MAIN PARTICULIARITIES OF GLACIATION OF CENTRAL ASIA ACCORDING TO THE LATEST DATA

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SUMMARY

During 1958-1959 a joint Expedition of the USSR Academy of Sciences and the Academy of Sciences of the Chinese People's Republic had inspected glaciers in Alpine mountain ranges of Nan Shan and Eastern Tien Shan. In Nan Shan 965 glaciers have been recorded, mostly of a corrie and corrie-valley type, occupying an area of 1280 km². The glaciated territory of Eastern Tien Shan is about 2000 km²; we find there glaciers of a valley type up to 30 km long and with an area up to 100 km².

The territories studied belong to the Central-Asiatic continental glacier province, with an extreme continental climate. Their glaciation is substantially different from glaciations of adjoining territories of Western Tien Shan, belonging to the subcontinental Atlantic glacier province and of Eastern Nan Shan located on the margin of the subcontinental Pacific glacier province. These differences are reflected in the height of the snow line, amount of supplied and discharged matter of the glaciers, the volume of glaciation energy, the temperature and hydrological regime of the glaciers. Thus, the glaciers of Western and Central Nan Shan, as well as those of Kuenlun, end at much greater heights than the glaciers of Tien Shan and Eastern Nan Shan; they are characterized by a less intense exchange of matter in the glaciers, a lesser energy of glaciation, a lower temperature regime, prevalence of a surface run-off of meltwater, a more inert reaction to a change in external climatic factors.

Numerous traces of ancient glaciation have been discovered. Old glaciers were descending in Nan Shan up to the marks of 2900-3800 m. They came out to the bottoms of intermontane depressions, but were not filling them, as it was thought before. In Tien Shan ancient glaciation was more extensive. Largest glaciers descended up to 1800 m. At the present time Tien Shan glaciers retreat faster than the glaciers of Nan Shan.

RÉSUMÉ

L'expédition de l'Académie des Sciences de l'U.R.S.S. et de l'Académie des Sciences de la République Populaire de Chine en 1958-59 a investigué les régions glaciaires alpines du Nan-Chan et du Thian Chan Oriental. Dans le Nan-Shan, l'on a révélé 965 glaciers couvrant une superficie de 1280 km². L'aire de glaciation du Thian-Chan Oriental excède 1700 km².

Le Nan-Chan Central et Occidental, l'extrémité Orientale du Thian-Chan et le Kun-Lun sont situés dans les confins de la province glaciaire continentale de l'Asie Centrale, et leur glaciation diffère grandement de celle du Nan-Shan Oriental, situé dans la province subcontinentale Pacifique, et du Thian-Chan Central, qui se rapporte à la province subcontinentale de l'Atlantique.

Ces différences se font sentir sur la hauteur de la ligne de neige, sur la valeur de la recette et de la consommation de la neige, sur l'énergie de la glaciation, sur le régime de température et sur le régime hydrologique des glaciers.

Notamment, les glaciers de Nan-Chan se trouvent à une beaucoup plus grande altitude, en comparaison aux glaciers du Thian-Chan (conformément : 4000-5000 m et 2800-3500 m); ils se caractérisent par des plus petites valeurs de recette et de dépense de la substance, par un régime à température plus basse, par une prépondérence de déversement superficiel des eaux de fonte et par une série d'autres indices.

Des indices de l'ancienne glaciation dans le Nan-Chan peuvent être tracés jusqu' aux marques 2900-3800 m. Les glaciers anciens affleuraient sur les fonds des dépressions, mais ne les remplissaient pas, comme on le pensait jadis. Dans le Thian-Chan, la glaciation ancienne était plus vaste : des glaciers immenses descendaient jusqu'aux avant-pays avec des marques 1800-2000 m. Actuellement, les glaciers reculent sur le Thian-Chan plus vite que sur le Nan-Chan. Sur certains glaciers du Nan-Chan, il y a des indices d'avancement actuel.

The areas of mountain glaciation in Central Asia are among the least explored and are accessible with great difficulty. At the same time the ices and snows covering many of the Central Asian ranges and uplands are one of the main sources of water supply for oases at the foot of the mountains.

In connection with the problem of supplying with water the arid north-western provinces of China, a special expedition for the study of the high altitude ices and snow and the working out of methods for their practical utilization was organised jointly by the Academy of Sciences of the Chinese People's Republic and the Academy of Sciences of the U.S.S.R. in 1958-1959. As a result of the field work carried out and the analysis of the data obtained by means of aerial photography, the explorers determined the specific features of glaciation of the Nan Shan and the eastern Tien Shan ranges; determined (as a first approximation) the areas of glaciation and the minimum water resources contained in the glaciers, and carried out experiments in artificially accelerating the thawing of ice and snow in the mountains. The data obtained yield information on the morphology, hydrological regimes, temperature conditions, dynamics and evolution of the glaciers. For the first time in Central Asia, glaciological observations lasting all the year round, have been started at the newly established high-altitude stations: Laihukow in the north-western part of the Nan Shan (36°30′ N., 96°30′ E, 4060 m above sea level) and Tasikow in the Eastern part of the Tien Shan (43°06′, 87°15′, 3480 m above sea level). The author of this article who took part in the explorations work on the Soviet side, restricts his report mainly to the new data received by the expedition and presents some general results.

The main characteristics of the present-day glaciation of the Nan Shan, the Eastern Tien Shan and the western Kun Lung are to be found in Table 1.

The data concerning the glaciation of the Nan Shan are somewhat more complete than the others, although in the past the information available on this range was limited to brief descriptions (Przhevalsky, Roborovsky, Kozlov, Obruchev, Stein). Now over 1000 glaciers with a total area of about 1500 km^2 have been found. The approximate amount of water in these glaciers is close to 50,000,000,000 m^3.

The glaciers of the Nan-Shan are numerous, but relatively small in size. Most of them are suspended and tarn glaciers (40 and 30 per cent respectively). Tarn valley and valley glaciers of a small size are widespread, forming 25 per cent of the number of glaciers and 35 per cent of the glaciation area. The glaciers of these types, alongside the tarn glaciers are particularly important from the hydrological point of view. The glaciers originating on flat summits, which are concentrated in the south-western ranges of the Nan Shan, constitute 2,5 per cent of the total number of glaciers and about 10 per cent of the glaciation area, but their role in the run-off is insignificant. The area of perennial snow glaciers and small firn glaciers constitutes approximately 2,5 per cent of the total.

The expedition did not find any extensive glaciation sheet on the Ritter (Chahanbotu) range, which was indicated for the first time on the maps drawn up by Roborovsky and Kozlov under the name of Guchin-gurbu.shahalgyn (Roborovsky, 1900). According to Obruchev (1931), the area of this glacier must be close to 800 km^2. Here, as well as on the neighbouring ranges (Turgen-daban, Tsaidamo-shan) about thirty small glaciers originating on flat summits have been found. The biggest among them does not exceed 17 km^2. The total area of all the glaciers originating on the fiat summits of the Nan Shan constitutes 120 km^2, but they are scattered at different spots on the summits of several ranges, and do not form any continuous glaciation sheet.

The foci of glaciation in the Nan Shan territory are distributed with a certain regularity. Glaciation is most considerable in the central and western parts of the territory, where the altitude of the mountain ranges, as a rule, exceeds 5000 m. Glaciation in the south-eastern part of the Nan Shan is insignificant, in spite of a more humid

TABLE 1

The glaciation of Nan Shan, eastern Tien Shan and western Kun Lung.

Ranges (Altitude above sea level in meters)	Number of glaciers	Area of glaciation	Altitude above sea level				Ancient moraines	
			Snow line		Glacier margins			
			north slope	south slope	north slope	south slope	north slope	south slope
1.	2.	3.	4.	5.	6.	7.	8.	9.
NAN SHAN (From expedition report published in 1958, and the observations of the author)								
Lenglungling (4500-4800)	116	118,5	4250	4450	3860	4150	—	3300
Richthofen (4500-5900)	271	301,0	4360	4600	3880	4150	3150	—
Tolai-Shan (4500-5000)	79	46,1	4550	—	4200	—	2900	—
Tolai-nan-Shan (4500-5000)	85	70,6	4550	4600	4150	4400	3600	—
Ema-shan (4500-5300)	107	161,7	4700	4750	4250	4450	—	—
Süss (5000-6200)	130	500,0	4650	5100	4350	4650	4000	4200
Humboldt (4500-5500)	100	76,0	4700	4800	4400	4550	—	—
Ritter (4500-5500)	42	63,5	4750	—	4600	—	3900	4130
Mushketov (4500-5500)	102	175,6	4750	5150	4600	4750	—	—
Tsaidamo-shan (5000-5800)	25	49,0	5200	—	4800	—	—	—
Total for the Nan Shan range	1055	1565,0	4645	4780	4300	4440	—	—

TABLE 1 *(Continued)*

Ranges (Altitude above sea level in meters)	Number of glaciers	Area of glaciation	Altitude above sea level				Ancient moraines	
			Snow line		Glacier margins			
			north slope	south slope	north slope	south slope	north slope	south slope
1.	2.	3.	4.	5.	6.	7.	8.	9.
Kurlyk-tag (4000-4900)	66	102,0	3900	4100	3400	3450	2100	2260
Barkhalu-tag (4000-4200)	23	16,0	3900	—	3250	—	—	—
Bogdoshan (5000-5500)	24	70,7	3750	3950	3200	3300	2150	2340
Irenhabirga (4000-5500)	?	673,0	3800	4050	3200	3550	3070	3400
Source of river Haidyk-gol	38	40,0	3850	—	3500	—	2950	3200
Halyk-tau (4000-6000)	?	290,0	3850	4000	3400	3550	—	—
Kokshaal-tau	?	521,0	3750	4150	2950	2900	—	1900
Total for the Eastern Tien-Shan	?	1702,7	3830	4050	3270	3350	—	—
WESTERN KUN LINGI (According to G. Sobolevsky)								
Basin of the rivers Kiliang, Karakash and Yurungkash	68	—	4900	5180	4370	—	3600	4150

climate,—a phenomenon due to the lower altitude of the mountains. The only important glacier focus in this part of the mountain system is situated on the Lenglungling range, rising to 4800 m above sea level.

In conformity with the aridity of the climate which increases in the western and south-western directions, the level of the snow line and that of the ends of the glaciers becomes increasingly higher in that direction. On the northern slope of the Lenglungling range, the snow line lies at at altitude of 4250 m, while on the same slope of the Tsaidamo-shan range it is situated at 5200 m. The level at which the ends of glaciers are situated rises accordingly from 3800 to 4900 m. The general regularity in the modification of the snow line level is displayed most distinctly in comparing the levels of flat-summit glaciers, on which the influence of the local orographic conditions is least noticeable. For instance, the snow line level of the Hsiaoshalung flat summit glacier is situated at 4500 m (Richthofen range in the eastern part of the Nan Shan) while in the glaciers of the same type situated in the south-western ranges of the Nan-Shan, this level is never below 5150-5200 m. Alongside this general regularity, reflecting the changes in climatic conditions, sharp fluctuations in the height of the firn line of glaciers are observed, which are due to local orographic conditions.

The degree of the glaciation of the mountain slopes is found to be directly dependent on their exposure. The snow boundary on the northern slopes usually lies at a level which is 200 or 300 m below that of the southern slopes. The Tolai shan, the Tsaidamo-shan and the Tolai-nan-shan carry on their northern slopes many glaciers which often descend by many hundred metres below the ridges of the watersheds, while the southern slopes of these ranges are practically free from modern glaciation. On the whole, about 72 per cent of the Nan Shan glaciers lie on the slopes with a northern exposure; 21 per cent of them are situated on the southern slope, and only about 7 per cent fall to the share of the eastern and western slopes (Fig. 1). This is not only due to differences in insolation found on slopes with a different exposure, but is also accounted for by orographic conditions, such as the latitudinal or nearly latitudinal direction taken by the Nan Shan range (a direction of this kind favours the formation of slopes and hollow relief forms on the northern and southern sides,

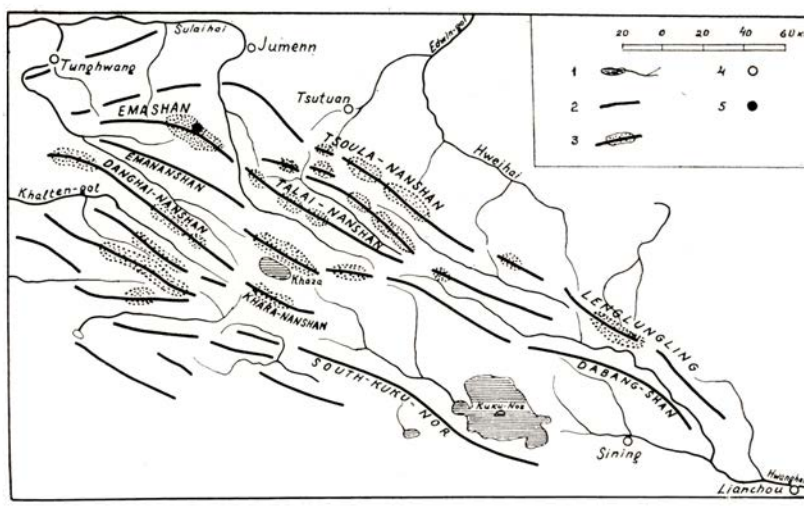

Fig. 1 — Scheme of present day glaciation foci of Nan-Shan: 1- rivers and lakes; 2- mountain ranges, 3- foci of present day glaciation, 4- settlements, 5- glaciological station Laohukou.

preferably to those exposed to the East and West). A considerable role is also played by the greater altitude, width and ramification of the northern slopes of most Nan Shan ranges compared with their southern slopes.

The above mentioned specific features of the geographical distribution of the Nan Shan glaciers are reflected in the relative role of the thaw waters of the glaciers in the run-off of the rivers, which rises from 5 per cent in the South-East to 30-35 per cent in the North-West and to 60-80 per cent in South-West, parallel to the increasing general aridity of the climate in the same direction.

From the morphological viewpoint, most of the Nan Shan glaciers are distinguished by firn basins with steep slopes, a great number of fissures and ice drifts, as well as tongues descending along relatively gentle slopes and reaching the bottoms, of valleys. The surface of glacier tongues has usually a small number of cracks, but is as a rule, distinguished by considerable ablation breaks. The glacier tongues end in steep protruding "fronts" 40-60 m high. In some of the glaciers the ends of the tongues are concealed by a thick cover of moraines. In some spots big terminal moraine ridges up to 100 m high are found. They contain inclusions and pieces of dead ice. Lateral moraines, both ancient and modern, are widely developed. At the same time there are many glaciers with very weakly developed moraines, which practically leave only fluvio-glacial deposits in their retreat. The destruction of the glacier tongues, due to the thermal radiation of the basic slopes, the destructive action of the lateral (marginal) streams of thaw waters and the periodic crumbling of the icy slopes undermined by water,—is more manifest on the sides than in the central part (axis) of the glacier tongue. Due to this, the tongue bulges in its central part, and on its edges vertical ice walls are formed. By studying them it is possible to get an idea on the internal structure of the glaciers. In these sections various forms of ice tectonics folds, breaches, faults, etc.) may be found, which make it possible to judge of the complex nature of glacier motions and their effect on their bed. The alternation of ice layers enriched by moraine inclusions to a different degree bears witness to the repeated succession of the conditions under which a glacier existed, particularly the succession of periods with predominating ablation and those when accumulation became the prevailing characteristic.

The structure of the upper horizons of firn and ice in the firn basins of many glaciers permits the explorers to determine the degree of pure accumulation (minus run-off and evaporation) in a number of preceding years. At the typical valley tarn glacier "July 1", situated on the northern slope of the Tolai-shan range at an altitude of 4850 m, pure accumulation amounted in the last six years to a mean annual figure of 400 mm (in terms of water), for all the ablation zone. As the "July 1" glaciers has a glacier coefficient of 1.15, this ablation must be compensated by accumulating in the firn basin at least 355 mm of precipitation. This figure is close to the mean annual accumulation in the firn basin, established by means of analysis. As during the warm season thawing sets in almost on the entire surface of the Nan Shan glaciers, including the firn basins, the amount of snow precipitation must naturally be more considerable than pure accumulation. We do not know the figure yet, but it should not be very considerable. According to the observations made in 1958-1959, the line of the zero balance at the "July 1" glacier passed at an altitude of 4550 m in the central and western parts of the firn basin, where avalanches play an important role, while in the eastern part of the glacier it was situated at an altitude of 4650 m. These altitudes are close to that of the firn line observed in 1958, towards the end of the ablation period. According to technical observations, the speed of the glacier movement in the central part of the tongue amounted on an average to 11.4 m a year, the glacier being about 70 m thick in this part (according to the Lagally formula). The data cited here indicate that the glaciation energy of the Nan Shan glaciers is less considerable than that of glaciers in many other mountainous regions in the temperate zone.

Another essential feature of the Nan Shan glaciers is their low temperature regimen. For instance, at the "July 1" glacier, at an altitude of 4580 m, the temperature of the ice at a depth of 9 m was −7°,9C (taken on July 18, 1959 by means of a thermosound driven into the ice). At the No. 20 glacier of Laohukow in the Ema.shan range at an altitude of 4440 m, the temperature of the ice at the depth of 5 m amounted to −10°.I (June 31, 1959). In the middle of the warm season, low temperatures below zero were observed already in the ice at a depth of one metre (fig. 2). The first data of temperature observation (on which there are not many, for the time being) show that the Nan Shan glaciers are among the coldest glaciers of the temperate zone (they are colder than the Tien Shan glaciers and their temperature is close to that of the Suntar-Hayat glaciers situated in the neighbourhood of the pole of cold of the northern hemisphere). The low temperature regimen of the Nan Shan glaciers is a consequence of the local sharply continental climate. In the course of the winter season, when cold and very dry weather of the anti-cyclone type prevails, and there is practically no precipitation, the temperature of the glaciers becomes much colder. The summer is cold, with frequent snowfalls, and there are fluctuations above and below zero practically every day. It is natural that under these conditions both ablation processes and the warming up of the glaciers take a very slow course. The presence of temperatures below zero in the layers of ice near its surface lead to a predomination of superficial run-off of the thaw waters and lend some specific features to the processes of ice formation. According to the data of the meteorological stations, about 80 per cent of the annual precipitation in the foothills and some of the mountain valleys of the Nan Shan occurs in the period from May to September. The data taken at

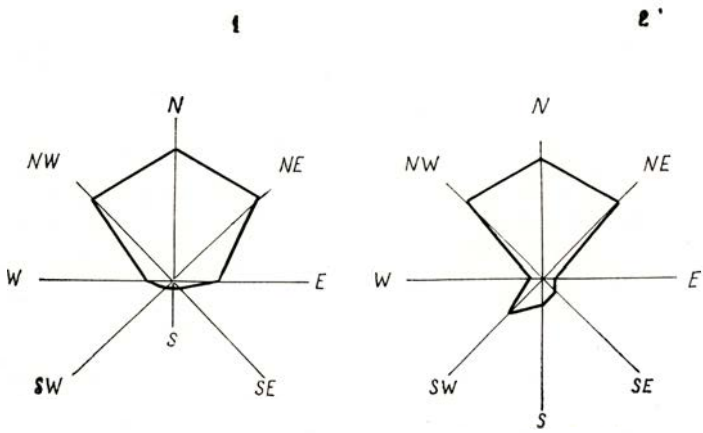

Fig. 2 — Roses of glaciers' exposition (m %%): 1- of Western Kun-Lun, 2- of Nan-Shan (for the whole mountain system, without the range Züss).

the Laohukov high altitude station (4060 above sea level), as well as the observations of the expeditions have shown that this ratio also applies to the high altitude zone, with the difference that there precipitation usually occurs in solid form (snow, hail, sleet) even during the warm season. Thus the Nan Shan glaciers are mainly fed by the precipitation of the warm season. The process in which snow is transformed into ice takes a very rapid course. In the ablation hours, thaw sets in not only in the glaciers tongues, but also in their firn basins. Yet the thawing of the firn basins yields practically no run-off, as the thaw waters penetrate to the level of constant negative temperature, which is located near the surface and freeze again. This is favoured by the drop

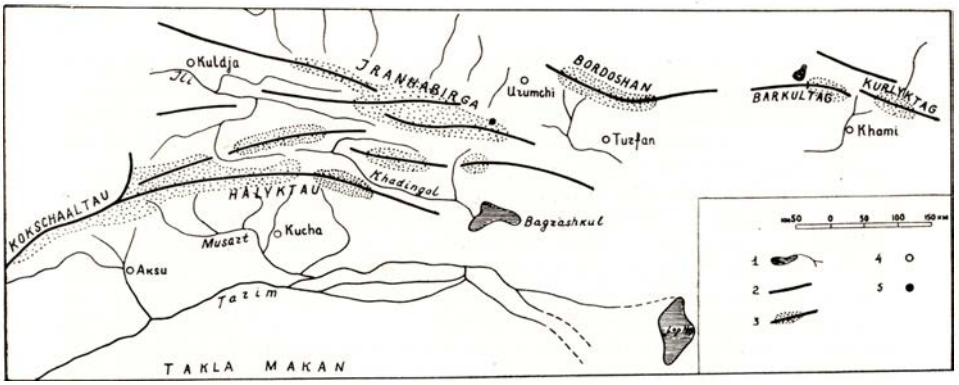

Fig. 3 — Scheme of present-day glaciation foci of Eastern Tien-Shan: 1- rivers and lakes, 2- mountain ranges, 3- foci of present-day glaciation, 4- settlements, 5- Alpine station Dasi-Kou.

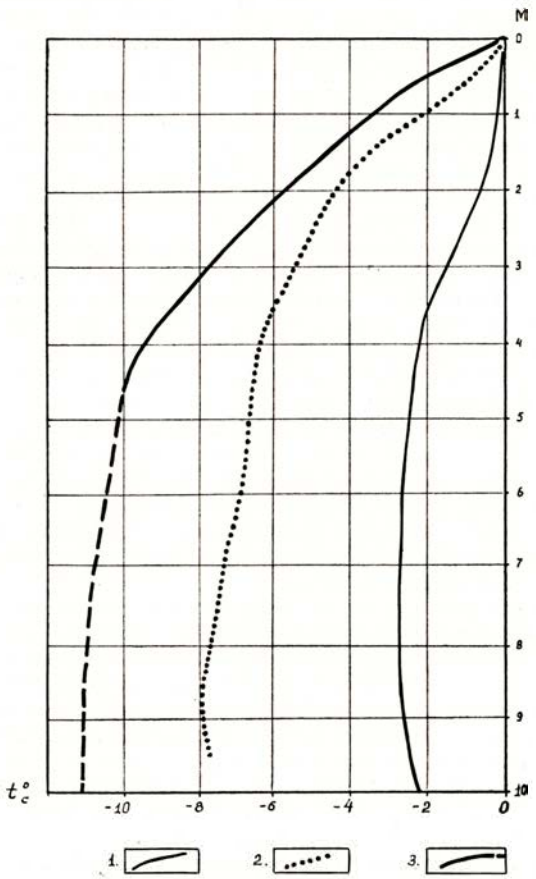

Fig. 4 — Temperature graph in the ice's thickness: 1- of Karabatak glacier in central Tien-Shan, altitude 3460 m (average data for summer periods 1948, 1949 and 1949-50 acc. to G.A. Avsjuk); 2- Glacier «Ist July») in Central Tien-Shan, altitude 4580 m, 18 July 1959, 3- of glacier no. 20 Laohukou in NW Nan-Shan, altitude 4440 m, 31 of June, 1959.

of temperature below zero, which frequently occurs at night. The frequent repetition of this process alternating with snowfalls leads to the formation of a stratified layer consisting of firn and infiltration ice. In the course of one or two years the ice streata replace the firn almost entirely. Therefore the Nan Shan glaciers consist of ice almost entirely, not only on the tongues, but in the firn basins.

The glaciers of Eastern Tien Shan differ considerably from those of Nan Shan. The glaciation area of the Eastern Tien Shan exceeds 1 700 km^2, with an estimate amount of water equalling about 100,000,000,000 m^3. The Tien Shan range forms complex ramifications and outcrops and rises to an altitude of 5000-7000 metres. The situation of the Tien Shan mountain system in the sphere of influence of the Atlantic determines the lower level of the snow line and leads (in combination with orographic conditions) to the formation of glaciers distinguished by larger size and belonging to a different type. Apart from the types of glaciers found in the Nan Shan, Tien Shan glaciers are often of the complex valley type, with scores of tributaries and a length of 20-30 km. The area of Karagul, the biggest of these glaciers constitutes 90 km^2 (without the avalanche spots from which it is fed). The tongue of the glaciers are encumbered by moraines over a distance of many kilometres. They abound in fissures, thermo-karst precipices, lakes and other signs pointing to degradation processes. Considerable parts of the tongues have become areas of dead ice. The valley glaciers in the terminal parts of the tongues have no surface run-off of thaw waters: under-ice and intraglacier run-off predominate. Out of the cave of a glacier a river of considerable size often takes origin. The stream which issues from the cave of Karagul glacier had in July 1959 a mean monthly discharge of 26.5 m^3 per second, the maximum discharge being 50 m^3 per second. The ablation of the glaciers in the Eastern Tien Shan mountains considerably exceeds that of the Nan Shan glaciers, a fact which is accounted for by the extremely low hypsometric position of their tongues with regard to the snow line (the ends of the glaciers Karagul, Muzart and Tugbelich on the south-eastern side of the Khan-Tengri massif descend respectively to 2920, 2730 and 2780 m, the snow line being situated at an altitude of 4150 m). The great negative difference in glaciation is determined by the tremendous development of the gorges and precipices, and, in this connection by the predomination of avalanche reinforcement to the glaciers from the surrounding slopes.

The intensity of glaciation in Eastern Tien Shan drops in the direction from West to East, in accordance with the increasing aridity of the climate in the same direction. The Tien Shan ranges lying in the extreme East of the system (Kurlyk-tag, Barkultag) are closer in type to the western Nan Shan than to the eastern Tien Shan in the glaciation areas, the types of glaciers and their regimen.

As far as it is possible to judge from the scant data published, the glaciation of the northern ranges of the Kun Lun is also closer in its main characteristics to the south-western part of the Nan Shan.

Comparing the glaciation of the inland mountains of Central Asia with that of the surrounding periphereal ranges, we find some essential features of difference between them. These differences find expression in the regular rising level of the snow boundary from the periphery towards the inland parts of Central Asia; the drop in the intensity of ablation and accumulation processes (and consequently the energy of glaciation) in the same direction; in the lower temperature regimen of the Central Asia glaciers; in the predominating surface run-off of thaw waters in the glaciers of the inland mountains of Central Asia, and in the lower regularity of the run-off in the glacier-fed rivers of Central Asia (inland) compared with these of the periphereal ranges. The morphological differences are also essential. All this makes it possible to raise the question of singling out a special Central Asian continental glacier province, including the glaciers of the Nan Shan (with the exception of its south-eastern part, which is in the sphere of influence of the pacific monsoon), those of the Kun Lun, the

Altyn-tag and the ranges of the eastern part of the Tien Shan. We leave open the question of the inner areas of the Tibetan highlands as there are no data on its modern glaciation.

The continental Central Asian glacier province borders in the West on the subcontinental Atlantic province (Central and Western Tien Shan, Pamirs- Altai, Altai, etc.); in the East on the subcontinental Pacific province (Eastern Nan Shan, the eastern borderline ranges of the Tibet); on the South, with the Indian monsoon province (Himalayas, Karakorum).

The modern stage in the evolution of Central Asian glaciers is distinguished by their retreat everywhere. The intensity of this retreat is greatest in the region of Mount Khan-Tengri in the Tien Shan and lowest in the north-western part of the Nan Shan, on Ema-shan range, where stationary and even advancing glaciers are found alongside retreating ones. Yet in the Nan Shan and especially in the Tien Shan, degradation processes obviously predominate. In the last fifty years, for instance, the Muzart glacier (region of Khan-Tengri) has retreated 560 m, according to verbal information and geomorphological indications. In the terminal part of its tongue, it has become thinner by 30 or 40 m over a distance of several kilometres.

Ancient glaciation was considerably more extensive and the ice sheet was thicker than in the present-day process. Traces of ancient glaciation (lateral and terminal moraines and geomorphological signs) are found in the Nan Shan up to an altitude of 2900-3900 m; in the Kun Lun, up to 3600 m; and in the Tien Shan (region of Khan Tengri) up to 1900 m. Glaciers sheets of the Scandinavian type, covering the "Syrts" of the Tien Shan and the Nan Shan were widespread. Large valley glaciers descended in spots to the bottom of the depressions between the mountains and to the sloping plains of the foothills, where they formed glaciers situated at the foot of the mountains. Yet ancient glaciation was less gigantic than imagined by some of the explorers (Sinitsyn, 1959). Field observations and aerial photography show that many of the longitudinal inter-mountain valleys of the Nan Shan were filled with glaciers only partly, in their most elevated central parts (such is the case with the valleys of the rivers Tatung-ho, peitaho and Suleho which were filled with ice in their upper reaches situated close to each other, but had only scattered small foothill glaciers near the mouths of the lateral troughs in the periphereal parts). For instance, the ancient glaciers descending from the Lenglungling range along the valley of the Ganshiga river, came out into the bottom of the wide trensversal Peishui-ho valley, ending in a wide and short tongue at the altitude of 3050 m, at a distance of 10 km from the ends of the modern glaciers situated in the upper reaches of the river Ganshiga. Hypsometrically it was situated 850 m lower than these glaciers. On the terminal moraine of this ancient glacier a thick soil cover was formed, with a luxuriant steep vegetation. There are indirect indications to the effect that the retreat of the glaciers began about 5000 years ago. On the northern slope of the Tolai-shan range, ancient glaciers descended to the 2900 m mark in the basin of the Peitah river. They have left behind stone moraines lying on the intact surface of losse-like loam, on top of the pro-alluvial deposits. Present day suspended glaciers on the slopes of the ancient circular mountain wall are situated at a distance of 5-6 km from this spot, at an altitude of 4200 m.

In the Tien Shan, the ancient glaciers descended still lower. For instance the Muzart (on the eastern side of the Khan-Tengri massif) was an extremely complex huge valley glaciers which had a length of almost 100 km. It came out into the valley to an elevation of 1900 m, forming a wide (8 × 8 km) tongue. The glaciers of the northern slope of the Kurlyktag range also reached the foothills at an altitude of 2100 m.

The materials collected permit us to speak at most of two strictly different stages of ancient glaciation.

The traces of the reduction of present-day glaciation are numerous and testify to several (3-5 or more) stages or retreat repleced at times by advance movements.

LITERATURE

Map of the Nan Shan drawn by V.I. ROBOROVSKY and P.K. KOZLOV, 1893-1895. Appendix to the works of the RGO expedition to Central Asia in 1893-1895, pp. 1 and 2, St. Petersburg, 1900.

V.A. OBRUCHEV. Signd of the glaciation period in Northern and Central Asia, *Bulletin po izuch. chetvert. perioda*, no. 3, 1931.

G. SOBOLEVSKY. Modern and ancient glaciation in Western Kung Lun — *Izvestia RGO*, vol. 124, 1918, issue I, Petrograd, 1913.

V.M. SINITZYN. Central Asia. Geographical Publishing House, Moscow, 1958.

L.D. DOLGUSHIN. Modern glaciation in the Nan Shan. Izvestia Academii Nauk. geogr. series, no. 6, 1959.

Report of the expedition for the study of modern glaciers in the Nan Shan. Col ection of articles no. 1 Scientific Publishing House of the Academy of Sciences of the Chinese People's Republic 1959 (in Chinese).

G.A. AVSJUK. Ice temperatures in the glaciers. Publications of the Geographical Institute of the USSR Academs of Science, N67 (5), 1956.