

# GLACIATIONS OF THE PINDAR RIVER VALLEY, SOUTHERN HIMALAYAS

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ABSTRACT. The Pindari Glacier is situated in the heart of the Kumaon Hills in lat.  $30^{\circ} 17' N$ . and long.  $80^{\circ} 0' E$ . This glacier was visited by the authors in October 1959 when morphological and other observations were made. On the basis of these observations, it appears that during the last hundred years the rate of retreat of this glacier has been phenomenal, and it may be as much as 132 ft. (40.2 m.)/yr. There is also evidence that in the past the Pindari valley suffered at least two glacial advances.

RÉSUMÉ. Le "Pindari Glacier" est situé au cœur des "Kumaon Hills" à la latitude de  $30^{\circ} 17' N$  et à la longitude de  $80^{\circ} 0' E$ . Ce glacier a été visité par les auteurs en Octobre 1959 qui y ont réalisé des observations morphologiques etc. Sur la base de ces observations, il apparaît que durant la dernière centaine d'années la vitesse de retrait de ce glacier a été phénoménale, puisqu'elle a pu atteindre jusqu'à 40,2 m/an. Il est d'autre part évident que dans le passé la "Pindari valley" a subi au moins deux avances glaciaires.

ZUSAMMENFASSUNG. Der Pindari Gletscher liegt im Herzen der Kumaon Berge in  $30^{\circ} 17' N$  geogr. Breite und  $80^{\circ} 0' O$  geogr. Länge. Dieser Gletscher wurde von den Verfassern im Oktober 1959 besucht, dabei wurden morphologische und andere wissenschaftliche Beobachtungen angestellt. Auf Grund dieser Beobachtungen offenbart sich ein phänomenaler Rückzug, der in den letzten hundert Jahren 40,2 m/Jahr beträgt. Es ist ausserdem klar, dass das Pindari-Tal in der Vergangenheit mindestens zwei glazialen Vorstössen unterworfen war.

THE Pindari Glacier, which lies in lat.  $30^{\circ} 17' N$ . and long.  $80^{\circ} 0' E$ . 75 miles (121 km.) north of Almora, is one of the most easily accessible glaciers in the Kumaon region. It is situated almost midway between the well-known peaks of Nanda Devi and Nanda Kot (Fig. 1) in the Himalayas. Kapkot, to the south, is reached from Almora by bus or car, and from there the last 30 miles (48 km.) to the glacier have to be covered either on foot or by pony.

Owing to its ease of access the Pindari Glacier area has been a tourist resort since the beginning of the last century. It is therefore fortunate that a number of visitors have recorded their observations in the log books at the Phurkia Dak bungalow. The first published account of this glacier seems to be that of General R. Strachey (1847). In July 1906 the glacier was visited by Cotter and Brown (1906) who recorded the position of its snout. A Swiss expedition led by A. Heim visited this area in 1939, but it was mainly concerned with petrological studies. The present observations were made when the authors visited the Pindari Glacier in October 1959.

## THE PINDARI GLACIER

The Pindari Glacier (Fig. 2) is about 4 miles (6.4 km.) long and it terminates just above the medial moraine of the Pindari and Banghatia Glaciers. This glacier is fed by the *névé* fields on the north-western side of Nanda Kot, the cirque on the eastern slopes of Nanda Khat and the Banghatia and Baria Glaciers.

The ice flowing from Nanda Kot and Nanda Khat merges at Traill's Pass, the saddle between the two peaks. As this ice moves southwards it becomes the Pindari Glacier. Since the Baria and Banghatia Glaciers are the main sources of the ice forming the Pindari Glacier, a detailed study of them was considered worthwhile.

The Baria Glacier is nourished by the *névé* fields along the western walls of the Pindari valley. It flows northwards and then turns east joining the Pindari Glacier south of Traill's Pass. The Banghatia Glacier is fed by the Tail-chhanguch and Shel-chhanguch Glaciers, the former receiving its ice from the cirque on the western side of Nanda Kot, while the latter is fed by the *névé* fields situated along the eastern wall of the Pindari Glacier, between Lamchhir Point (lat.  $30^{\circ} 14' N$ ., long.  $80^{\circ} 2' E$ .) and Nanda Bhanar (lat.  $30^{\circ} 17' N$ ., long.  $80^{\circ} 3' E$ .).

Furthermore, the Banghatia Glacier joins the Pindari Glacier from the east at a height of 12,500 ft. (3,810 m.). A number of hanging glaciers descend from the east to the Pindari valley but all of their snouts lie above 16,000 ft. (4,877 m.).

From Traill's Pass the Pindari Glacier descends in two stages, each of about 2 miles (3.2 km.). In the first stage it descends 1,000 ft. (305 m.) but in the second it falls more than 3,500 ft. (1,067 m.).

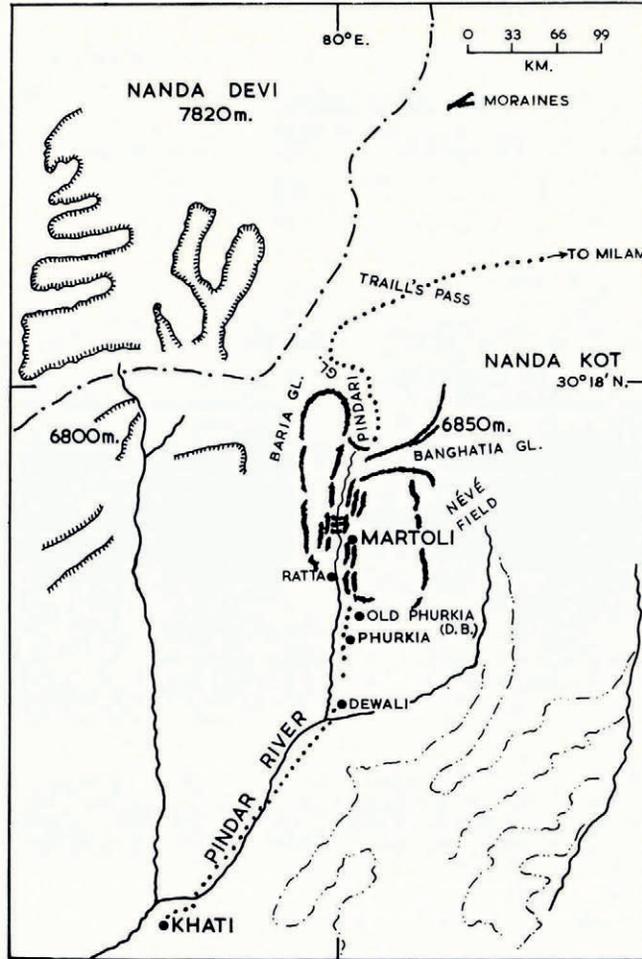


Fig. 1. Map of the Pindar River valley, reconstructed from information by Heim and Gansser (1939)

The upper half of the glacier has an almost unbroken surface but the lower half is traversed by transverse and longitudinal crevasses. All the melt water from the glacier is collected by a subglacial stream which emerges from an ice cave at the snout and this is called the Pindar River.

#### THE PINDARI VALLEY

The glaciated section of the Pindari valley has an elliptical bowl shape, being 3 to 4 miles (4.8 to 6.4 km.) in length with a maximum width of about 2 miles (3.2 km.). The Pindar

River emerges from this part of the valley through a narrow gorge and then flows in a roughly V-shaped valley (Figs. 3 and 4).



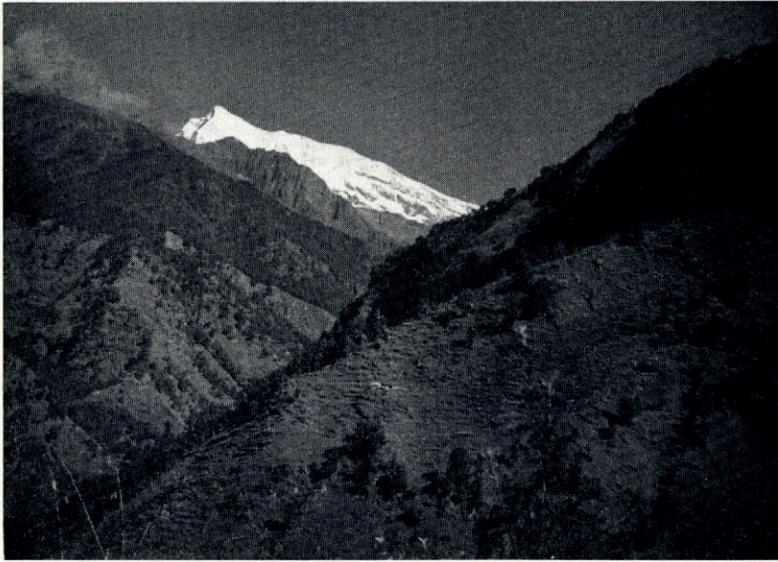
*Fig. 2. The Pindari Glacier, showing its snout, the ice cave and the source of the Pindar River. Part of the medial moraine between the Banghatia and Pindari Glaciers is in the right foreground of the photograph*



*Fig. 3. View of the Pindari Glacier from approximately 3 miles (4.8 km.) south of Khati village*

The glaciated part of the Pindari valley is flanked by steep walls. The western wall rises from the bank of the river in three steps which are at heights of 11,000 ft. (3,353 m.), 16,000 ft. (4,877 m.) and 19,000 ft. (5,791 m.) south of Martoli. The eastern wall rises gradually up to

12,000–13,000 ft. (3,658–3,962 m.) above which there is a steep rise to 16,000 ft. (4,877 m.). North of Martoli the eastern lateral moraine rises steeply from the banks of the Pindar River



*Fig. 4. The Pindari valley viewed from 2 miles (3.2 km.) north of Khati village*



*Fig. 5. The lateral moraine along the eastern wall of the Pindar River north-east of Martoli*

to a height of 500–1,000 ft. (152–305 m.) and the area between the eastern lateral moraine and the eastern valley wall slopes gently in a south-westerly direction.

## MORAINES

With the exception of some dirty ice near its snout, the Pindari Glacier does not appear to carry much morainic material; most of it has been washed away by the melt-water stream. Consequently, the Pindari Glacier could not deposit any high end moraines; however, between Martoli and its snout several low end moraines of recent origin were recorded. The western lateral moraine is poorly developed and rests on the rocky side of the valley, but the eastern lateral moraine and the medial moraine are well developed. The eastern lateral moraine (Fig. 5) is more than 1 mile (1.6 km.) long and ends 0.5 miles (0.8 km.) north of Martoli. The medial moraine is about 660 yd. (605 m.) in length and it has now completely dammed the southward movement of the Pindar Glacier. Near Martoli several crescent-shaped, grass-covered end moraines lie across the bed of the Pindar River. They rise gradually from the valley floor above the western lateral moraine. However, there are also moraines at several localities between the gorge of the Pindar River and the newly built Phurkia Dak bungalow. Due to continued erosional activity of the Pindar River and other melt-water streams, morainic types are seldom distinguishable.

The morainic material brought down by the Pindari Glacier is composed mostly of clay and silt, and it contains very few boulders and cobbles; however, some large boulders and cobbles occur in the old moraines.

## THE PLEISTOCENE GLACIATION

It appears that in the past the Pindari valley was intensely glaciated and it has probably experienced only *two glacial advances*. During the first advance (which was also probably the period of maximum glaciation) the glacier descended to at least 2 miles (3.2 km.) below the present gorge of the Pindar River. The lateral and subglacial moraines and the rough U-shape of the valley as far as this point provide sufficient evidence of this limit. Terra and Paterson (1939), and Heim and Gansser (1939) have recorded that in most parts of the Himalayas the maximum advance of glaciers was down to about 6,000 ft. (1,829 m.), but unfortunately this valley does not show any definite evidence of glacial advances below 9,000 ft. (2,743 m.). It would appear that the constriction of the Pindari valley at the gorge caused most of the ice to be dammed up, and the little that escaped from the gorge melted before it could reach a level of 9,000 ft. (2,743 m.).

During the *first phase* of the Pindari glaciation a 3,000 ft. (914 m.) deep valley was cut in gneisses, suggesting a prolonged period of glaciation which possibly included the first three Himalayan glaciations postulated by Terra and Paterson (1939).

After its first advance the Pindari Glacier gradually retreated to some distance above the Pindar River gorge and halted near Martoli. Due north of this point the western valley wall rises from the bed of the Pindar River without a break, but in the south it has a step cut at 12,000 ft. (3,658 m.). This pattern further implies that in the north the glaciation continued without a break while in the south the advance was preceded by a retreat.

During its *second advance* the glacier reached the Pindar River gorge, but it appears that it did not advance very far beyond this point. The presence of morainic material below the gorge may represent the remnants of the end moraines of this glaciation. The glacier perhaps occupied the whole of the valley above the gorge, since there is glacial till up to a height of 13,000 ft. (3,962 m.) along the eastern wall.

After this second advance the glacier's retreat was very swift in its initial stages but it slowed down as the recession reached Martoli. No end moraines have been recorded between Martoli and the gorge, but north of Martoli there are traces of several end moraines. During this retreat the Pindari Glacier was probably moving straight towards the Pindar River gorge but later on it was gradually forced towards the western wall by the overloaded and swift-moving Banghatia Glacier. This abrupt change in its direction was further influenced by the medial moraine which dams the Pindari Glacier at its confluence with the Banghatia

Glacier. Subsequent to this retreat the two lateral moraines, as well as the end moraines between them, were deposited.

#### CONCLUSIONS

From all the available evidence it appears that during the last hundred years the rate of retreat of the Pindari Glacier has been phenomenal. During 1885–94 a retreat of 100 yd. (91 m.) was recorded by Mitchell (unpublished). Cotter and Brown (1906) recorded the position of the glacier snout about 1 mile (1.6 km.) from the end of the medial moraine. When the authors visited this glacier they observed that the snout position was not far above the end of the medial moraine, at a height of 12,500 ft. (3,810 m.). The Banghatia Glacier had also retreated farther up-valley. In the light of these observations, the authors are of the opinion that the annual rate of retreat may be about 132 ft. (40.2 m.). The authors also believe that the morainic material recorded north of Khati is of pro-glacial origin, since this part of the valley is V-shaped. During Pleistocene times the Banghatia Glacier was probably more active than at present and carried a large amount of coarse morainic material.

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