47. *Geomorphology of the Japanese High Mountains.*

(*Second Report*)

Approximate Height of the Climatic Snow-line in the Ice Age.

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There are four different opinions on the height of the climatic snow-line in the Ice Age of Japan. In the first place, there are some who endeavour to fix the climatic snow-line so high that no part of Japan, they say, ever experienced any glacier at all. There is another school¹⁾ that insists upon a very low climatic snow-line; namely, at the height of 700 metres in Central Japan, an opinion entirely opposite to the foregoing. According to this opinion, almost all parts of Japan proper were covered by a gigantic ice sheet; lately, the propounders of this theory have been putting the past climatic snow-line lower and lower, the latest report being an astonishingly low one of 200 metres in Northern Japan.

A third opinion, chiefly worked out by Yamasaki,²⁾ places the Quaternary climatic snow-line at the height of 2550 metres in the Northern Japanese Alps. This opinion is based mainly upon the fact that the so-called cirques have their lowest points at about this altitude. Still another opinion, a modification of the foregoing one, was recently proposed.³⁾ This states that the rough accordance of the height of the cirques is the result of the existence of a pre-glacial erosion surface, so that the Quaternary snow-line determined by Yamasaki is nothing but the height of the average topographical snow-line. This new theory is supported by the results of an investigation of animal distribution and by the fact that the so-called glacial cirques in Central Japan are not so deeply carved as those of a real glaciation.

Such a chaos of opinions may be attributed to the difficulty of recognizing the glacial and fluvio-glacial deposits in the field on one hand, and to an insufficient study of the landforms produced by glacial sculpture on the other. But we may be allowed to find the approximate position of the past climatic snow-line by treating other available data by means of a method of interpolation.

1) Ogawa, T.: On the Pleistocene Glaciation of Central Japan. Proc. **8** (1932), 12.

2) summarized in: Yamasaki, N.: Glaciation of the Mountains of Japan. Amer. Jour. Sc. 5th. Ser. **3**, 1922.

3) Imamura, G. and Okayama, T.: Geomorphology of the Japanese High Mountains (First Report). Proc. **9** (1933), 624.

Thanks to elaborate investigations,¹⁾ we have quite a number of observations on the height of the Quaternary climatic snow-line at least in the Northern Hemisphere. These are arranged in such a way that, in Table I, are listed those regions that are thought to have been comparatively arid during the Ice Age, and, in Table II, those regions having a rather humid climate during the same epoch. The influence of climate upon the height of snow-line has not hitherto received deserved attention of scholars so the present study may be called one of the first efforts to approach the problem from this point of view. Although this classification is not an exact one, it will answer the purpose well enough. In the course of the present investigation if a local fluctuation was met, it was averaged off: but those fluctuations which could be explained as the result of the difference in climatic regions were treated independently.

TABLE I.

Height of the Quaternary Snow-line in Arid Regions.

Region	No.	Latitude	Height of Snow-line	Remark
West Sajan	1	53	1650 (?)	
North Altai	2	52	1500	
Riesengebirge	3	51	1200	
Altai (1)	4	50	2100 (?)	
Tatra	5	49	1500	
Rockies (1)	6	48	1800	
Altai (2)	7	48	2850 (?)	
Saur	8	47	1900	
Südalpen	9	46	1800	

1) Partsch, J.: Die Vergletscherung des Riesengebirges zur Eiszeit. Forsch. deut. Land. Volk. 1894. Penck, A. und Brückner, E.: Die Alpen im Eiszeitalter. 1909. Sawicki, L.: Die eiszeitliche Vergletscherung des Orjen in Süddalmatien. Zeit. Gletsch. **5**, 1911-12. Machatschek, F.: Die Depression der eiszeitliche Schneegrenze. Zeit. Gletsch. **8**, 1913-14. Dainelli, G.: Il limite delle nevi nel bacino superiore dell'Indo (Caracorum e Himälaja occidentale). Rec. Trav. J. Cvijič, 1924. Gregory, H. E.: Entdeckung von Spuren diluvialer Vereisung auf Hawaii. Die Eiszeit, 1925. Jäger, F.: Forschungen über das diluviale Klima in Mexico. Pet. Mitt. Erg. **190**, 1926. Reinhard, A.: Glazialmorphologische Studien in west- und zentralen Kaukasus. Zeit. Gletsch. **14**, 1926. Louis, H.: Die Verbreitung von Glazialformen im Westen der Vereinigten Staaten. Zeit. Geomorph. **2**, 1927. Klute, F.: Die Bedeutung der Depression der Schneegrenze für eiszeitliche Probleme. Zeit. Gletsch. **16**, 1928. Lautensach: Die eiszeitliche Vergletscherung der Sierra da Estrella. Verh. deut. Geographentag Magdeburg, 1929. Nowack, E.: Die diluviale Vergletscherungsspuren in Albanien. Zeit. Gletsch. **17**, 1929. Reinhard, A.: Über die Eiszeitspuren am Nordhange des Kitschikaltai. Zeit. Gletsch. **17**, 1929. Romer, E.: Epoka lodowa w Tatrach. Mém. Acad. Pol. Sc. Let. **1**, 1929. Obrutschew, W. A.: Die Verbreitung der eiszeitlichen Spuren in Nord- und Zentralasien. Geol. Rund. **21**, 1930. Nilsson, E.: Quaternary Glaciations and Pluvial Lakes in British East Africa. Geogr. Ann. **13**, 1931. Klebelsberg, R.: Die eiszeitliche Vergletscherung der Apennin. Zeit. Gletsch. **18-20**, 1930-32. Suter, K.: Die alte Vergletscherung des Zentral-Apennin. Geogr. Zeit. **38**, 1932. Kayser, K.: Morphologische Studien in Westmontenegro. Zeit. Ges. Erd. Berlin, 1932.

Region	No.	Latitude	Height of Snow-line	Remark
South Saigem	10	46	2750	
Rockies (2)	11	44	2600	
Caucasus (1)	12	43	2550	after Reinhard
Caucasus (2)	13	43	2650	after Machatschek
Tian Shan (1)	14	42	3050	
Tian Shan (2)	15	41	3300	
Wasatch	16	40 30	2650	
Altai (3)	17	40	3200	after Machatschek
Altai (4)	18	40	3050	after Reinhard
Rockies (3)	19	40	3000	
South Altai	20	40	2200 (?)	
Rocky (4)	21	39	3300	after Machatschek
Rocky (5)	22	38	3200	after Louis
North Himalaya	23	35	4000	
Atlas	24	31	3800	

TABLE II.

Height of the Quaternary Snow-line in Humid Regions.

Region	No.	Latitude	Height of Snow-line	Remark
Kamchatka	1	55	700	
Deutsche Mittelgebirge	2	48	900	
Cascade (1)	3	48	1000	
Ostalpen	4	47 30	1000	
Nordalpen	5	46 30	1200	
Cascade (2)	6	44	1200	
Meeralpen	7	44	1800	
West Montenegro	8	43	1600	
Pyrenees	9	42 30	1650	
Dalmatia	10	42 30	1200	
Apennines (1)	11	42 30	1720	
Central Apennines (1)	12	42	1650	North Slope
Central Apennines (2)	13	42	1850	South Slope
Albania	14	40 30	2000	
Sierra da Estrella	15	40 20	1640	
Apennines (2)	16	40	1940	
Sierra Nevada (1) (U.S.A.)	17	40	2000	
North Japan	18	38 40	ca 200	
Sierra Nevada (2) (U.S.A.)	19	38	3000	
Sierra Nevada (1)	20	37	2900	after Machatschek
Sierra Nevada (2)	21	37	2800	after Klute
Mt. Whithney	22	36 30	3000	
Central Japan (1)	23	36	2550	after Yamasaki
Central Japan (2)	24	36	ca 700	after Ogawa
South Himalaya (1)	25	34	3400	after Machatschek
South Himalaya (2)	26	34	3500	after Dainelli
Formosa	27	23 30	3800	
Hawaii	28	20	3700 (?)	
Mexico	29	20	3850	
Mt. Elgon	30	1	ca 3800	

I admit that the above tabulated values are not very exact, but as a first approximation I may be able to say that the height of the climatic snow-line in the Ice Age is a function of the latitude. The existence of secondary factors, however, causes some irregularities as shown in the accompanying figure. These are explained by the post-

glacial crustal movements or by the difference in climatic regions or by some other local effects. But on the whole the height of the climatic snow-line is a function of the latitude; especially is this shown by the effect of the horse latitude in the humid regions even as far back as the Ice Age.

Any theory which strongly deviates from this general relation ($\otimes 18$ and $\otimes 24$) must be regarded as a doubtful one. If we were to put the Quaternary climatic snow-line at about 700 metres in Central Japan, then we must expect it to be at about 1500 metres in Formosa; consequently we should have to find distinct evidences of past glaciers at the height of several hundred metres in such a tropical country and to estimate the depression of the snow-line during the glacial period in Central Japan to be at least 3500 metres, which would be quite an unreasonable conclusion.

All these contradictions show the absurdity of trying to determine a worldwide phenomenon such as the Quaternary glaciation through any amount of field observations in such a restricted region as Japan proper.