*Annals of Glaciology* 16 1992


# Characteristics of the distribution of glaciers in China

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ABSTRACT. About 80% of the glaciers in China have been inventoried. Based on the inventory and an estimate of the area that has not been inventoried, there are about 45 375 glaciers in China, with a total area of 58 735 $km^2$ and an ice volume of about $5.31 \times 10^{12}$ $m^3$. These glaciers are widespread in high mountains and in highland areas in western China, between 27°06′ to 49°09′ N and 71°32′ to 103°54′ E. The glacierized area in China comprises about 16% of the alpine glacier area in the world, and 47% of that in Asia. There are about 230 large glaciers, with areas exceeding 100 $km^2$, in the world outside Antarctica and Greenland. Among them, 65 (28%) are in Asia and 31 (13%) in China.

## 1. RELATIVE GLACIER AREA IN VARIOUS MOUNTAINOUS REGIONS

Table 1 gives the distribution of glaciers in various mountainous regions in China (Fig. 1), and Table 2 provides statistics on the largest of the glaciers. Only those parts of the glaciers that lie within the territory of China are included.

*Table 1. Statistics on the number of glaciers in various glacierized areas*

| *Mountainous region (1)* | *Mountainous area* | *Highest peak* | *Number of glaciers* | *Glacierized area* | *Ice volume* | *Snowline* | *Relative glacier area* | *Mean glacier area* | *Glacierized ratio* |
|---|---|---|---|---|---|---|---|---|---|
| | $km^2$ | m a.s.l. | | $km^2$ | $10^8$ $m^3$ | m a.s.l. | % | $km^2$ | % |
| Altay | 28 800 | 4374 | 403 | 280 | 159 | 2800–3350 | 0.48 | 0.69 | 0.97 |
| Tarbagatay | 4400 | 3835 | 21 | 17 | 7 | 3310–3380 | 0.03 | 0.80 | 0.38 |
| Tien Shan | 211 900 | 7435 | 9128 | 9257 | 10 122 | 3620–4450 | 15.76 | 1.01 | 4.37 |
| Pamirs (2) | 23 800 | 7649 | 1823 | 2623 | 2176 | 4400–5860 | 4.47 | 1.44 | 11.10 |
| Karakoram (3) | 26 600 | 8611 | 1926 | 4769 | 6114 | 4900–6010 | 8.12 | 2.48 | 15.64 |
| Kunlun | 478 100 | 7167 | 7615 | 12 263 | 12 857 | 4500–6080 | 20.87 | 1.61 | 2.56 |
| Altun | 56 300 | 6295 | 229 | 266 | 151 | 4800–5360 | 0.45 | 1.16 | 0.47 |
| Qilian | 132 500 | 5827 | 2815 | 1930 | 935 | 4300–5160 | 3.29 | 0.69 | 1.46 |
| Qiangtang Plateau (4) | 441 900 | 6822 | 2283 | 3355 | 2739 | 5700–6200 | 5.71 | 1.45 | 0.76 |
| Tanggula range (5) | 141 300 | 6621 | 1570 | 2206 | 1264 | 5300–5800 | 3.76 | 1.41 | 1.56 |
| Gandise range (5) | 158 300 | 7095 | 2982 | 1615 | 635 | 5000–6200 | 2.75 | 0.54 | 1.02 |
| Nyainqêntanglha range (5) | 110 600 | 7162 | 3900 | 7536 | 4900 | 4200–5700 | 12.83 | 1.93 | 6.81 |
| Himalayas (6) | 202 500 | 8848 | 9000 | 11 000 | 10 000 | 5400–6250 | 18.73 | 1.22 | 5.43 |
| Hengduan | 356 300 | 7556 | 1680 | 1618 | 1070 | 4600–5100 | 2.75 | 0.96 | 0.45 |
| Total | 2 373 300 | 8848 | 45 375 | 58 735 | 53 129 | 2800–6250 | 100.00 | 1.29 | 2.47 |

Remarks: (1) Divided according to Chinese glacier inventory (Wang, 1988). For the transnational regions only those parts in the territory of China are accounted (the same below).
(2) Exclusive of data in the disputed area between China and former Soviet Union.
(3) Exclusive of data in source of Shiyork River.
(4) Exclusive of data in eastern tributary of Indus and source of Shiquan River.
(5) Parts are accounted by inventory, the rest are estimated on air photographic maps.
(6) Estimated on air photographic maps and Landsat images.



https://doi.org/10.3189/1992AoG16-1-17-20 Published online by Cambridge University Press

Table 2. Data on large glaciers in China

| No | Glacier | Mountainous region | Nearest mountain peak and its altitude | Length | Area | Snowline | Altitude of glacier front | Morphological type of glacier |
|---|---|---|---|---|---|---|---|---|
| | | | m a.s.l. | km | $km^2$ | m a.s.l. | m a.s.l. | |
| 1 | Mainbari | Himalayas | Kamit (7730) | 15.0 | 130.00 | 5750 | 5100 | Valley |
| 2 | Qiaqing | Nyainqêntanglha | 6356 | 35.0 | 151.50 | 4510 | 2530 | Valley |
| 3 | Jiangpu | Nyainqêntanglha | 6382 | 21.0 | 132.70 | 4495 | 3160 | Valley |
| 4 | Tanggulha | Tanggulha | Mt Tanggulha (6099) | 17.0 | 188.00 | 5720–5740 | 5380–5420 | Ice cap/valley |
| 5 | Jingyanggangri | Qiangtang Plateau | Jingyanggang (6136) | 12.0 | 105.30 | 5340–5540 | 5120–5950 | Small ice cap |
| 6 | Tuzegangri | Qiantang Plateau | Mt Tuzegang (6356) | 21.0 | 127.20 | 5740–5940 | 5380–5950 | Small ice cap |
| 7 | Zangsergangri | Qiangtang Plateau | Mt Zangser (6508) | 29.0 | 191.60 | 5740–5940 | 5260–5930 | Small ice cap |
| 8 | Purongangri | Qiantang Plateau | Mt Purog (6482) | 30.0 | 263.40 | 5660–5820 | 5300–5800 | Small ice cap |
| 9 | Malan | Hohxili | Mt Malan (6056) | 25.0 | 172.80 | 5340–5630 | 4971–5204 | Small ice cap |
| 10 | Chongce | Kunlun (south) | Mt Kunlun (7167) | 28.7 | 163.06 | 6120 | 5320 | Wide-terminus |
| 11 | Gongxing | Kunlun (south) | Mt Kunlun (7167) | 20.5 | 113.80 | 5940 | 5360 | Highland valley |
| 12 | Zhongfeng | Kunlun (south) | Mt Kunlun (7167) | 23.4 | 241.00 | 5965 | 5400 | Highland valley |
| 13 | Keliya | Kunlun | Mt Kunlun (7167) | 12.4 | 119.33 | 6100 | 5500 | Flat topped |
| 14 | Muztag | Kunlun | Mt Muztag (6973) | | 240.00 | 5500 | 5100–5350 | Small ice cap |
| 15 | Yulong | Kunlun (north) | Mt Kunlun (7167) | 30.9 | 137.07 | 6020 | 5140 | Valley |
| 16 | Duofeng | Kunlun (north) | Mt Kunlun (7167) | 31.0 | 251.70 | 5760 | 4590 | Branched valley |
| 17 | Kunlun | Kunlun (north) | Mt Kunlun (7167) | 23.6 | 200.02 | 5920 | 4882 | Valley |
| 18 | W. Yulong | Kunlun (north) | Mt Kunlun (7167) | 21.9 | 125.86 | 5900 | 5140 | Valley |
| 19 | W. Kunlun | Kunlun (north) | Mt Kunlun (7167) | 18.5 | 131.78 | 5900 | 5120 | Valley |
| 20 | Yengisogat | Karakoram | Mt Kalang (7295) | 42.0 | 379.97 | 5420 | 4000 | Branched valley |
| 21 | Muztag | Karakoram | Mt of No Name (7410) | 29.4 | 196.76 | 5230 | 4100 | Turkistan valley |
| 22 | Taram Kangri | Karakoram | Mt Taramkangri (7441) | 28.0 | 124.53 | 5390 | 4520 | Turkistan valley |
| 23 | Gashelolum | Karakoram | Mt Bulod (8501) | 26.0 | 119.80 | 5540 | 4250 | Turkistan valley |
| 24 | Kyagir | Karakoram | Mt Apusalasesi (7243) | 20.8 | 105.60 | 5420 | 4760 | Turkistan valley |
| 25 | Chemurke | Pamirs | Mt Gongar (7649) | 20.5 | 106.81 | 4808 | 3500 | Valley |
| 26 | Tomur | Tien Shan | Mt Tomur (7435) | 41.5 | 337.85 | 4350 | 2780 | Turkistan valley |
| 27 | Qongterarg | Tien Shan | Mt Tomur (7435) | 23.8 | 165.38 | 4300 | 3038 | Turkistan valley |
| 28 | Tukbiniqi | Tien Shan | Mt Tomur (7435) | 36.1 | 313.69 | 4200 | 2680 | Turkistan valley |
| 29 | Wukor | Tien Shan | Mt Hantangri (6995) | 32.4 | 184.95 | 4240 | 2790 | Turkistan valley |
| 30 | Muzart | Tien Shan | Mt Xuelian (6627) | 33.0 | 137.70 | 4220 | 2950 | Turkistan valley |
| 31 | Inylchek | Tien Shan | Mt Tomur (7435) | 63.5 | 392.84* | – | 2900 | Turkistan valley |

* Glacier area within the territory of China only.



https://doi.org/10.3189/1992AoG16-1-17-20 Published online by Cambridge University Press

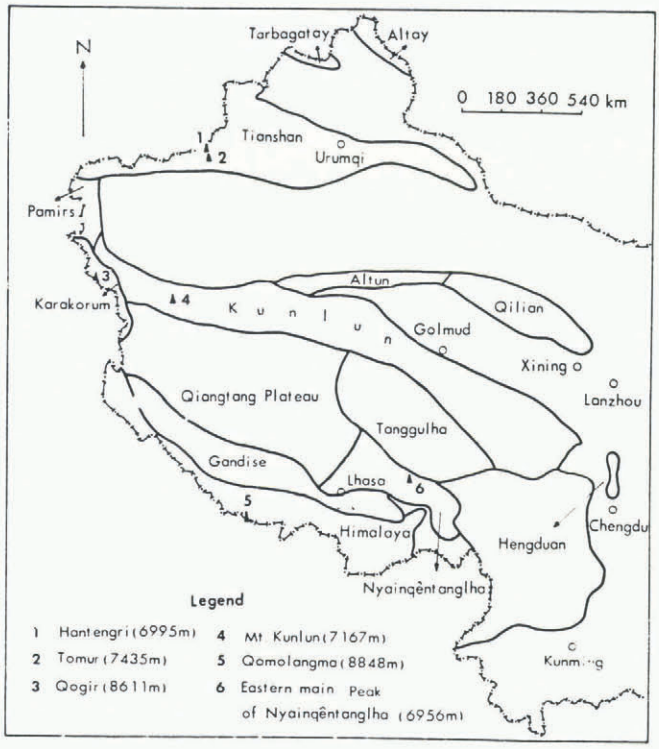


*Fig. 1. Map showing the mountainous regions and main peaks in western China.*

In Table 1, relative glacier area is the glacierized area in a region divided by the total glacier area in the country. This provides a comparative measure of the glacierized area in various mountain masses.

The figures in Table 1 indicate that many glaciers develop in the Kunlun mountains, the Himalayas, the Tien Shan mountains, the Nyainqêntanglha range, and the Karakoram mountains. There are about 44 800 $km^2$ of glacierized area in these five mountainous regions, making up 76.3% of the glacierized area of China. Of 31 large glaciers with areas more than 100 $km^2$, 24 are located in these regions (Table 2). In these regions, furthermore, glaciers are concentrated in five large centres (Fig. 1), namely, the Mount Qogir area of the Karakoram mountains, the Mount Hantengri–Tomur area of the Tien Shan mountains, the Kunlun Peak area of the Kunlun mountains, eastern main peak area of the Nyainqêntanglha range, and the Mount Qomolangma (Everest) area of the Himalayas.

In the Mount Qogir area, there is a total of 8000 $km^2$ of glacierized area, of which 2300 $km^2$ is located in the territory of China, and there are five large glaciers, including Yengisogat Glacier, the largest one in China, with a length of 42 km and an area of 379.97 $km^2$. In the Mount Hantengri–Tomur area, the glacierized area is more than 5000 $km^2$, also including five large glaciers, with an area of 2808 $km^2$ in the territory of China. In the Kunlun Peak area, there is about 4000 $km^2$ of glacierized area with nine large glaciers. Here is the largest glacier centre completely located within the territory of China. In the eastern main peak area of the Nyainqêntanglha range, there is about 3700 $km^2$ of glacierized area with two large glaciers. Here is the largest maritime glacier region in China. In the Mount Qomolangma area, the entire glacierized area is ~1976 $km^2$, of which 772 $km^2$ is within the territory of China. The total glacierized area in these five centres is 14 000 $km^2$, making up 31% of the glacierized area in the five mountainous areas mentioned above. Of 24 large glaciers developed in these five areas, 21 are located in these glacier centres.

## 2. MEAN GLACIER AREA IN VARIOUS MOUNTAINOUS REGIONS

Mean glacier area, which can be used as a measure of glacier scale, is the total area divided by the number of glaciers in a mountainous area. As shown in Table 1, the mean glacier area is 1.29 $km^2$ in China. There are six mountainous areas with the mean glacier areas more than 1.29 $km^2$. They are the Karakoram mountains, the Nyainqêntanglha range, the Kunlun mountains, the Qiangtang Plateau, the Pamirs, and the Tanggula range. The mean glacier area is smaller in the Altay mountains, Qilian mountains and Gandise range. The distribution of mean glacierized areas is not identical with that of relative glacierized areas. For example, the relative glacierized area is 0.48% in the Altay mountains, which is much larger than the value of 0.03% in the Tarbagatay mountains, but the mean glacierized area in the Altay mountains is 0.69 $km^2$, which is close to the value of 0.8 $km^2$ in the Tarbagatay mountains. The relative glacierized area is 20.87% in the Kunlun mountains, the maximum in China, and is about 8.12% in the Karakoram mountains. However, the mean glacierized area is as large as 2.48 $km^2$ in the Karakoram mountains, which is much larger than the value of 1.61 $km^2$ in the Kunlun mountains.

## 3. GLACIERIZED RATIO IN VARIOUS MOUNTAINOUS REGIONS

The glacierized ratio is defined, in this paper, as the glacier area divided by the area of the mountain. This can be used to evaluate the concentration of glaciers in a mountainous area. The area of the mountains can be calculated by the following methods: when the outline of the mountain is clear and compact, as in the Altay and Tien Shan mountains, the area is bounded by the break in slope at the base of the range; when the mountains are composed of several ranges like the Himalayas, the area is calculated from the break in slope of the outermost range; when the area is in a plateau, as in the Qiangtang Plateau, the whole plateau, including some of the area of the valleys and lake basins, is included.

The mean glacierized ratio is 2.47%. There are six regions having glacierized ratios greater than 2.47%. They are the Karakoram mountains, the Pamirs, the Nyainqêntanglha range, the Himalayas, the Tien Shan mountains, and the Kunlun mountains (Table 1). In the five large glacier centres mentioned above, the glacierized ratio becomes larger: 45.7% in the Mount Qogir area, 30.7% in the Hantengri-Tomur area, 19.5% in the eastern main peak area of Nyainqêntanglha, and 14.1% in the Mount Qomolangma area.



https://doi.org/10.3189/1992AoG16-1-17-20 Published online by Cambridge University Press

Glacierized ratio is not entirely coincident with the relative glacier area. The maximum relative glacier area is in the Kunlun mountains, for example, while the maximum glacierized ratio is in the Karakoram mountains. Also, glacierized ratio does not completely coincide with mean glacier area. The minimum glacier area is in the Gandise range, while the minimum glacierized ratio is in the Tarbagatay mountains.

It is clear that one of the three indices (relative glacier area, mean glacier area, and glacierized ratio) or the glacierized area on its own account, represent only one aspect of the distribution of glacier area in a mountainous region. For instance, the relative glacier area is 8.12% in the Karakoram region, which is the fifth highest among the 14 mountainous regions in China, but the mean glacier area here is 2.48 $km^2$, and the glacierized ratio is 15.6%. Both of the latter are maximum values in China. Similarly, the total glacier area in the Karakoram mountains is not particularly large, but the glaciers themselves are large in scale, with the highest concentration of large glaciers in China.

Generally speaking, glacierized ratio is more important than relative glacier area or mean glacier area. The larger the glacierized area, for example, the higher potential for utilization of glacier meltwater, the greater the influence on local climate, and the greater the problems caused by glacier floods and debris flows. With increasing glacierized ratio, the importance of glaciers to human activities increases in significance.

## 4. CONCLUSIONS

Glaciers in China are distributed inhomogeneously in and among the various mountainous areas. They are concentrated in a few mountainous regions, especially in five large glaciated centres. Analyses using the relative glacier area, mean glacier area, and glacierized ratio indices contribute to our understanding of potential for utilization of glaciers and for problems related to glaciers.

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https://doi.org/10.3189/1992AoG16-1-17-20 Published online by Cambridge University Press