

Ground Photogrammetry of Yala Glacier, Langtang Himal, Nepal Himalaya

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Abstract

Yala Glacier in Langtang Himal was surveyed in November 1981 by the method of ground photogrammetry, and a contour map was made. This map was retouched using the aerial photographs taken in November 1982, and the final result was obtained as a map of Yala Glacier with a scale of 1/5,000 and a contour interval of 10 m. One problem of the map is that the contour lines are those of 1981 while most of the surface structures are that of 1982. Another is that the accuracy of the described figures is not uniform because various means were employed to draw the surface structures.

1. Introduction

The form of a glacier is one of its most fundamental characteristics, making maps of glaciers extremely important. In the Nepal Himalaya, the most detailed maps published have a scale of 1/25,000 or 1/50,000. For example, "Chomolongma-Mount Everest" (Deutscher Alpenverein et al., 1957) has a scale of 1/25,000, and "Khumbu Himal" (Research Scheme Nepal Himalaya, 1965) has a scale of 1/50,000. But such detailed maps have covered only the eastern part of the Nepal Himalaya. Also, they are insufficient for studying phenomena on a scale of less than 10 m. To provide better maps, Yokoyama and Iwata (1980) surveyed several glaciers in the Khumbu Himal by the method of ground photogrammetry and showed that this method can be fairly useful.

In 1981 and 1982 an intensive glacier research program including drilling of glacier ice was carried out on the Yala Glacier (Dakpatsen Glacier) and the area surrounding it in Langtang Himal by the Glaciological Expedition of Nepal (G.E.N.) (Higuchi, 1984). But when the program started there was no detailed map of this region to provide the necessary data of the glacier topography. As a part of this research program the present author surveyed Yala Glacier (Fig. 1) in November 1981 using the method of ground photogrammetry and com-

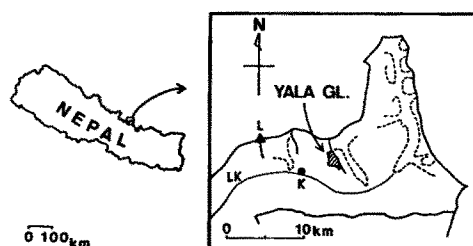


Fig. 1. Location of Yala Glacier. L: Langtang Lirung. K: Kyanchen Gompa. LK: Langtang Khola.

piled a map with a scale of 1/5,000 (Appendix 4). The results will also aid in analyzing changes of the glacier.

2. Procedure of ground photogrammetry

2.1. Instruments

A Zeiss TMK camera was used for photographing. A 60.10 mm lens was used, and the size of a dry plate is 12 cm × 9 cm.

A Wild T2 precision theodolite was used for angle measurement, and a Sokkisha RED-1 optical distance meter was used for distance measurement.

2.2. Field work

The field work was carried out in November 1981.

The operation in the field consisted of the following three steps: (1) establishment of base points and control points, (2) survey of these points to determine the relative location and (3) photographing from the base points.

Figs. 2(a) and 2(b) show the arrangement of the base points and control points, and the direction of axes of photographic exposures. The base points were set on a platform opposite to the glacier. The points were marked by crosses cut into prominent rocks. The length of the base line was 189.382 m, and the distance between the base line and the glacier was 2–3 km. Thus the base-height ratio was about 1/10 to 1/15; this value is within the acceptable range which is said to be 1/4 to 1/40 (Ozaki, 1961).

Fixed points were chosen as control points, so as to compare the results of repeated surveys and to observe changes of the glacier. Control points No. 1 and No. 3 were the tops of rock pinnacles on the upper margin of the glacier, while control point No. 2 was a cross painted on the bedrock.

These base points and control points were surveyed by the method of triangulation.

The pictures were taken from the base points with parallel exposing axes which were horizontal and perpendicular to the base line. The average picture scale was about 1/40,000. Fig. 3 is the set of pictures used for plotting.

2.3. Plotting

A Wild Autograph A7 plotter was used for plotting. A contour map of Yala Glacier and

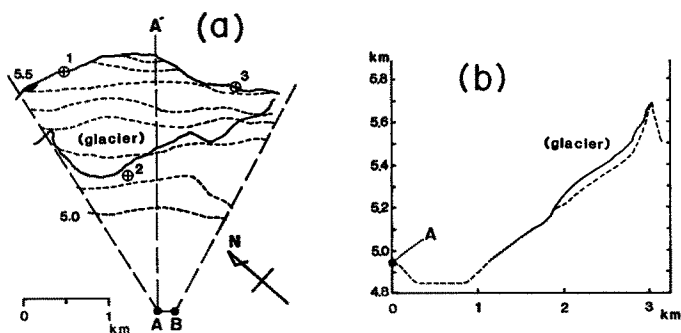


Fig. 2. Arrangement of the base points and control points set for the ground photogrammetry; the plane view (a) and the profile along A-A' (b). A and B are the base points. Nos. 1, 2 and 3 indicate the control points. Dotted lines in (a) were contour lines. Arrows indicate the exposing axes.

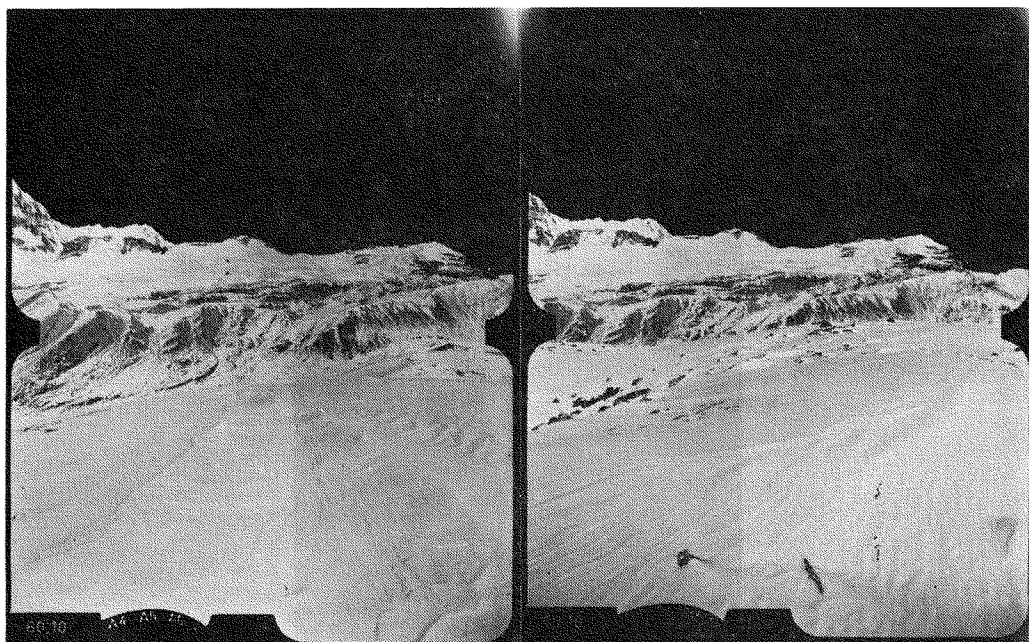


Fig. 3. Set of photographs used for plotting. They were taken from the base points A (left) and B (right).

the neighboring area was drawn with a scale of 1/5,000 and a contour interval of 10 m. The co-ordinate system (X, Y, Z) was as follows. The origin was the base point A. The X-axis was in the direction A-B, while the Y-axis was A-A' (see Fig. 2(a)). The Z-axis was vertical. The elevation of base point A was calculated to be 4934 m above sea level from the results of the survey by Ageta (1983). Thus the Z co-ordinate is zero at 4934 m a.s.l.

This map covered the greater part of Yala Glacier. The margin of the glacier and remarkable ice cliffs (usually accompanied by crevasses) were also drawn on the map. However, the other surface structures such as crevasses, depressions and so on were not drawn, since they could not be seen on the pictures. This is because the slope of the glacier is gentle and the base points, i.e. the photographing point, were lower in elevation than the glacier termini and consequently the surface of the glacier and the exposing axes were nearly parallel.

3. Aerial photograph

After the ground photogrammetry in 1981, aerial photographs of Yala Glacier were taken by the G.E.N. 1982. Those photographs were used to retouch the map of Yala Glacier.

3.1. Photographing

Aerial observations were carried out in November 1982 by the G.E.N. Yala Glacier was photographed almost vertically using a single-lens reflex camera with a 50 mm lens. Forty-five pictures of Yala Glacier were obtained during five passes over the glacier. Fig. 4 is an example of the aerial photographs, which covers the area surrounded by the dotted line in Fig. 6. These average picture scale was about 1/20,000.

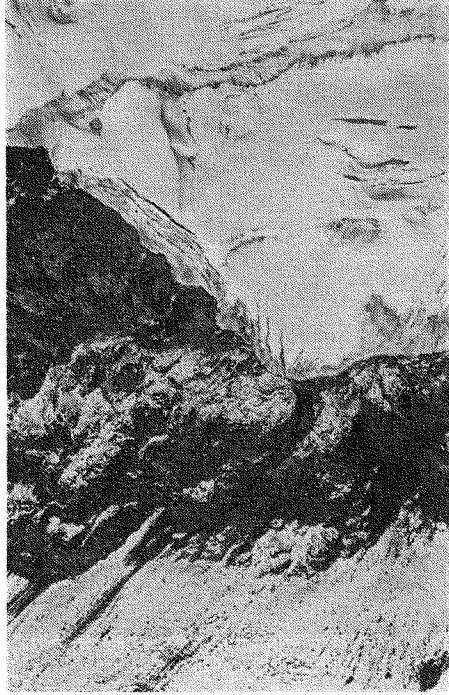


Fig. 4. Aerial photograph. The pictured area is the part surrounded by dotted line in Fig. 6.

3.2. Drawing surface structures

It was attempted to draw the surface structures of the glacier by plotting using the aerial photographs. Both relative orientation and absolute orientation are necessary in order to use a set of pictures for plotting. The control points for orientation were the stakes set on the glacier for ablation measurement and those used for route marking. The former were denoted as S0, S1, ..., S9 and the latter as R1, R2, ..., R9. The locations of those stakes were surveyed in 1982 and the results of the survey (Ageta, 1983) could be connected to the co-ordinates of the present author.

For only four sets of pictures both of orientation were accomplished and they were used to draw surface structures by plotting. The resulting drawings are shown in Fig. 6 as the part surrounded by the thin broken lines.

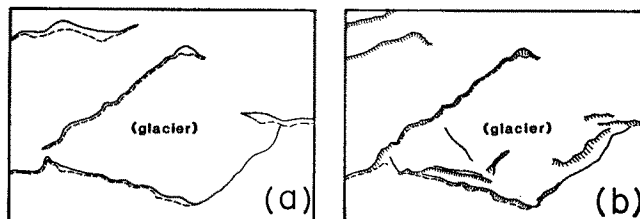


Fig. 5. The margin and the surface structures of the glacier:
 (a) is from the contour map made by ground photogrammetry.
 (b) is from the hand-drawing using the aerial photographs.

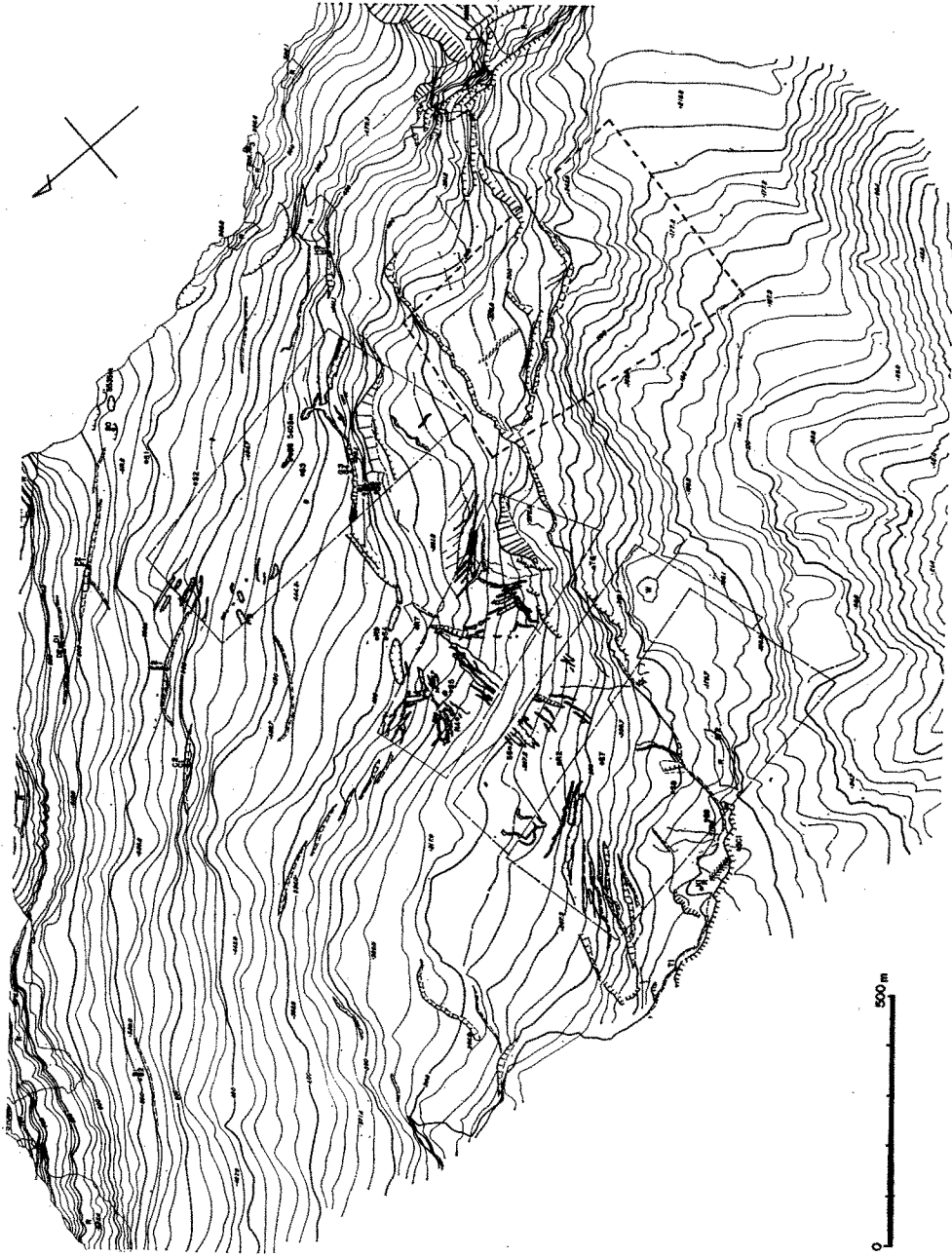


Fig. 6. Original map of Yala Glacier. The original scale is 1/5,000.

The other pictures were printed on a scale approximately equal to that of the contour map for tracing surface structures. A hand drawing of the distribution of surface structures was made from the trace of those pictures which could be roughly oriented.

The difficulty of the orientation was due to insufficient overlap between adjacent pictures and that films were not flat. The latter may be inevitable to some extent when an ordinary camera and roll films are employed.

4. Compiling the results

Three drawings obtained as the results of each work are, (A) the contour map by plotting, (B) the drawing of the surface structures by plotting and (C) the hand-drawing of the surface structures.

They were compiled as follows, and the result is shown in Fig. 6. The base map of compiling was the contour map (A). The contour lines in (A) were not retouched. The glacier margin in (A) was compared with that in the aerial photographs and where a difference between two figures was found, the margin was retouched as in (C). Figs. 5(a) and 5(b) show an example of such cases. As discussed in Sec. 2.3, the surface structures described in (A) were few, so those described in (B) and (C) were combined with those in (A).

The final result of compiling is the map of Yala Glacier (Appendix 4), with a scale of 1/5,000 and contour interval of 10 m. The azimuth is the mean of the value observed at the base line A-B and that calculated from the result of the survey by Ageta (1983).

5. Remarks

The resulting map is a detailed one but it has two problems as discussed below.

As mentioned in the preceding sections, the ground photogrammetry was carried out in November 1981, while the aerial photographs were taken in November 1982. So, in a strict sense, the glacier topography in the compiled map (Appendix 4) is that in 1981 and the surface structures are those in 1982.

Another problem is that of the accuracy of the figures. The map was compiled from three drawings. The accuracy of the figures was not uniform among them, consequently that of the final map is not uniform. The accuracy is higher in the area where the surface structures were plotted.

The compiled map of Yala Glacier (Appendix 4) could not be complete as discussed above, so it should be used understanding these limitations.

6. Acknowledgments

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