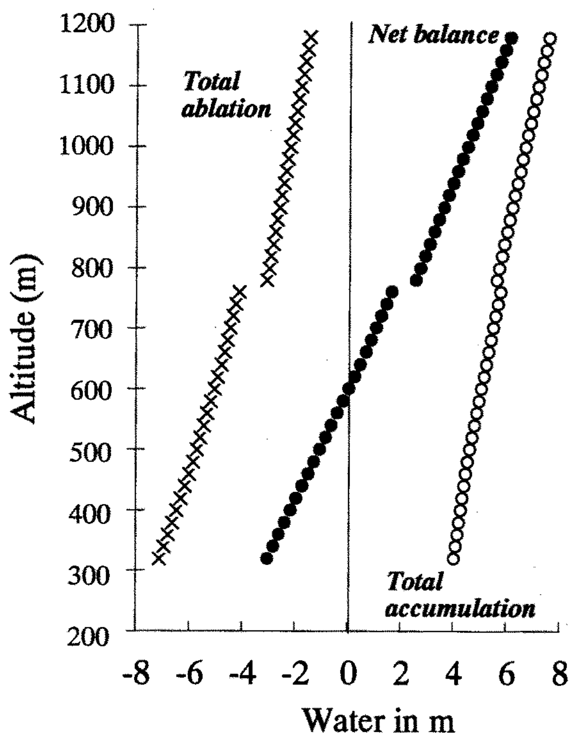

Fig. 10 Estimated mass balance of Koryto Glacier in the balance year of 1995/1996.

6. Concluding remarks

Mass balance features of the Koryto Glacier, a clean-type valley glacier, in the Kronotsky Peninsula, Kamchatka, were studied in the field from July 8 to July 20, 1996.

The glacier is a temperate type, and situated at the lowest altitude as compared with other glaciers in Kamchatka. Altitudinal dependence of the temporal balance between the summer surface in 1995 and July 1996 was reconstructed from shallow corings, and it can be expressed as a linear equation (eq. 1) except for the altitude near the transient snow line.

Short term ablation was less dependent on altitude probably because of local weather conditions during the observed period. Valley wall effect on ablation was found clearly at the terminus and slightly at the uppermost part of the glacier, but the effect was not significant. It was found that accumulated amount of snowmelt could be expressed as a linear function of accumulated hourly melting indices. This relationship is further converted to the relation between total snowmelt (cm) and positive degree day, and introduced two degree day factors : 0.72 for the altitude of 545 m and 0.55 for the altitude of 1005 m.

Mass balance of the glacier in the balance year of 1995/1996 was estimated by using average air temperature at the coast of the peninsula and by the observed data during the field research. The summer balance was considered to be equal to the summer ablation and calculated by the degree day factors multiplied by the air temperatures. The winter balance was considered to be equal to the winter accumulation and calculated by the residual winter snow plus melted amount of snow between the end of winter and the day of coring. The resulted specific net balance was +3.03 m with ELA of 590 m in altitude. The extremely high positive balance was ascribed to the abnormal high amount of winter accumulation in the year of 1995/1996.

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