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THE SCOTTISH GEOGRAPHICAL MAGAZINE.

SOME NOTES ON GLACIAL PHENOMENA IN THE NORTH-JAPANESE ALPS.

By PROFESSOR K. OSEKI.

(*With Sketch-map and Diagrams.*)

FOR about twenty years our Japanese Alps have been well known to journalists and geographers, not only in Japan but also throughout the world, especially because their mountains have from the scientific—notably in connection with topography and glaciology—and literary points of view similar interesting characters to those of the European Alps. There is much difference of opinion regarding the occurrence of an Ice Age in Japan. In 1903 N. Yamasaki, Professor of Geography in the University of Tōkyō, believed that he had recognised traces of glaciation, moraines, and glacial striae in the North-Japanese Alps;¹ but M. Yokoyama, the palæontologist of Tōkyō, found no remains of a fauna indicating cold climatic conditions in the quaternary deposits in the vicinity of the Bay of Tōkyō, and in consequence he denied that the occurrence of a glacial period could be established.² K. Jimbō, the well-known mineralogist of the University of Tōkyō, has, in the geological conferences of the University of Tōkyō, repeatedly stated that all the phenomena on which Yamasaki based his conclusions could be regarded as having been produced by weathering. The Japanese alpinists, *e.g.* Tujimura,³ on the other hand, have accepted the theories of Professor Yamasaki, and have frequently described corries, moraines, and other

¹ *Journal of the Geological Society of Tōkyō*, vol. ix., 1903. (Japanese.)

² "Climatic Changes in Japan since the Pliocene Epoch." *Journal of the College of Science, Tōkyō*, vol. xxxii., art. 5, 1911.

³ "Were the Cirques in Japan formed by Glaciers?" *Journal of the Geological Society of Tōkyō*, vol. xx., No. 238-239, 1913. (Japanese.)

Sketch-map of the North-Japanese Alps.

1. Shirouma Lake, 2033 m.	10. Higashi Tenjō Lake, 2811 m.
2. Tsurugigatake, 2998 m.	11. Yariyatake, 3178 m.
3. Oyama, 2992 m.	12. Hodaka Lake, 3103 m.
4. Harinoki Lake, 2820 m.	13. Nakao Pass, 2094 m.
5. Harinoki Pass, 2541 m.	14. Iwō Lake, 2458 m.
6. Yakushi Lake, 2986 m.	15. Abō Pass, 1583 m.
7. Kuro Lake, 2970 m.	16. Norikura Lake, 3026 m.
8. Gorō Lake, 2924 m.	17. Ontake, 2185 m.
9. Otenjō Lake, 2922 m.	

signs of glaciation. Yokoyama's views have been laid before the German public by Lepsius,¹ while Penck has identified corries and terminal moraines in photographs of the North-Japanese Alps which I have submitted to him.² H. Simotomai also has described recognisable evidence of glaciation from views of the North-Japanese Alps.³ For my own part, I have four times had opportunities of examining the North-Japanese Alps, and have observed indubitable glacial phenomena on certain peaks. At the suggestion of Professor Penck I shall proceed to describe these briefly.

The North-Japanese Alps, or the Hida Mountains (see sketch-map), form the eastern marginal range of the Hida Plateau, which has an elevation of about 1000 m., and is the highest plateau of the Japanese islands. The rocks of the Hida Mountains and of the plateau have the same strike, from S.W. to N.E. in the south, while farther to the north they strike more towards the east; this strike cuts obliquely across the long axis of

FIG. 1.—Iwō Dake.

(Sketch made Aug. 25, 1912, when direction of vapour was S. 75° W.)

the mountain range, which is north and south. Both in a geological and in a topographical sense the Hida Mountains can be divided into two parts: a southern, principally volcanic, and a northern, which is composed mostly of palæozoic rocks. The line of division can be drawn through the Abo Pass, which is only 1583 m. high, and forms a deep incision in the mountain range. Volcanic mountains are confined to the southern portion of the North-Japanese Alps, with the exception of the lofty mountain Iwō Dake (Fig. 1), an active volcano 2458 m. high. If we include Iwō Dake also in the southern portion of the North-Japanese Alps, it is necessary to draw the division line through the Nakao Pass, which is 2094 m. high, and is not a conspicuous depression in the Alpine chain. On the surface of the much eroded palæozoic plateau in the southern area of the North-Japanese Alps there stands a group of volcanic cones, running in a north and south direction, the Norikura

¹ "Keine diluviale Eiszeit in Japan." *Geologische Rundschau*, iii. 1912, s. 157.

² "Die Formen der Landoberfläche und Verschiebungen der Klimagürtel." *Sitzungsberichte der königlich preussischen Akademie der Wissenschaften*, iv. 1913.

³ "Die diluviale Eiszeit in Japan." *Zeitschrift der Gesellschaft für Erdkunde zu Berlin*, 1914, No. 1.

Group. The northern area of the North-Japanese Alps, on the other hand, has a greater elevation, and there are comparatively few traces of recent volcanic rocks. The name North-Japanese Alps is strictly applicable only to the northern part of the Hida Mountains, as only there have the scenery, the climate, and the flora a truly Alpine character.

In this region the most striking feature is the steep and precipitous easterly declivity; on this side lies the great Japanese trough, the fossa magna of Naumann, which, trending in a N.N.W. and S.S.E. direction, separates the two great tectonic arcs of Japan. A row of volcanoes, the Fuji chain, is connected with this depression, while on its margins are uplifted blocks forming various types of horst mountains.

The eastern slopes of the Hida Mountains are drained by three streams, the Hime Kawa, Takasegawa and Azusagawa. The two last-named arise in the interior, and after flowing through deeply incised valleys debouch into the Sai Kawa, which in its lower course is called the Shinanogawa. On the other side of the mountains the Jōgwanjigawa and Jinzūgawa take their origin; their valleys also are deeply eroded. The Kurobegawa flows parallel to the eastern face of the mountains to reach the Toyama Gulf. Many small streams flow from the southern part of the Hida Mountains to the Jinzūgawa and the Azusagawa, and the Kisogawa, with its tributary Mashitagawa, or Hidagawa, takes its course in a southerly direction to the Ise Gulf on the south coast.

With reference to the distribution of the different types of rock in this district, the following are the principal facts of importance. In the northern part of the area the rocks are Archæan, being mostly gneisses, but in the middle and southern parts of the Hida Mountains palæozoic rocks predominate (principally slates and hornstones), with ancient eruptive rocks such as granite, porphyry, and porphyrite. In the extreme south recent volcanic rocks occur, and they extend also into the northern part of the Hida Mountains.

In Japan there is no mountain that rises above the present snow-line. Even Fujisan, the Mount Fuji, 3778 m. high, has no permanent snow-fields. Small patches of snow last through the summer only in a few shaded and sheltered spots on the North-Japanese Alps. On the Hida Mountains the annual precipitation, mostly in the form of snow, is about 2500 mm. On the north-west side the rainfall is greater than on the south-east, where probably it is less than 2000 mm. As there are no meteorological stations in the mountains our information on these points is very incomplete; investigations of this kind have been carried out principally at some distance from the base of the mountains, as, for example, in the towns Matsumoto on the east, and Takayama on the west.

As already stated, the Hida Mountains can be divided into a northern and a southern portion. The former of these is subdivided into three parallel chains by the longitudinal valley of Kurobegawa and the aligned valleys of Takasegawa and Azusagawa. The three intervening ridges are (1) the western chain, or Tateyama chain; (2) the central chain; and (3) the eastern chain, or Otenjō chain. The central chain

is by no means straight or continuous, but consists of two ridges, between which lies the Harinoki Pass (2541 m. high). The part north of this pass might be called the Shirouma Dake Ridge, and the southern portion the Yarigatake Ridge. Accordingly we recognise the following subdivisions of the Hida Mountains:

A. Northern Hida Mountains (Main Chain).

(a) Western Chain, or Tateyama Chain.

(b) Central Chain.

1. Shirouma Dake Ridge.

2. Yarigatake Ridge.

(c) Eastern Chain, or Otenjō Chain.

B. Southern Hida Mountains (principal part of the Norikura volcanic group).

I shall now describe the evidence of glaciation and the occurrence of a glacial period in the different subdivisions of the North-Japanese Alps.

(a) *Western Chain, or Tateyama Chain.*

The Tateyama chain, in which a renowned pilgrim shrine is situated, which is a favourite resort of tourists in summer, has more than ten

FIG. 2.—View from the Tateyama Hut (Murodō), looking eastwards.
(Sketch made Aug. 23, 1904.)

peaks above 2600 m. The principal peak, though not the highest, is Oyama, 2992 m., which Professor Yamasaki and I ascended in 1904. On the western slope, at an elevation of approximately 2500 m., we found a corrie in front of which two series of terminal moraines had been deposited. Fig. 2 is reproduced from a drawing by the author of this paper. Tsujimura has also (*Journal of the Geological Society of Tokyo*, vol. xx., No. 239) given an instructive representation of the east side of the Tateyama chain up to Tsurugigatake, 2998 m., which shows clearly that this slope also is furnished with corries along its whole extent. In photographs which were taken last summer by my acquaintance, Mr. Tomono, I can recognise corries with complete certainty on

one of the Yakushi Dake. I have prepared a sketch (Fig. 3) from these photographs. It shows the east side of the ridge of Yakushi Dake

Yakushi Dake

FIG. 3.—East side of the Yakushi Dake (2986 m.).

(2986 m.) facing the valley of the Kurobegawa. Four corries are visible, side by side, their floors having an altitude of about 2800 m.

(b) *Central Chain.*

1. In the northern part of the central chain, the Shirouma Dake Ridge, there are a number of summits over 2600 m. The problem of the glaciation of this group was raised in 1903 by Professor Yamasaki's

FIG. 4.—Corrie on the east side of the Harinoki Dake.
(Sketch made Aug. 21, 1904.)

investigation of Shirouma Dake, or Hakuba Dake (that is, White Horse Mount). He found moraines and glacial striae. A year later Professor Yamasaki and I, during a journey along the eastern slope (about 2520 m.) of Harinoki Dake, found a great corrie (Fig. 4), and ascended to its

threshold, when we crossed the Harinoki Pass. The floor of this corrie is saucer-shaped, and the very steep rock-walls of Harinoki Lake rise above it on the western side. We did not observe any glacial striae during our hurried visit.

2. The summit peaks of the Yarigatake Ridge are higher than

FIG. 5.—Corrie on Gorō Lake. (Sketch made Aug. 22, 1904.)

those of the other group, and mostly have an elevation exceeding 2900 m. On Gorō Lake (2924 m.) Professor Yamasaki and I in 1904 saw a great corrie facing west, with a floor about 2540 m. level according to the provisional General Staff Chart (1:50,000). Fig. 5 repro-

FIG. 6.—The east slope of Kuro Lake.

duces one of my drawings of this corrie, but unfortunately we were not able to enter it. Subsequently alpinists have discovered corries and moraines on other mountains. Fig. 6, from a photograph by Mr. Tomono, shows the east slope of Kuro Lake (2970 m), one of the peaks of a chain not far from Gorō Lake, and running parallel to it towards the north, separated by the valley of Higashizawa, a lateral valley of the Kurobegawa valley. In the centre of the view there is a great corrie, the floor of which descends by steps. From the chart I estimate the altitude at 2800 m. On the left there is a smaller corrie, on the right a

larger one, with a steep south side rising like a wall. The view is taken from the great corrie of Goro Dake, already described, on the other side of Higashizawa.

Professor Penck has discussed the evidence of glaciation on the Yarigatake (3178 m.), which lies farther to the south. An inspection of the Yarizawa valley in the upper course of the Azusagawa, under the south-eastern slope of Yarigatake (the Spear Peak), reveals a ridge strewn with blocks which, according to Professor Penck, can be only a terminal moraine. Extensive snow-fields occur farther to the south in the group of jagged peaks known as Hodaka Dake (the highest summit, Oku-Hodaka Dake, rising to 3103 m.). Such snow-fields are not limited to this area, but very often occur also on the other high mountains in the North-Japanese Alps. For this reason we may also expect to find evidence of former glaciation.

Up to the present no traces of glaciation have been found in the eastern chain of the Hida Mountains which culminates in Otenjō Dake (Great Tenjō Dake), 2922 m. high. The Japanese General Staff Chart shows distinct corries on Higashi-Tenjō Dake (that is, eastern Tenjō Dake). In the southern Hida Mountains, also, where the volcanoes Norikura Dake (3026 m.) and Ontake (3185 m.) are situated, no evidence of glaciation is as yet known.

SUMMARY AND CONCLUSION.

1. Up to the present time evidences of glaciation in Japan have been obtained only from the occurrence of corries and morainic ridges in the northern Hida Mountains. Alpinists believe that in the South-Japanese Alps (the Akaishi Mountains and Kiso Mountains) the highest peak of which, Akaishi San, has an altitude of 3092 m., traces of glaciers have been detected, but I cannot confirm this from my own observations.

2. The traces of glaciation in the northern Hida Mountains are not very striking. During the glacial period small hanging glaciers must have descended to a level of about 2500 m. above the sea.

3. Moraines with striated boulders, striated surfaces, and roches moutonnées have hitherto not been identified with certainty in the corries. At the lowest point the elevation of the corrie-floors is about 2500 m. above sea-level, and it is to be assumed that this was the altitude of the snow-line during the glacial period. This is in accordance with the conclusions arrived at by H. Simotomai. As the highest peak of the mountain chain (Yarigatake, 3178 m.) does not reach the snow-line of the present day, we must conclude that the depression of the snow-line during the glacial period was not less than 700 m.¹

¹ I learn from Japan that Professor Hettner found a large striated block of biotite granite in 1913. It occurs on the banks of the Azusagawa, at an altitude of about 800 m., at the eastern base of the Hida Mountains, in a deposit of stones. Very evident striae may be seen in a photograph of this "Hettner Rock," which has been sent me by Professor T. Kato in Tōkyō. If these are really of glacial origin we must conclude that a valley glacier, 40 km. long, must have occupied the valley of the Azusagawa. This is a far greater glacier than any that has hitherto been proved to have existed in Japan. Otherwise we must be prepared to believe in a transport of glacial blocks by floods, such as we can only regard as very exceptional.