

SONAPANI GLACIER OF LAHAUL, KANGRA DISTRICT, PUNJAB, INDIA *

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ABSTRACT

This paper reports a survey of the Sonapani glacier in the Kangra district of Punjab State, India. The glacier is 14.72 km long and is situated 6 km N.N.E. of the confluence of Kulti Nala with the Chandra River. The position of the snout has been determined with reference to permanent bench marks and is at an altitude of 3,856 metres. The total area occupied by the glacier is 33 square km out of which 28.5 square km form the area of accumulation and the rest the ablation area. The present study indicates that the glacier has retreated by 899 metres during the past fifty years, and has lost roughly 142 million cubic metres of ice since the last survey. The glacier has a fairly steep gradient with numerous crevasses both of the longitudinal and transverse types. The total thickness of the snow cover is about 4.8 metres. The position of the snow line and firn line is at 4,267 metres above mean sea level and the lower limit of snow in winter is at about 1,524 metres above mean sea level.

RÉSUMÉ

Les auteurs présentent l'étude du Glacier Sanapani, district de Kangra, Punjab. Le glacier a une longueur de 14,72 km et il est situé à 6 km au N.N.E. de la confluence des rivières Kulti Nala et Chandra. Le front du glacier a été levé. Il est à 3856 m d'altitude. Le glacier occupe une surface de 33 km² de zone d'accumulation et le reste de zone d'ablation. Le front du glacier a reculé de 899 m durant les 50 dernières années et a perdu environ 142 millions de m³ de glace depuis le dernier levé. Le glacier a une forte pente et présente de nombreuses crevasses longitudinales et transversales. L'épaisseur totale de la surface de neige est de 4.8 m. L'altitude de la limite des neiges et de la ligne de névé est de 4267 m, et la limite inférieure de la neige en hiver est de 1524 m.

I. INTRODUCTION

A survey of the Sonapani Glacier of Lahaul, in the Kangra district of Punjab, India, was undertaken by the authors during the months of August and September, 1957. The name "Sonapani" has probably been derived from the golden hue of the altered biotite-schist over which the glacier stream flows in the lower part of its course.

Physiography : There are two main mountain ranges in the area and they are the Great Himalayan Range striking roughly N.N.W.-S.S.E. on the north and the Pir Panjal Range striking NW-SE. on the south. There are peaks reaching heights of even 6,100 metres on both the ranges. Lahaul area lies north of the Pir Panjal Range and the valley has altitudes varying between 3,050 and 3,650 metres above the mean sea level.

Climate : The climate of the area is characterised by a long and cold winter extending from October to about the middle of April. During the winter months the minimum temperature goes down very much below the freezing point. The area enjoys moderate summer with day temperatures not exceeding 24°C, the night temperature

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being above freezing. The area being well over 6,050 metres in altitude has abundant snowfall during the winter months, when the precipitation is totally in the form of snow. It is reported that areas lying at altitudes ranging between 3,050 and 3,350 metres get an average snowfall exceeding 6.1 metres per annum. Lahaul is considered as a cloudless and rainless country and the average rainfall of the area is 15 centimetres, all of which is confined to the months of June and July. The precipitation on the northern side of the Pir Panjal is negligible compared with that on the southern, the reason being that the hill ranges act as an affective barrier against the rain clouds. Months of July and August are considered to be very favourable for carrying out surveys in this region.

The line of perpetual snow, above which summer heat and rain fail to melt the snow, is about 4,260 metres in Lahul, but on the southern side of the Pir Panjal, inspite of the higher precipitation of snow, it is above 4,260 metres. The lower limit of snow-fall on the south face, however, is as low as 1,525 metres.

Previous work : The one and only earlier survey of the Sonapani glacier including its snout was carried out by H. Walker and E. H. Pascoe (1907) during September, 1906. Besides surveying the Sonapani glacier they undertook the survey of the Bara Shigri Glacier also and even made an attempt to survey the Perad Glacier. The excellent sketch map accompanying their report was extremely useful in the location of the previous snout. The present survey of the Sonapani Glacier is after a lapse of over fifty years and an attempt was made to prepare a similar sketch map which will help future workers in the location of the present snout even in the absence of cairns.

II. THE SONAPANI GLACIER

Location : The Sonapani glacier lies roughly N.N.E. of the old rest house at Khoksar, with the glacier snout and the ice caves being situated at a distance of about 5.6 kilometres from it. The glacier snout is at present on longitude $77^{\circ} 19' 4'' E$ and latitude $32^{\circ} 25' 53'' N$, see Fig. 1.

Type of Glacier : The Sonapani is a valley glacier fed by many converging mountain tributaries. The trend of the ranges in the area is NE-SW and the glacier flows in this direction for about 5.6 kilometres in the lower regions. The flow of some of the tributaries is not particularly controlled by the trend of the ranges.

The main glacier has two tributaries meeting about 3 kms above the snout. The branch from the south-east is fed by a large snowfield amidst some of the prominent peaks of the area. The other branch is fed by a number of radiating tributaries. Besides the above, there is at least one minor tributary glacier seen on the south-east of Saragaru with its confluence one and half kilometres up the snout.

A number of hanging valleys form a prominent feature of the glacier, especially towards its higher reaches; and even near the snout an icefall with a drop of about 24 metres and having numerous tributary glaciers with fairly steep gradients join the main glacier.

Gradient : The Sonapani glacier has an uneven gradient and is interrupted by falls. The total fall of the glacier is about 1,430 metres in a distance of eight kilometres along the lower reaches. At places, there are abrupt falls of the glacier and one such is seen in the vicinity of Saragaru.

Crevasses occur most commonly at places where comparatively thin ice is flowing over an abruptly steepened slope. Ordinarily the central areas of the ice sheet having thick ice and very gentle slopes are characteristically devoid of crevasses and even when present they do not generally extend beyond depths of 30 to 60 metres. The large

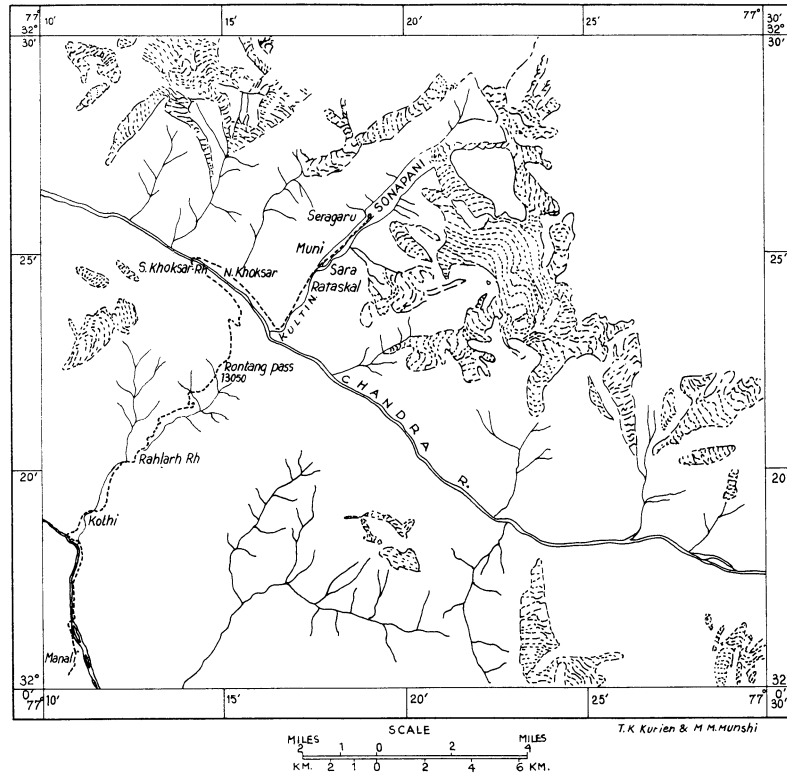


Fig. 1

number of longitudinal and transverse crevasses are characteristic of the Sonapani glacier. It can be deduced that this glacier has a rather steep bed rock gradient. However, towards the snout the gradient is less steep.

Length : The glacier has its source in the ranges SSW of the 19,229 foot peak and its present snout is in the vicinity of Saragaru, covering a total distance of 14.72 kilometres. Besides the main glacier, there is at least one subsidiary glacier, as has already been mentioned, flowing in a westerly direction, for a total length of about 6.4 kilometres.

Area : It has not been possible to estimate accurately the total area of the glacier without a detailed survey. The Sonapani glacier and snow-fields which feed it, lie amidst the 18,199, 19,481, 19,229 and 18,678 foot peaks and the area of the glacier is almost 33 square kilometres.

The snout : The snout of the glacier has a concave shape and has a width of 225 metres. It is situated at a height of 3,856 metres above mean sea level. The ice cliff in the snout region measures 46 metres in height. There are two ice caves, centrally situated, which are 103 metres apart, and streams emerge from them.

Position of the firn line : During the period of the present survey, there were inter-

mittent snowfalls at high altitudes in this region and the exact position of the firn line could not be determined. However, an attempt was made and the results indicate that the firn line lies at an altitude of 4267 metres.

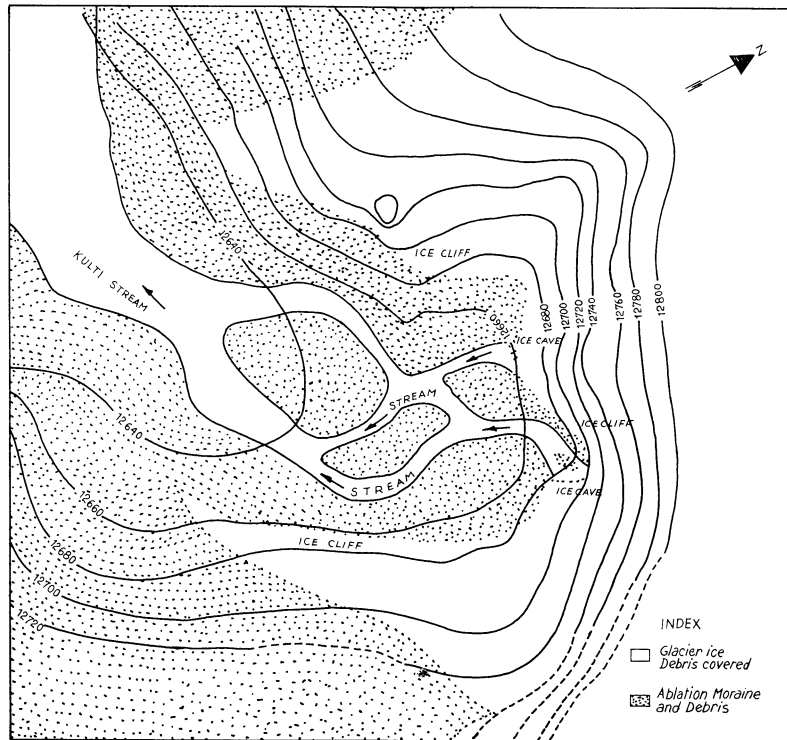
Approximate areas of accumulation and ablation : The area of accumulation of the Sonapani glacier is about 28.48 square kilometres and the area of ablation is about 3.88 square kilometres.

Lower limit of snow in winter : In winter the lower limit of snow in the Kulu valley is about 1,674 metres above the mean sea level. Manali, which is at an altitude of about 1,707 metres, has an average snowfall of about 1.2 metres per annum. It is, however, noteworthy that Manali and adjacent areas lie on the south face of the Pir Panjal range where the precipitation is more extensive than in the Lahaul area lying on the north of the Pir Panjal range. All the areas in Lahaul lie at altitudes exceeding 3,048 metres and they get abundant snowfall during the winter months. Khoksar and the neighbouring areas have an annual snowfall exceeding about 8 metres. The lower limit of snow in winter for this area can be assumed to be at about 1525 metres.

Inferred from morphological evidence : That the glacier during the early part of its history extended up to the Chandra valley is clearly indicated by the remnants of the moraine seen near the confluence of the Kulti Nala with the Chandra River. This is the oldest terminal moraine of the glacier and its position probably represents the position of the snout during Pleistocene times. The second oldest terminal moraine is at a distance of about 1.6 kilometres north of the confluence, but only scattered remnants of it are seen. The third and the largest terminal moraine is known as Rataskal and is situated at a distance of 2.5 kilometres from the oldest terminal moraine. A terminal moraine, partly covered by grass, is noticed on the left bank of the stream at a distance of about 2,438 metres from the Rataskal moraine. This moraine is younger than those mentioned earlier and the thinness of the grass cover shews it is recent. Further upstream at a distance of about 1,220 metres terminal moraines, thinly covered, are seen on both the right and left banks of the stream. Whereas all the other moraines are considerably eroded by the glacial stream, these have not been much affected. The younger terminal moraines are seen on the southwest of the red cliff and they stand out as small ridges amidst the ablation moraines of an earlier period. The glacier snout during the early part of the present century was very near the red cliff on the left bank. The area between the cliff and the present snout is covered by moraines of various types. Some of the terminal moraines in this locality are of small dimensions. It is often difficult to locate the terminal moraines of the more recent times and it can only be inferred that the glacier, in spite of its pronounced retreat during the early part of its history, has been only retreating rather sluggishly during the past few hundred years.

The snout of the glacier is concave and the ice-cliffs at the snout are nearly vertical. A concave snout indicates retreat of a glacier, whereas the vertical ice-cliffs indicate advance. These indications by themselves are not very significant, but when coupled with the other important evidences mentioned above, they go to prove beyond doubt that the glacier has retreated.

It may be hypothetically stated that the snow line in this area had commenced to rise by about the period when the snout started to retreat. Recession of the snout is common to most of the glaciers in the Himalayan region; but such retreats are rather irregular in amount, rate and time of occurrence. This may partly be attributed to the large annual fluctuations in the snowfall. An unusually long terminal retreat or advance in a glacier may be due to the ice being rather thin in the zone of ablation, especially at the snout and neighbourhood. The thickness of the ice at the snout of the



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Fig. 2

Sonapani glacier is only 46 metres and consequently variations in the thickness of the ice in the ablation zone will have a pronounced effect on the position of the snout.

Change in the volume of the glacier : The Sonapani glacier shows a total terminal recession of 899 metres, but it has not been possible to estimate the total thinning in the terminal zone. It is generally accepted that far more ice is lost owing to the thinning of the glacier below the firn line than by the inward migration of the snout itself. Ablation thins the ice in the zone where it operates and consequently the rate of flow of the glacier is affected. It has been found that the rate of flow varies approximately as the square of the thickness and hence even a small decrease in the thickness tends to decrease the flow of the glacier rather disproportionately. It has been estimated fairly accurately that out of the total ablation measured about 99 per cent is due to thinning of the terminal zone alone. The Sonapani glacier has lost a volume of about 142 million cubic metres during the past fifty years owing to terminal retreat alone, and from this one can easily visualise the loss of volume of the glacier due to thinning.

Morphological characters : The glacier follows a valley more or less uniform in width up to the locality just above the icefall and at the fall the valley narrows down considerably. Transverse crevasses are a prominent feature of the icefall. At the bottom of the icefall the glacier fans out into a broader valley and assumes a piedmont form

with longitudinal crevasses. The interrupted gradient below the icefall has been responsible for a number of transverse crevasses and this has resulted in a number of seracs. Marginal crevasses due to the higher velocity at the middle portions of the glacier are prominent on the left bank of the ice fall and they sometimes extend up to the middle of the glacier.

Streaks of lateral moraines are seen on either side of the glacier above the snout and below the icefall.

Snow features : The newly-fallen snow which has been superficially melted and refrozen into a crust, known as sun crust, is a common feature of the snow in this area. Thin ice found on the top of old hard snow, but separated from it by small air space is known as film crust. This has been noticed in the snow near the snout and is due to the high contrasts between night and day temperatures.

For about three days there was heavy snowfall in the area during the month of September. Initially, when the temperature of the atmosphere was near the freezing level, moist, dense type of snow was observed, but later when the temperature went below the freezing point, dry, powdery snow was noticed.

According to the Forest Research Division of the Punjab Government the actual average depth of snow accumulating at the end of the season, is about 3.05 metres at an altitude of 2,985 metres and 5 metres at 3,962 to 4,876 metres, above which precipitation does not increase perceptibly with increase in height. The measurement of accumulated depth of snow tends to be rather inaccurate, because of the rapid shrinkage at depth of newly-fallen snow, and hence the total amount of snowfall in the region should be more than the measurements taken at the end of the season. No systematic measurements of the total thickness of snow cover were made and only the total thickness of the accumulated snowfall is all that has ever been measured. Hence the figures available for this area may be considered as very approximate.

REFERENCES

- WALKER, H. and PASCOE, E.H. Notes on certain glaciers in Lahaul, *Rec. Geol. Surv. Ind.*, Vol. 35, Pt. 4, 1907.