# OBSERVATIONS ON THE SURFACE MOVEMENT AND ABLATION OF THE GORNER GLACIER (SWITZERLAND)

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The Gorner Glacier, with an area of 67 km.$^2$, ranks second in size among the Swiss glaciers, that is to say immediately after the Great Aletsch Glacier. Eight confluent glaciers go to make up this great glacial mass which terminates about 3 km. above Zermatt at an altitude of 2000 m. The end section is called the Bodengletscher and the glacial stream the Gornera. All references to the geography and topography of this region are taken from Sheet No. 568 (Mischabel-W.) of the Swiss National Topographical Survey, 1:50,000.

As the water from the Gornera is to be used in the near future for the production of hydro-electric power the Gorner Glacier has, since 1948, been the subject of very complete and highly interesting hydrological and glaciological studies. These researches have been undertaken by the S.A. l'Energie de l'Ouest-Suisse (EOS), the work itself having been carried out by the Grande Dixence S.A. of Lausanne. The writer wishes to record his gratitude to these two companies for their permission to publish the observations in this paper. The full range of this research covered the sub-glacial topography as recorded by seismic and thermic soundings,[1] precipitation over the whole area, run-off, the movement of the glacier surface and the ablation taking place upon it.

The observations on the movement, the variations in the height of the ice and the ablation form a distinct group separate from the remaining investigations, and are alone dealt with in the present article.

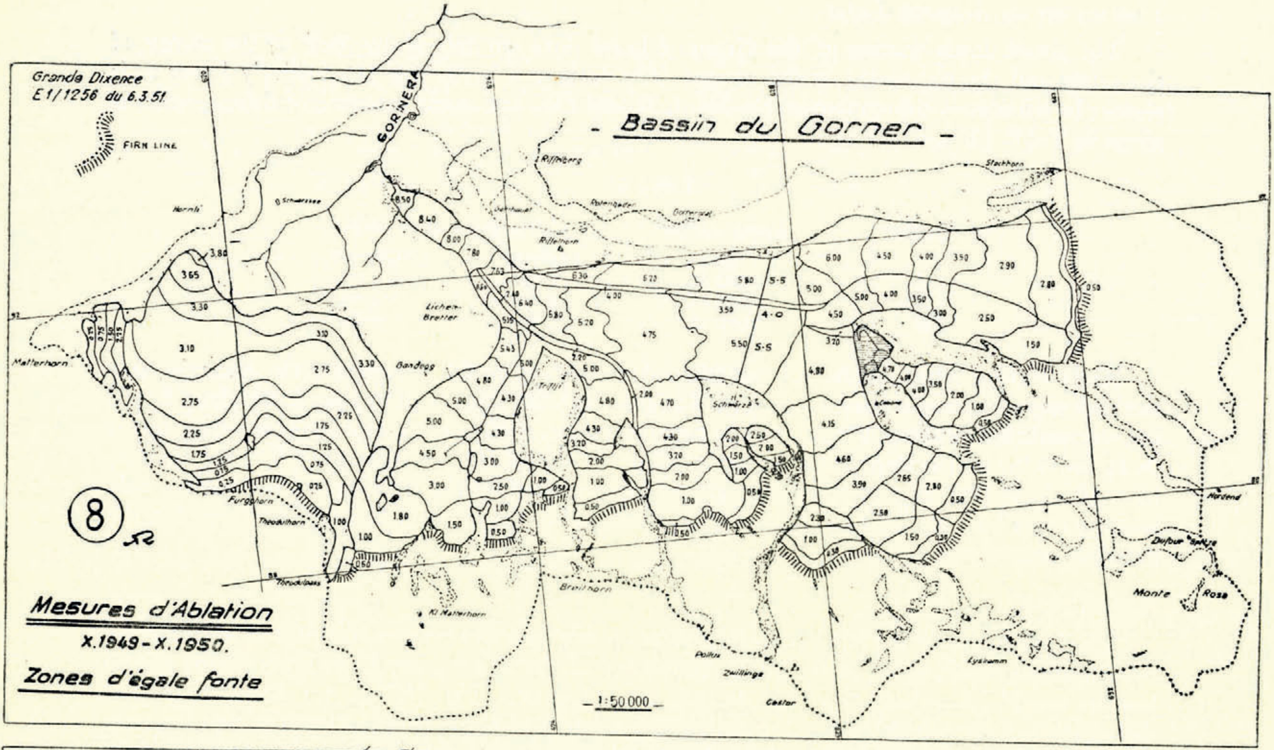
The method of research was to sink solid wooden posts into the ice; measurements were then made of their progressive emergence due to surface melting, and this and their horizontal displacement gave the movement and the variation in height of the glacier surface.

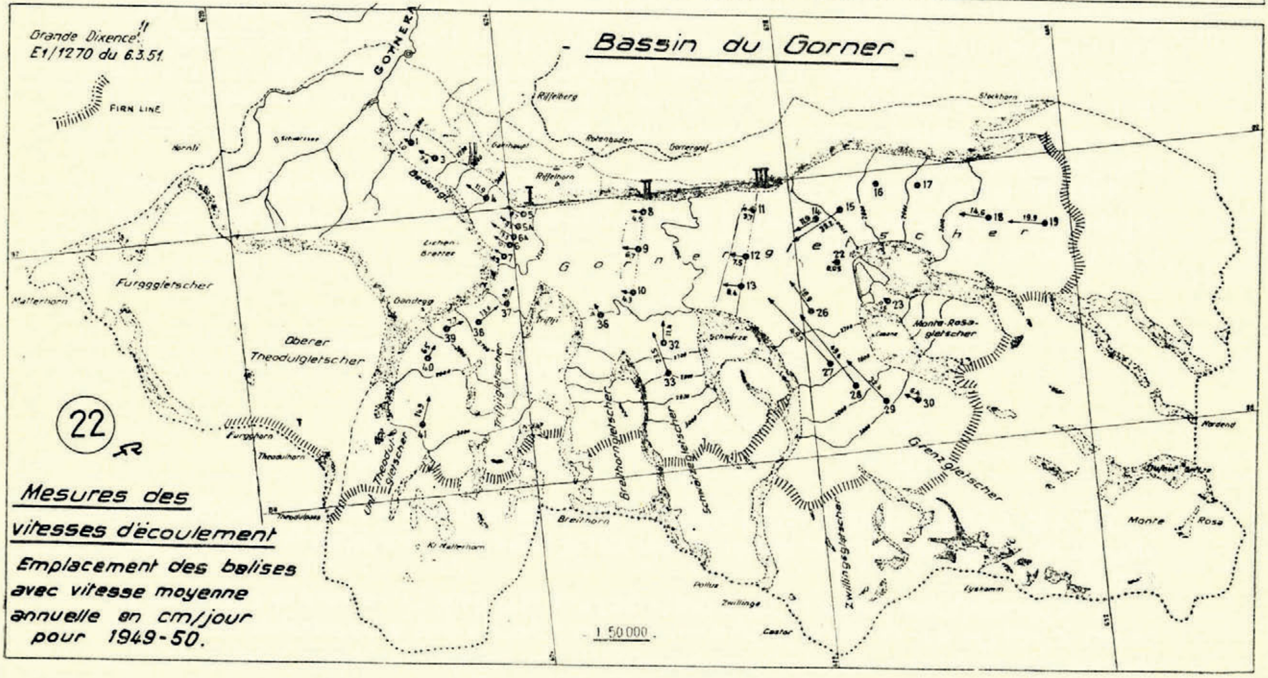
At the writer's suggestion a network of more than forty posts was set up in 1948 by Monsieur André Riva in different parts of the ablation area; at the beginning of each summer they were replaced by further posts in their carefully determined original positions. The horizontal co-ordinates of these points have naturally remained unchanged, but their heights, determined each year at the same time, enables us to follow the change in the height of the surface.

The researches have not yet been completed so that it is impossible to give an analysis of the results, and we must confine ourselves to a typical account of the most characteristic observations.

## Surface Movement

Fig. "22" (p. 55) shows the sites of the posts and their mean annual speed in centimetres a day from 1949 to 1950. The speeds vary from one confluent to another. The greatest speeds are to be found below the firn line, that is to say between 2700 m. and 2900 m. depending upon the local features. From these maxima they diminish both upstream and downstream. The greatest speed observed was that of the Grenzgletscher, the main trunk glacier. The values found for 1949–50 are in general less than those measured in 1948–49, except that there is a slight increase in the higher regions. The winter speed is some 12 per cent less than that of the summer. The differences from one tributary to another are due to the varying thrust exerted upon them from above, such thrusts coming from the accumulation areas and being determined by (*a*) the mean height of the accumulation area, (*b*) its area, (*c*) its depth and (*d*) its slope.

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## Variations of Surface Level

The actual down-wasting of the Gorner Glacier does not only show itself by the retreat of the snout and the narrowing of the tongue. The surface is becoming progressively lower as is shown by surveys of the transverse Profiles I, II and III. The mean lowering of these profiles is given in Table I below.

Table I

| *Profile* | *Mean altitude* | *Mean decrease in height* | |
|---|---|---|---|
| | 1949 | 1948–49 | 1949–50 |
| I | 2460 m. | 7 m. | 4·5 m. |
| II | 2570 m. | 4 m. | 1·8 m. |
| III | 2600 m. | 5 m. | 1·0 m. |

Since the time when the district was mapped in 1929–33 the fall in height of the glacier surface in these regions averages some 1·5 to 2 m. The very high fall from 1948 to 1949 is explained by the exceptionally hot summer of 1949, but in 1950, in spite of a still greater amount of ablation, thrust from above became evident in the upper profiles. On Profile III, for instance, where the ablation in 1950 was as high as 5 m. the thrust almost compensated for the melting and the surface only became lower by 1 m. This can probably be attributed to the increase in speed mentioned in the previous section.

## Ablation

The importance of the following observations is considerably greater than that of all the other investigations made, since, so far as the knowledge of the writer goes, in no other alpine glacier has the superficial melting ever been so fully studied as here. Fig. "8" (p. 55) shows the general distribution of the effects of ablation during the summer of 1950. It is not uniform and depends upon the altitude, the orientation of the slopes, the nature of the debris lying on the surface of the glacier tongue, and sometimes, as was established in 1948 on the Bodengletscher, upon local factors difficult to particularize. The ablation is zero at the firn line which in 1949 and 1950 lay approximately at an altitude of 3250 m. but was a little lower in 1948. It increases down-stream in intensity and duration (number of days of thaw) to reach its maximum value in the terminal zone (Bodengletscher).

Table II, below, gives the principal results for each year, the area of the surface exposed to ablation, the volume of ice dissipated and the mean rate of the corresponding annual melt, assumed to be uniformly distributed over the surface so exposed.

Table II

| *Year* | *Surface exposed to ablation* (km.$^2$) | *Volume of ice dissipated* ($10^6$ m.$^3$) | *Mean annual rate* (m.) |
|---|---|---|---|
| 1948 | 26,130 | 41,019 | 1·57 |
| 1949 | 29,143 | 102,933 | 3·54 |
| 1950 | 29,090 | 109,393 | 3·76 |

Fig. 1 (p. 57) gives a graphic representation of the variation of rate of ablation depending upon altitude, and for the whole of the glacier without taking into account variations between the tributary glaciers.

If we disregard that portion of the ablation curve of 1948 lying below 2200 m. (where the intensity is perhaps due to special conditions) one can assume a first approximation to the effect that the rate of ablation increases proportionately as the difference in height between the firn line and the point under consideration.

The Rule proposed by Hess [2] according to which the annual ablation is about 4 m. at 400 m. below the firn line (Gorner 2850 m.) finds remarkable confirmation for the years 1949 and 1950. But so far as the year 1948 is concerned, a year of considerable cold, the ablation at 2850 m. is only 3·2 m.

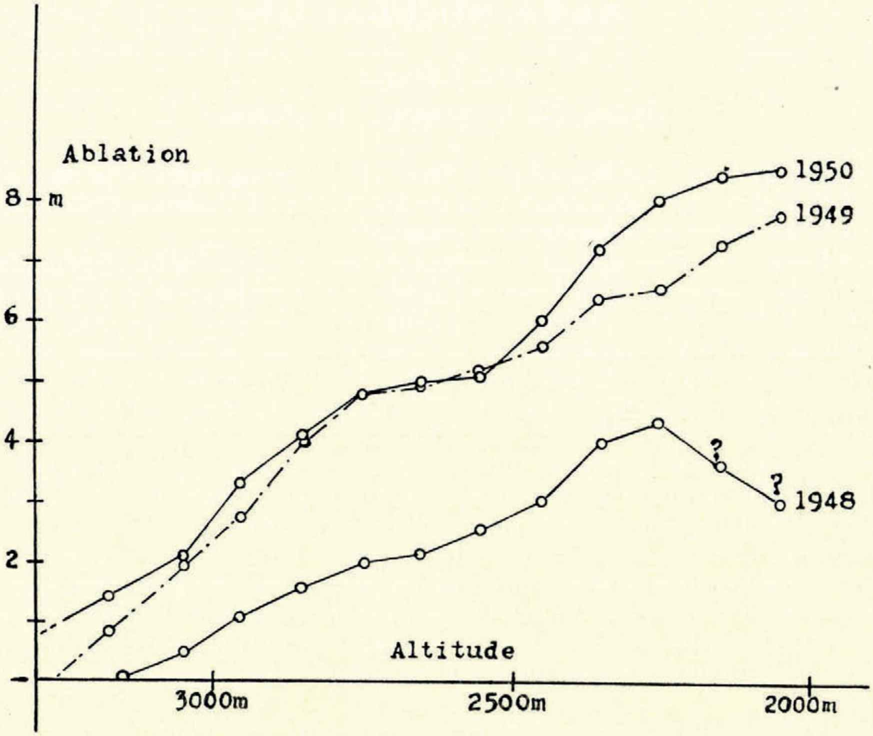


*Fig. 1*

The writer has calculated the gradient of ablation, that is to say the increase in rate corresponding to the lowering of altitude by 100 m. This gives a mean gradient of 0·6 m. per 100 m. for 1948, 1949 and 1950 for that part of the ablation area situated between 3175 m. and 2150 m. This figure is appreciably lower than any recorded on other alpine glaciers, for instance, the following:

| | | |
|---|---|---|
| Glacier du Rhône | between 1800 and 2800 m. | 1·2 per 100 m. |
| Hintereisferner | ,, 2325 and 2725 m. | 1·2 per 100 m. |
| Mer de Glace | ,, 1300 and 1700 m. | 0·8 per 100 m. |

It is not proposed to discuss these considerable differences at the present stage but it seems suitable to draw attention to them in order to encourage glaciologists to carry out other measurements of ablation wherever it is possible for them to do so.

## REFERENCES

1. Süsstrunk, A. Sondage du glacier par la méthode sismique. *La Houille Blanche*, No. spécial, A/1951, p. 309–17.
2. Hess, H. *Die Gletscher*, Braunschweig, 1904, p. 218.



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