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In Situ Growth Experiments on "Gohei Twins" Snow Crystals Observed at Inuvik in Arctic Canada

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Abstract

Growth experiments on the "Gohei Twins" snow crystals observed in the Arctic were carried out at Inuvik, N.W.T., Canada (68°22'N, 133°42', W) from December 1995 to January 1996 to examine in more detail their structure and growth mechanisms. A summary of the growth and nucleation conditions of the Gohei Twins follows : 1) The Gohei Twins can grow as twins when the tip of the crystals is closed macroscopically. The thin prism planes at this tip can grow at low supersaturation. 2) The tip of the Gohei Twins can grow when the prism planes are thin. After that, the larger the Gohei Twins grow, the thicker the prism planes became. 3) When the tip of the crystalline boundary of the Gohei Twins is thin, the Gohei Twins can grow as twins successively. When the tip is thick, the shape of the Gohei Twins changes to other types of snow crystals depending on humidity conditions. 4) When the crystal forms in the skelton structure at the nucleation in high supersaturation, the specific crystalline boundary can grow as the Gohei Twins.

1. Introduction

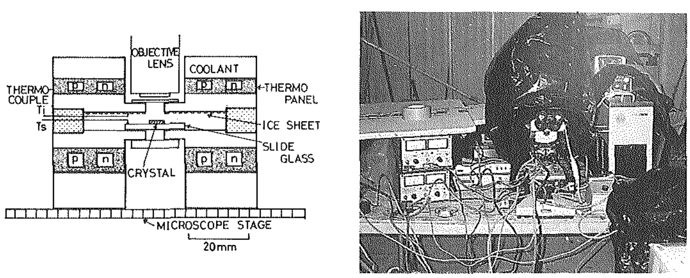
Artificial experiments to grow low temperature type snow crystals have been carried out to date by Sato and Kikuchi (1983, 1988, 1989) and Kikuchi and

Sato (1984). As a result, various kinds of low temperature type snow crystals reported by Kikuchi (1969, 1970) were grown artificially and the frequency of their shapes compared to the regular shapes in the relatively low temperature conditions, that is, columns, crossed plates, combination of bullets and so on was studied by Kikuchi and Sato (1984). The formation mechanism of the Gohei Twins was explained by the introduction of the cubic structure twice at formation process by Sato and Kikuchi (1985).

In order to examine in more detail the structure and growth mechanism of low temperature type snow crystals, especially the Gohei Twins, growth experiments of these crystals collected in nature have been carried out at Inuvik, N. W.T., Arctic Canada (68°22′N, 133°42′W). This paper will describe the results of the growth experiments on these snow crystals.

2. Experimental method

Snow crystals collected on a sampling board by the sedimentation method were picked up on the glass slide and they were examined by a stereoscopic microscope. A Gohei Twins snow crystal was selected and moved onto a fine thread stretched on a plastic frame or on a cover glass. The plastic frame or cover glass supporting the crystals was moved into a thermal diffusion type cold chamber mounted on the stage of a polarizing microscope. Figure 1(a) and (b) represents an outline of the chamber schematically and the arrangement in storage, respectively. This chamber was made in such a way as to cool the temperatures of the upper and lower stages in the chamber independently. Controlling the temperatures of upper and lower stages, experiments of condensation (growth) and evaporation of the snow crystals introduced into the cham-



(a) (b)

Fig. 1. Schematic outline of the thermal diffusion type cold chamber (a) and the arrangement of the chamber in a storage at Inuvik, N.W.T., Canada (b).

ber were repeated. The temperature of the lower stage for the growth of ice crystals was regarded as the growth temperature of snow crystals generally. The degree of supersaturation was calculated by the temperature difference between the upper and lower stages. The growth of the crystals was recorded by successively taking 8mm video camera photographs at appropriate intervals under a microscope. The principal axis of crystals was determined by the use of crossed nicols and a sensitive color plate in the polarizing microscope.

3. Results and considerations

Typical peculiar shaped snow crystals including the Gohei Twins were observed frequently on January 12, 1996. Meteorological conditions are shown in Fig. 2. It is estimated from these sounding curves that the cloud layer is between −20 and −35°C under the condition above ice saturation close to water saturation. The growth and evaporation experiments on the Gohei Twins were carried out successively. Most experiments were carried out at the lower stage temperature of about −25°C, and −35°C as the growth temperature.

The Gohei Twins couldn't grow successively when the prism planes at the tip of the crystal was thick. Proceeding the Gohei Twins evaporation, the prism planes at the tip of crystals became thin and the tip of the crystal closed ;

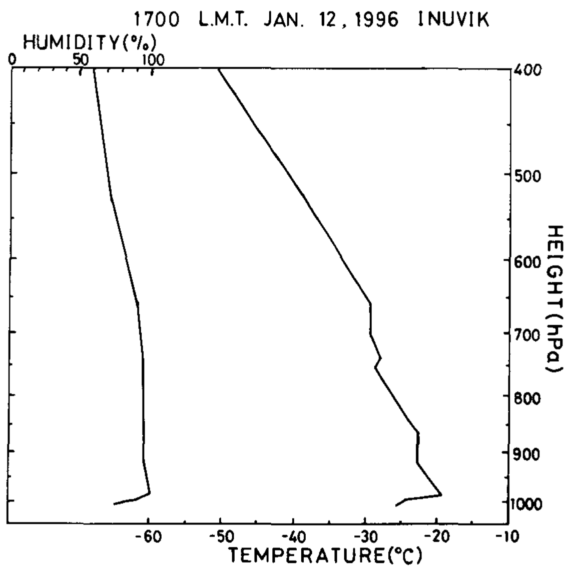


Fig. 2. Upper air sounding curves at Inuvik on 17 LMT January 12, 1996.

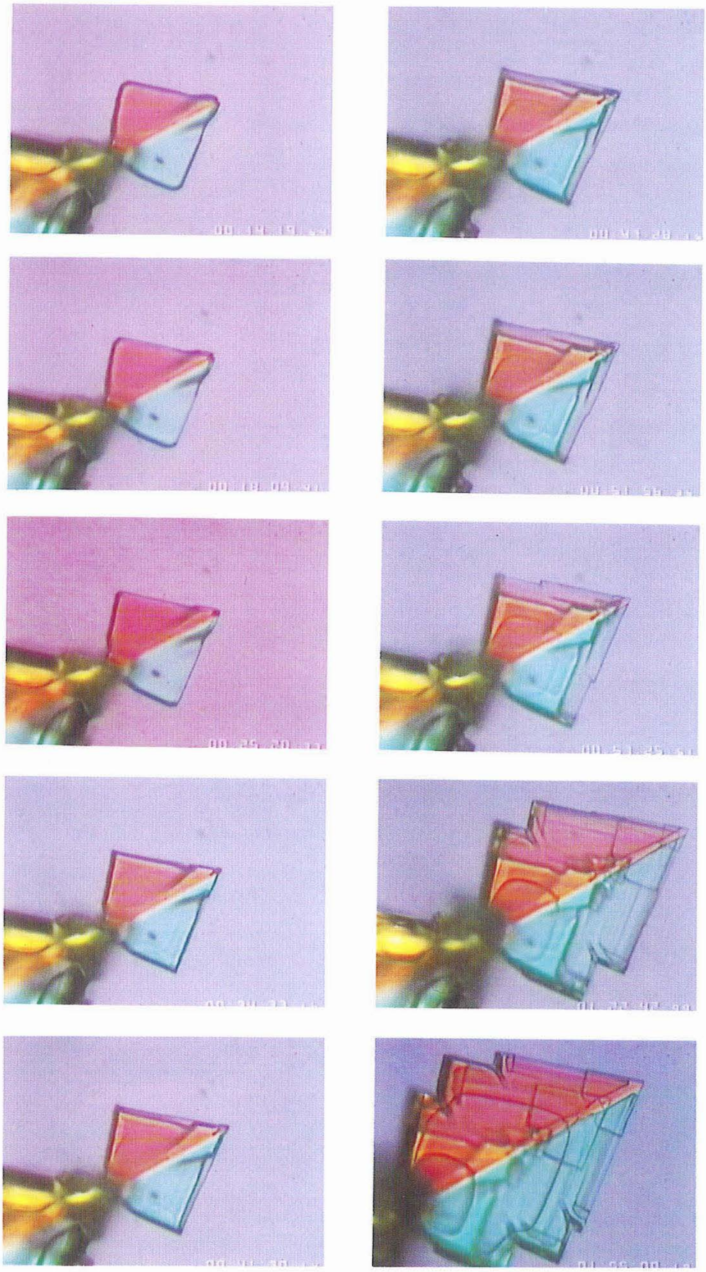


Fig. 3. Successive microphotographs of the growth stages of the "Gohei Twins".

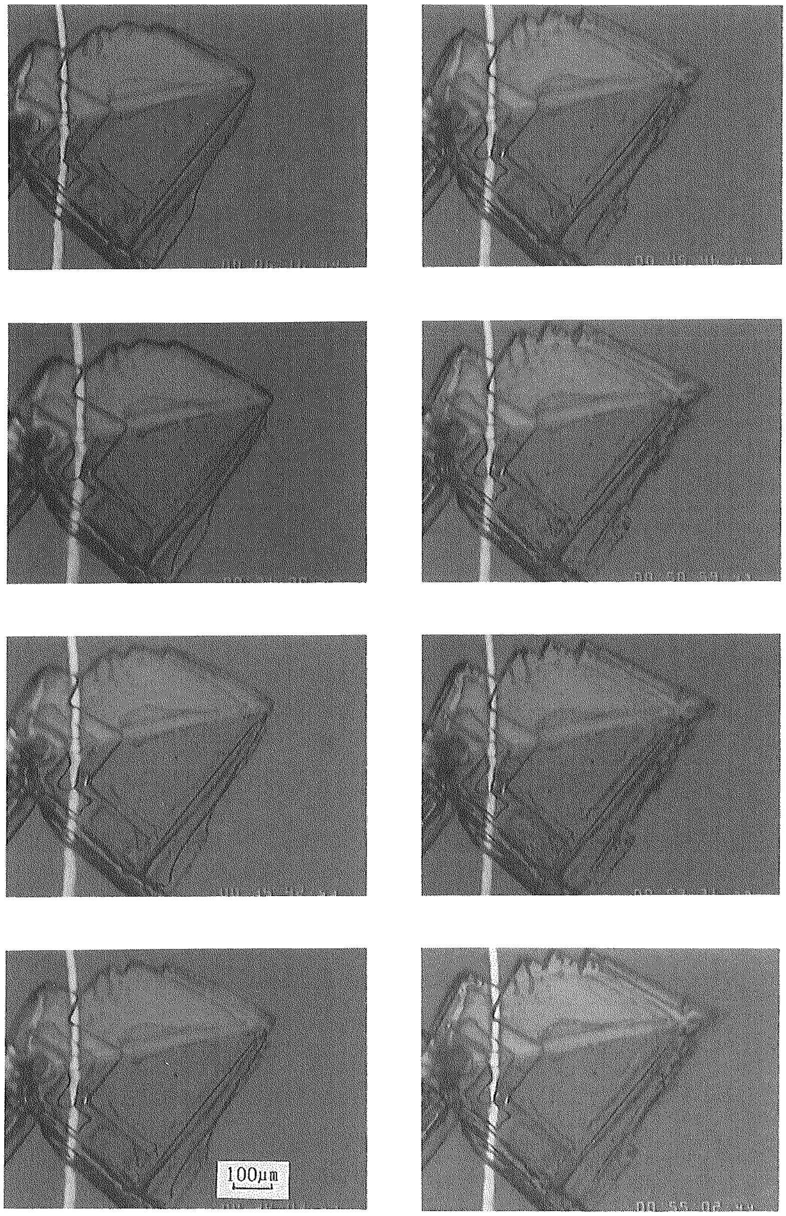


Fig. 4. Same as Fig. 3.

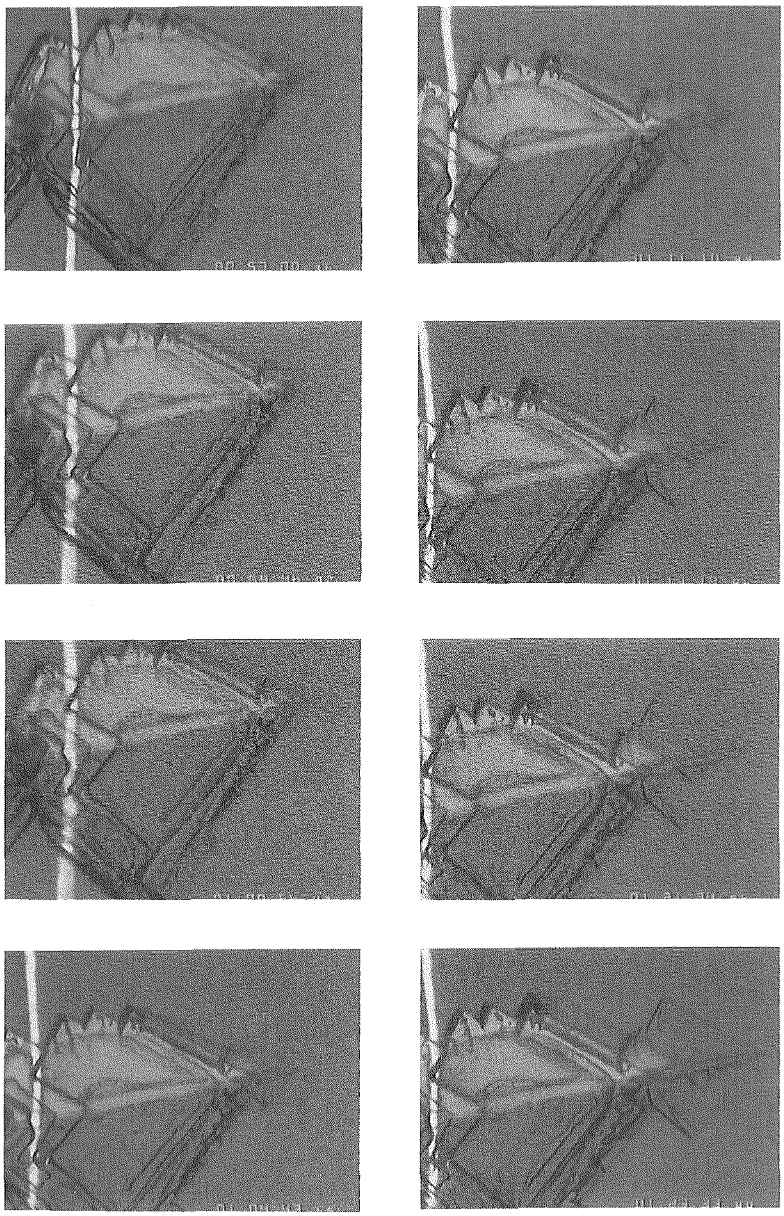


Fig. 4. (Continued).

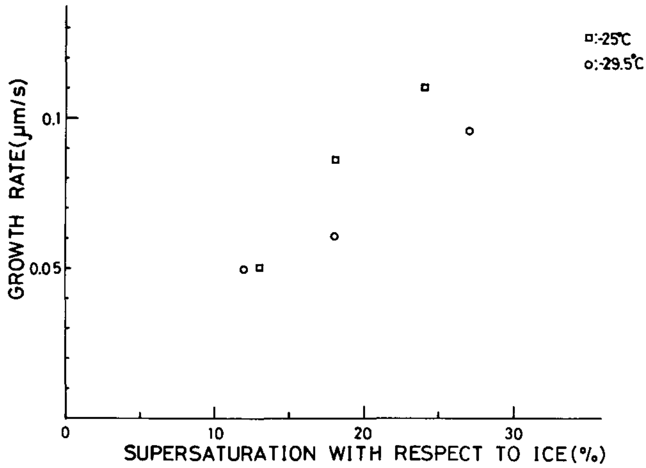


Fig. 5. Growth rates of the crystal to the supersaturation with respect to ice surface.

the crystal was able to develop into the Gohei Twins as shown in Fig. 3. As seen this figure, the direction of principal axis of the crystal is from the lower right to the upper left in the bluish color part and from the upper right to the lower left in the reddish color part, respectively. Another example is shown in Fig. 4. The whitish vertical line in each photograph is a fine thread stretching on a plastic frame in the cold chamber. The growth rates of the crystal depended upon supersaturation with respect to the ice surface as shown in Fig. 5. This figure shows that in the initial growth stage of the Gohei Twins, the water molecules at low supersaturation fill up the groove at the tip of the crystal.

The Gohei Twins began to grow in the direction of a right angle (upward or downward from the Gohei Twins) to the horizontal growth direction in this case at the high supersaturation. The growing crystal had a skelton structure at the tip of the crystal as shown in the left column in the Fig. 6. Another Gohei Twins, however, began to grow as twins at the tip with a skelton structure as shown in the right column in Fig. 6. It is estimated that the condition of the nucleation of the Gohei Twins is high supersaturation and the formation of skelton structure. The boundary of the Gohei Twins seems to be indefinite from the appearance of prism planes in the growth and evaporation experiments. The Gohei Twins grew into other types of crystals when the tip of the Gohei Twins wasn't filled up at the groove of the crystal. Specifically, the growth mode of the crystal is similar to the snow crystals of "Double Gohei

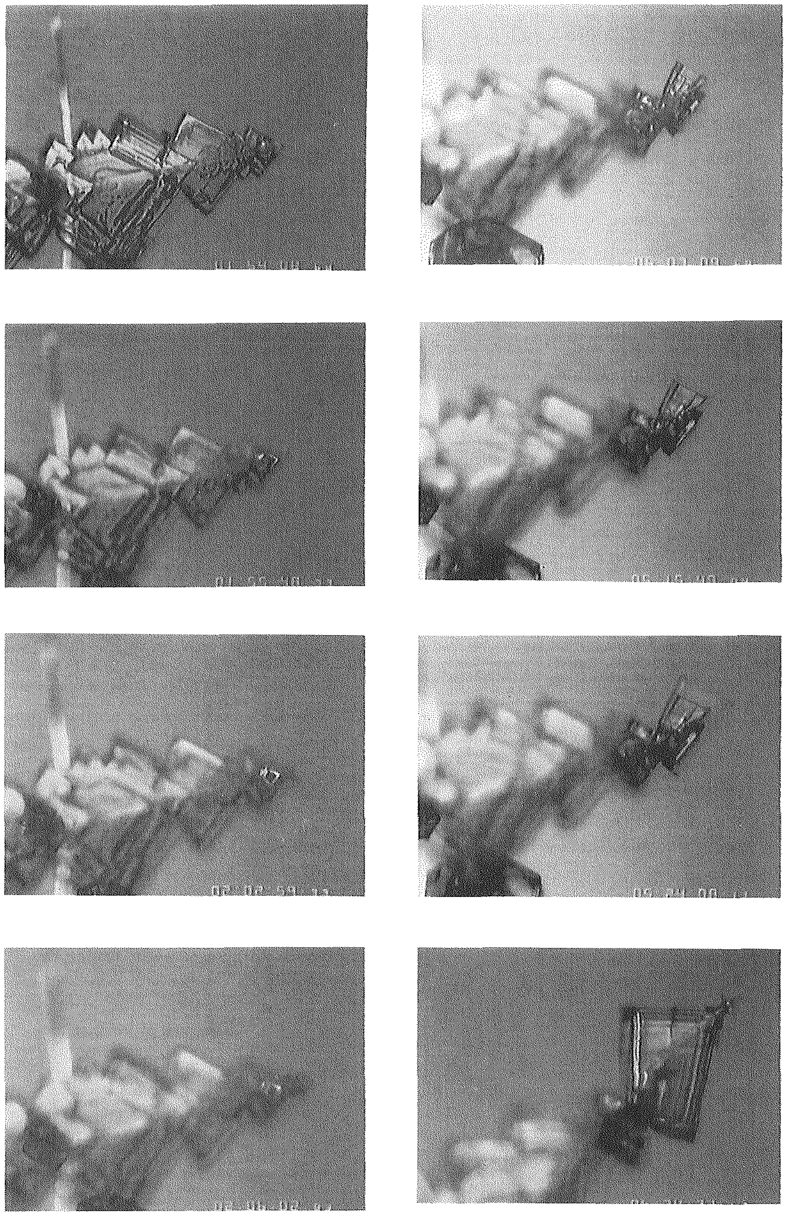


Fig. 6. Same as Fig. 3.

Twin Types" which were observed at the Northern Norway by Kikuchi et al. (1991). The special growth mode of low temperature type snow crystals has been reported from the same place, Inuvik, by Kikuchi.

4. Concluding remarks

The results of in situ growth experiments were summarized on the growth and nucleation conditions of the Gohei Twins as follows: 1) The Gohei Twins can grow as twins when the tip of the crystals is closed macroscopically. The thin prism planes at this tip can grow at low supersaturation. 2) The tip of the Gohei Twins can grow when the prism planes are thin. After that, the larger the Gohei Twins grow, the thicker the prism planes become. 3) When the tip of crystalline boundary of the Gohei Twins is thin, the Gohei Twins can grow as twins successively. When the tip is thick, the shape of the Gohei Twins changes to other types of snow crystals depending on the humidity conditions. 4) When the crystal forms in the skelton structure at nucleation in high supersaturation, the specific crystalline boundary can grow into a Gohei Twins type crystal.

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