Mountain Glaciation in the U. S. S. R.: Extension, Classification and Ice Storage in Glaciers

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Abstract

During the last few years detailed calculations of the area of glaciation in the mountains of the U. S. S. R. have been carried out. However, there is a general lack in information concerning the thickness of the glaciers. Thus, in order to make evaluations on the thickness all glaciers were classified into three groups based on the actual measurements of thickness (the adopted average thickness of glaciers is given in brackets): (1) hanging, corrie-hanging and corrie glaciers are found mostly in the Urals, Western Caucasus, and in some regions of the Altai and Northeastern Asia (30～50 m); (2) corrie-valley and valley glaciers are frequently observed in all regions of glaciation (70～100 m); (3) large valley and gigantic dendritic glaciers are located only in the mountains of Central Asia (200～300 m). The average density of glacier ice is 0.86 g/cm^3; the variation of the density of glaciers is small. According to calculations the ice storage in glaciers is given as follows: the surface area of glaciers is 20 506 km^2 the ice volume 2 831 km^3 and the amount of accumulated water is 2 433 km^3.

The U. S. S. R. territory has many large regions of recent mountain glaciation: the Caucasus, the Central Asia mountains, the Altai and the Northeast Asia mountains. The main moisture source of glacier feeding is the Atlantic Ocean and only the glaciers of the northeastern regions of the U. S. S. R. are fed by moisture coming from the Pacific Ocean. According to their regime the overwhelming majority of glaciers are regarded as "continental" (the Central Asia and Siberian mountains). The warmer glaciers of "maritime" type are found in Kamchatka and in the Caucasus. The measurements in deep pit-holes showed, however, that zero temperatures in the ice depth are common for many glaciers situated in the continental regions. As a rule the regimes of different parts of the glaciers are different, but in a certain geographic area they show a more or less uniform change with the altitude. Each glacial area has its peculiar zones and types of ice formation, however local conditions may cause exceptions, among which are the lack of certain zones or even zone inversion (Elbrus).

In the maritime glacial region of Kamchatka the main period of snow accumulation occurs in winter. In the Caucasus and the most humid regions of the Thian Shan—in winter and spring and in the inner parts of the Thian Shan and the Pamir as well as in the mountains of Siberia (the Altai, Suntar Khayata, Kodar etc.) the main snow accumulation occurs in transitional seasons (April, June, September and October) and in summer. The prevailing winter snow accumulation hinders the cooling of the ice mass; the prevailing transitional season accumulation leads to winter cooling of the ice mass. The thick snow cover formation in April–May produces low temperatures in the ice

mass and maintains the low temperatures in the ice mass until the ablation period and prevents the rise in temperature of the ice mass from spring through to summer. Thus additional heat is required for bringing the temperature of the snow cover and ice up to the freezing point.

Inland, the quantity of solid precipitations falling directly on the glacier surface during the cold period decreases, and in the glacier regime the following factors begin to play a significant role: (a) snow accumulation in transitional seasons, especially abundant summer snowfalls; (b) redistribution of snow by snow-drift and avalanches and (c) the growing relative contribution of evaporation in the total ablation of the glaciers.

In recent years detailed calculations of the area of glaciation in the mountains of the U.S.S.R. were made. Firstly, among them must be mentioned the works of Ivankov (1958, 1959 a, 1959 b), concerning the Caucasus and Kamchatka, Vaskovski (1955), describing the Northeast of the U.S.S.R., Tronov (1949), dealing with the Altai, Zabirov (1955, 1958) for the Thian Shan and the Pamirs. The area calculations were made on the basis of recent aerial surveys and large-scale maps. Certainly, errors could not be excluded, because deciphering of the aerial cartographic data are at present far from perfect. Thus, each new study leads to corrections in previous works and therefore the figures given below are not conclusive.

There is a decided lack in information about the thickness of glaciers. During the last decade the data concerning the ice thickness in the main glacial regions of the U.S.S.R. have became available, however, available data is still so limited that in working out general descriptions of glacier thicknesses and in calculating mean values of the ice thicknesses generalization and extrapolation can not be avoided. For the evaluation of glacier thickness on the basis of the actual measurements all the mountain glaciers of the U.S.S.R. were classified into three groups.

The first group includes hanging, corrie-hanging and corrie glaciers, which prevail in the Urals, the West Caucasus and some regions of the Altai and Siberia. The thickness of the largest glaciers of this type may reach 70~90 m, but as a rule it does not exceed 50~60 m. According to electrosounding, the maximum thickness of the Obruchev Glacier in the Polar Urals is 90 m; the corrie glaciers of the Kodar range according to indirect estimations have a maximum thickness 70 m.

The second group—the corrie valley and valley glaciers have the greatest extensions. They are found in all glacial regions and may have a wide range of thicknesses, but as seismosounding data show, the prevailing thickness of such glaciers is somewhat over 100 m. For instance, the thickness of the Tsentralni Tuyuksu Glacier (the Zailiysky Alatau range) in the feeding zone reaches 120 m, in the middle part of the tongue it is 70 m and at the snout it decreases to 30 m. The thickness of the Glacier No. 31 in the Suntar Khayata range in the feeding zone is 100~150 m, in the middle part of the tongue—130 m and not far from the snout—about 50 m. The larger valley glaciers, naturally, have greater thicknesses. So, the greatest thickness of the Bolshoy Aktroo Glacier (the Altay) is about 250 m and that of the Bolshoy Tandurinski Glacier is 170 m.

The last, the third group includes large valley and gigantic dendritic glaciers, which in the U.S.S.R. are found in the mountains of Central Asia only. Their thicknesses reach several hundreds meters and the thickness of the largest of them exceeds 0.5 km. The

thickness of Inilchek Glacier (Thian Shan) in the section of dead ice is 100～120 m and in the main part it reaches 400 m. According to seismosounding data the thickness of the Fedchenko Glacier in the middle section is about 800 m and in the lower part—about 300 m.

The mean thickness values for different glaciers are lower than the above mentioned extremes due to the thinning of the glacier to the lateral margins and to the glacier snout. The averages for whole region are still lower (but not very much) due to the presence in any glacial region of corrie and hanging glaciers of negligible thickness. Taking this into account we assumed the mean thickness of the glaciers to be 30～50 m for the first group, 70～100 m for the second group and 200～300 m for the third group.

The mean glacier ice density is 0.86 g/cm^3. The variation of density for glaciers of different dimensions is not great, because large glaciers with long tongues which have no firns, have at the same time extensive areas of firn feeding and in small glaciers which have no tongues, a considerable thickness of firn are generally absent as well; the ice formation on such glaciers is completed in 1～2 years.

Table 1. The ice storage in mountain glaciers of the U. S. S. R.

The region	Area km^2	Average ice thickness m	Ice storage km^3
THE CAUCASUS			
	North slope		
The West Caucasus	282	40	11
The Central Caucasus	834	100	83
The East Caucasus	115	30	3
	South slope		
The West Caucasus	163	30	5
The Central Caucasus	385	100	39
The East Caucasus	1	25	0
The Maliy Caucasus	25	25	1
The Caucasus as a whole	1805		142
THE THIAN SHAN			
The Saur	17	40	0
The Jungarski Alatau	956	100	96
The Zailiyski Alatau	544	70	38
The Kungey Alatau, the Kirghiz Alatau, the Talasski Range	1 027	70	72
The Terskey Alatau	1 080	70	76
The Akshiyrak	440	90	40
The Kuyliu	236	80	19
The Khan Tengri and the Pobeda peak region	1 517	250	379
The Kokshaal	717	80	57
The Jetim, the Jetim Bel, the Bor Koldoy and the Fergana Ranges	629	70	44
The Alay, the Turkestan, the Zeravshan, the Gissar Ranges etc.	1 335	100	113
Altogether	8 498		934

Table 1. (Continued)

The region	Area km²	Average ice thickness m	Ice storage km³
THE PAMIRS			
The Zaalayski Range	1 469	200	294
The Zulumgar	462	120	56
The North Tannimas	422	200	84
The Academia Nauk	1 500	300	450
The Pter Pervi	484	200	97
The Darvazski	520	200	104
The Vanchski and the Yasgulemski	834	150	125
The Muzkoll	376	150	56
The Rushanski and the Bazardarinski	984	200	197
The Shugshanski and the Bakchighir	262	120	31
The Ishkashimski and the Shakhadarinski	436	130	57
The South Alichurski and the Vakhanski	142	50	7
The Sarikolski	150	70	9
Altogether	8 041		1 567
THE ALTAI AND THE SAYANS			
The South Altai	80	70	6
The South Chuyski Range	146	100	15
The North Chuyski Range	130	130	17
The Katunski Range	232	120	28
The Western area of small glaciers	20	40	1
The Eastern area of small glaciers	21	30	1
The Sayan-Tuvin Plateau	23	35	1
Altogether	652		69
THE NORTHEAST OF THE U. S. S. R.			
The Birranga	45	60	3
The Verkhoyanski Range			
The Kharulakh	3	40	0
The Orulghan	20	60	1
The Suntar Khayata	206	100	21
The Cherski Range			
The Buordakh Massif	95	100	10
Other chains of the range	49	70	3
The Ilin Tas and Pekulney Ranges	6	40	0
The Kodar Range	15	80	1
The Koryatskoye Plateau	180	100	18
Kamchatka	866	70	61
Altogether	1 485		118

The information on ice storage in glaciers is summarized in Table 1. The Caucasus data are given separately for the south and north slopes; the differences between glaciation features of the West, Central and East Caucasus were taken into account as well. Unfortunately, only the thickness of the Elbrus Glacier is known at present. According

to seismosounding data and the results of ice cliff height measurements, it amounts to 60~80 m and locally at times it is 100 m.

The ice storages in the Thian Shan are tremendous where the thickness maxima of the majority of glaciers exceed 100~150 m. For instance, in the Jungarski Alatau, according to the data obtained by different methods, the ice thickness in the lower parts of the glaciers varies from 65 to 130 m and in the upper parts—from 100 to 155 m. The largest glaciers 400 m in thickness are connected with the regions of the Khan Tengry and the Pobeda peak.

The largest glaciers of the U.S.S.R. are situated in the Pamirs. For the majority of the Pamir ranges the average ice thickness about 200 m is assumed, and this is an intermediate value between the average thickness of the gigantic glaciers of Fedchenko type and relatively small ones, 5 to 10 km long, similar to the Tsentralni Tuyuksu in the Thian Shan. In the ranges of the arid East Pamirs the glacier thicknesses are far less; in nearby regions (outside of the borders of the U.S.S.R.) the measured glacier thickness averages about 100 m.

The ice storage in Siberia is relatively small. Here the corrie and corrie-valley glaciers of small thickness prevail, but in some regions (the Suntar Khayata, the Buordakh Ranges, the Koryatskoye Plateau) the most wide-spread type is valley glacier and the average thickness increases here to 100 m. Kamchatka shows outstanding feature where such singular glaciers as volcanic cone glaciers (the ice thickness is about 50 m), crater and cauldron glaciers (the ice thickness is about several hundreds meters), atrio and barrankos glaciers (the thickness is about 50 m) and cauldron-valley glaciers (the thickness is about 100 m).

Thus, at the present time the mountain glaciers of the U.S.S.R. are estimated to contain 2 831 km^3 of ice (Table 2), in which 2 433 km^3 of water is accumulated. These figures concerning the natural ice in the U.S.S.R. are of course in round numbers and are intended to give some idea of the scope of glaciers in U.S.S.R. According to very rough estimations on the glaciers in the Soviet Arctic regions an accumulation of approximately 10 000 km^3 of water is present. Annually, to the end of winter the seasonal storage of snow in the U.S.S.R. reaches about 3 350 km^3 of water. All these values, however high they may be, are by far not comparable to the recent glaciation of, say,

Table 2. The amount of water, accumulated in the mountain glaciers of the U.S.S.R.

The area of glaciation	The area of glaciers km^2	ice storage km^3	The amount of accumulated water km^3
The Urals	25	1	1
The Caucasus	1 805	142	122
The Thian Shan	8 498	934	803
The Pamirs	8 041	1 567	1 347
Siberia and the Far East	1 485	118	101
The Altai and Sayans	652	69	59
Altogether	20 506	2 831	2 433

Antarctica, where the annual snow accumulation is approximately equal to the mass of all mountain glaciers of the U.S.S.R.

References

1) Васьковский, А. П. 1955 Размеры современного оледенения на Северо-Востоке СССР. Колыма, № 10.
2) Забиров, Р. Д. 1955 Оледенение Памира. М., Географгиз.
3) Забиров, Р. Д. 1958 *Оледенение Средней Азии.* В сб. *Работы Тянь-Шанской физ. геогр.* станции. Гляциология, вып. I. Фрунзе.
4) Иваньков, П. А. 1958 Оледенение Камчатки. Изв. АН СССР, серия геогр. № 2.
5) Иваньков, П. А. 1959 а Современное оледенение Малого Кавказа и Армянского нагорья. *Изв. АН Арм. ССР, серия геол. и геогр., т. 12, вып. 2.*
6) Иваньков, П. А. 1959 б Оледенение Большого Кавказа и его динамика за годы 1890–1946, Изв. Всес. геогр. об-ва., т. 91, вып. 3.
7) Тронов, М. В. 1949 Очерки оледенения Алтая. М., Географгиз.