Ice Temperature of Khumbu Glacier*

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Abstract

Thermal drilling was carried out in August of 1974 on the Khumbu glacier. The drilling site was set at 5360 m above sea-level in the upper part of the ablation area of the glacier. The drilling was stopped due to the freezing of the drilled hole at a depth of 20.3 m. The analysis of the relationship between the depth and the time of drilling indicated that there were 7 layers down to the maximum depth reached and there was a possibility that the deepest layer was at the melting point. A simple calculation of the freezing rate of the drilled hole showed that the ice temperature at a depth of 2 m was below -2°C at the drilling time. The measurement of the resistance of a thermistor put into the hole showed that the ice temperature at a depth of 2.7 m was -5.3°C at the end of November. Therefore, it was concluded that the ice temperature above the deepest layer (its depth was 16 m) was below the melting point, but it was at the melting point below the layer. This conclusion was supported by the analysis of the flow velocity of the glacier.

1. Introduction

In order to study the flow of glaciers and its response to climatic change, we must examine phenomena not only on and near the glaciers but also within them. Nevertheless, most observations performed in the Himalayan region have been limited to the surface of the glaciers. In the summer of 1974 we carried out thermal drilling at 5360 m above sea-level in the Khumbu glacier as a preliminary test for future borehole experiments. From the test we obtained interesting data on ice temperature and I will report and discuss them in this paper.

2. Thermal drilling and temperature measurements

The details of the results and analysis of the drilling will be published in an other paper (Mae, Wushiki, Ageta and Higuchi, 1975), and they are simply reviewed in this section.

The relation between the depth and the time of the drilling indicates that the depth-time curve is divided into 9 stages. Excluding the upper two stages near the surface for simplicity, there are 7 layers down to a depth of about 20 m

which have their own drilling speed. Assuming that the heat generated from the heater worked to melt the ice, the drilling speed, v , is given by

$$v = (H_h / L\rho\pi)r^{-2} \quad (1)$$

where H_h is the heat from the heater, L is the heat of fusion of ice per unit mass, ρ is the density of ice, and r is the radius of the hole. Using this equation, the physical features of the layers were inferred (Table 1, in the paper by Mae, Wushiki, Ageta and Higuchi, 1975). This table shows that we can consider that the deepest layer (its depth is 16 m) is at the melting point.

After the stop of the drilling due to the freezing, the depth of the freezing level was measured. 12 hours after it the depth was 3 m and 32 hours after it the depth rose up to 2 m. A simple calculation of the freezing rate indicates that the ice temperature at a depth of 2 m is below -2°C even in the summer. The measurement of temperature using a thermistor put into the drilled hole showed that the temperature at a depth of 3 m was -5.3°C at the end of November.

3. Vertical distribution of temperature

From the above description we may conclude that the ice temperature at the drilling site is as follows: above a depth of 16 m, the temperature is below the melting point and below 16 m it is at the melting point.

This conclusion is supported by the analysis

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of glacier flow and the temperature measurement at the Rongbuk glacier at the northern slope of Mt. Sagarmatha.

According to Kodama and Mae (1976), the flow of the Khumbu glacier is very similar to the Blue glacier of which the temperature is at the melting point. For the flow velocity is determined by plastic deformation in the deeper portion which is at the melting point.

Academica Sinica (1975) measured ice temperature down to a depth of 10 m in May of 1966 at 5400 m above sea-level in the Rongbuk glacier. The measurement showed that the minimum ice temperature was -4°C at a depth of 3 m and it gradually increased with depth. If the relation between the depth and the temperature is extrapolated below 10 m, the depth where the temperature reaches the melting point is estimated to be 16 m. This value is approximately equal to the depth of the layer at the melting point. Therefore, there is a possibility that the ice

temperature below 16 m is at the melting point in the Khumbu glacier.

The temperature was measured only in the upper part of the ablation area. Therefore, in order to understand the thermal features of the Khumbu glacier it is necessary to measure ice temperature in the lower part too. For the same reason precise understanding of Himalayan glaciers requires extensive temperature measurements.

References

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