Snow Crystal Observations at Mt. Yalung Kang, Kangchenjunga Region, East Nepal*

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Abstract

The shape and size of snow crystals were recorded by making plastic replicas of them during the snowfall on April 23 and May 17, 1973, at Camp II (6470 m) along the climbing route to the summit of Mt. Yalung Kang (8505 m). It was found by observation of the photomicrographs of replicas that the shapes of snow crystals at 1705 NST, April 23, were hexagonal plates, crystals with broad branches, ordinary dendritic crystals and others, and that the time variation of crystals shapes during the period from 1000 NST to 1110 NST, May 17, was from plates to ordinary dendritic crystals through crystals with broad branches. In both cases, the altitudes of the tops of the precipitating clouds and the thickness of the cloud layer suitable for formation of snow crystals were estimated on the basis of experiments on artificial snow crystals.

1. Introduction

Studies of the precipitation mechanism in the high altitude area of the Nepal Himalayas are important in research on the accumulation process of glaciers and the process of latent heat transfer between the mountain area and the atmosphere. As one of the studies on the precipitation mechanism in the premonsoon season, observations of snow crystals during the snowfall were carried out at the camps along the climbing route to the summit of Mt. Yalung Kang (8505 m), Kangchenjunga region, East Nepal in April and May 1973, as a part of the Kyoto University Yalung Kang Expedition, 1973. Since the making of the replicas at Camp II was successful, the results obtained from the observations at this point will be described in this paper.

2. Observation procedures

The shape, size and number of snow crystals were recorded by making plastic replicas of them by the use of a solution of formvar (Schaefer, 1942). The plastic replicas of snow crystals were made at Base Camp (5210 m), Camp I (5950 m), and Camp II (6470 m) along the climbing route to the summit of Mt. Yalung Kang (8505 m). These observation points are located on the south slope of the west ridge from Kangchenjunga (8600 m), as shown in Fig. 1. After taking these replicas back to the laboratory in Japan, the photomicrographs of them were taken in order to observe their shapes and size.

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Fig. 1. Drainage basin of the Yalung glacier (B.C.: Base Camp (5210 m); C1: Camp I (5950 m); C2: Camp II (6470 m)).
Since it is difficult to make a plastic replica of graupels, the photographs of them were taken by the use of a camera at Ramser (4470 m), Base Camp, and Camps I and II. The sizes of the graupels were measured on the prints of these photographs.

3. Snow crystals observed at the Camp II

3.1. Shapes of snow crystals observed on April 23

Snowfall occurred on April 23 when a trough was found near East Nepal on the 500 mb chart (Inoue, 1975). Plastic replicas of snow crystals were made at 1705 and 1730 NST (Nepal Standard Time), and the photographs of graupels were also taken at the same time. The snowfall stopped at 1800 NST when the meteorological observations at Camp II indicated that the upper clouds were Ci 4, the clouds near the Camp Ac 3, the clouds lower than the Camp Sc 4, and the air temperature -10.5°C.

It was found by observing photomicrographs of the plastic replicas that shapes of snow crystals at 1705 NST were hexagonal plates, plates with simple extension, plates with dendritic extension, crystals with sector branches, crystals with broad branches, stellar crystals, ordinary dendritic crystals, and stellar crystals with plates at ends, according to Magono and Lee's classification (1960). Examples of snow crystals of these shapes are shown in Fig. 2. As seen in Fig. 2c), some of snow crystals are rimed one. At 1705 NST, clouds near the camp were getting thinner enough to recognize sunlight, and so it was possible to see

![Fig. 2. Snow crystals observed at 1705 NST, April 23, 1973, Camp II (6370 m), Yalung Kang. The scale in the photographs indicates 0.5 mm.]
Fig. 3. Snow crystals observed on May 17, 1973, Camp II (6470 m), Yalung Kang. The scale in the photographs indicates 0.5 mm.
he peak of Mt. Jannu (7710 m) from the Camp II through thin clouds, the peak being about 8 km to the west. However, just after that, visibility at the camp became nearly zero in clouds. Then, graupels and densely rimed crystals started to fall as recorded by taking photographs of them. The diameter of the graupels was 1~2 mm.

Plastic replicas made at 1730 NST were not so good, but hexagonal plate, stellar crystals and densely rimed crystals were found on them.

3.2. Shapes of snow crystals observed on May 17

Snowfall occurred on May 17 when a trough was found near East Nepal on the 500 mb chart (Inoue, 1975). Plastic replicas of snow crystals were made at 1000, 1010, 1100 and 1110 NST, but the air temperature was not observed. Snowfall stopped after 1200 NST.

Shapes of snow crystals at 1000 NST were hexagonal plates, thick plates of skeleton form, plate with simple extension, plate with sectorlike extension, crystals with sectorlike branches, crystals with broad branches, and hollow columns. The predominant shape was plates as shown in Fig. 3a), and columns were quite few. Some of the snow crystals were rimed.

Shapes of snow crystals at 1010 NST were hexagonal plates, thick plates of skeleton form, plates with simple extension, plates with sector extension, stellar crystals with plates at ends, hollow columns and side planes. The predominant shape was rimed plates as shown in Fig. 3b).

Shapes of snow crystals at 1100 NST were hexagonal plates, thick plates of skeleton form, plates with sectorlike extension, crystals with sectorlike branches, crystals with broad branches, stellar crystals, and stellar crystals with plates at ends. The predominant shapes were six branched crystals such as crystals with broad branches and crystals with sectorlike branches as shown in Fig. 3c). Nearly all of the snow crystals were rimed, and some were densely rimed.

Shapes of snow crystals at 1110 NST were hexagonal plates, thick plates of skeleton form, crystals with sectorlike branches, crystals with broad branches, and ordinary dendritic crystals. The predominant shape was ordinary dendritic crystals as shown in Fig. 3 d-1) and d-2), and rimed crystals were few.

4. Concluding remarks

As in the case of snow crystal observations at Lhajung (4420 m) in the Khumbu region of East Nepal (Higuchi 1976), it is possible to estimate cloud condition from the shapes of snow crystals observed at the Camp II.

In the case of April 23, since the size of hexagonal plates in the centers of six branched crystals were quite small as seen in Fig. 2b), c) and d), it is reasonable to consider that the air temperature at the top of precipitating clouds corresponds to the lower limit of the temperature region for dendritic growth which is $-17^\circ C$ according to Nakaya (1954) and $-16^\circ C$ according to Kobayashi (1961). At 1800 NST, the air temperature was $-10.5^\circ C$ at Camp
II, and −5.0°C at Base Camp. Therefore, it is possible to estimate the altitude of this top layer as 1300 m to 1500 m above the Camp II, when the lapse rate in the clouds is estimated as 0.44°C/100 m on the basis of the temperature difference between Base Camp and Camp II. Since the altitude of the Camp II is 6470 m above sea level, the altitude of the tops of the precipitating clouds is estimated as 7770 m to 7970 m. Since the altitude of the ridge from Kangchenjunga to Kambachen through Yalung Kang is from 8600 m to 7900 m as seen in Fig. 1, it is reasonable to consider that the altitude of the cloud top is lower than that of the ridge near the Camp II.

The thickness of the cloud layer suitable for the formation of snow crystals is estimated as 310 m for ordinary dendritic crystals of 1.5 mm, and 410 m for crystals with broad branches of 1.0 mm, on the basis of the growth rate and fall velocity of crystals at 400 mb. These values are quite reasonable in comparison with the estimated value of the altitude of the cloud top described above.

It is difficult to estimate the cloud condition from observations of graupels which usually form in convective clouds. However, it should be noted that the formation of graupels means the occurrence of convective clouds at such a high altitude above 7000 m. It can also be explained by the occurrence of convective clouds that visibility at the Camp II changed rapidly at 1705 NST as described in 3.1.

In the case of May 17, the characteristic of snowfall is time variation of crystal shapes such as change from plates to ordinary dendritic crystal through crystals with broad branches as seen in Fig. 3. According to experiments on artificial snow crystals (Nakaya, 1951; Kobayashi, 1961), such a change of crystal shapes indicates a possibility that the water vapor density in the clouds increased under nearly the same temperature condition. The thickness of the cloud layer suitable for formation of snow crystals is estimated as 570 m for ordinary dendritic crystals of 2.8 mm as shown in Fig. 3d-1) and d-2).

As described above, it is possible to estimate the altitude of the cloud top and the thickness of the cloud layer from the shapes and sizes of snow crystals observed on the ground at high altitude. Therefore, it may be possible to study on the drift and turbulent diffusion of crystals during formation in cloud and falling from it, on the basis of the conditions of clouds and wind. Since the wind is strong and the altitude of ridges is quite high in the Himalayas, the drift and diffusion of crystals could be complicated, but important for understanding the precipitation and accumulation process in the accumulation area of glaciers at high altitude.

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References


