THE BARA SHIGRI GLACIER, KANGRA DISTRICT, EAST PUNJAB, INDIA*

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Abstract. During the monsoon of 1956 the Geological Survey of India sponsored an expedition to the Bara Shigri Glacier (lat. 32° 16′ N., long. 77° 40′ E.), Kangra District, in the great Himalayan ranges of the Punjab, as part of the Indian programme for the International Geophysical Year 1956–57. Topographical maps of the terminal 5 miles of the glacier, on scales of 1 : 63,360 and 1 : 10,000, were prepared for comparison of morphological changes since it was last surveyed 50 years ago. The glacier appears to have shrunk considerably but its full extent could not be assessed because of insufficient earlier data. The Shigri Stream now emerges from a different part of the glacier snout. In order to assist future surveys three photographic stations were established.

Résumé. Au cours de la mousson de 1956 le "Geological Survey of India" [Service Géologique des Indes] a organisé une expédition au glacier de Bara Shigri (lat. 32° 16′ N, long. 77° 40′ E), dans le district de Kangra, dans les grandes chaînes Himalayennes du Punjab, en tant que participation au programme Indien pour l'Année Géophysique Internationale 1956–57. Des cartes topographiques des 8 derniers kilomètres du glacier, aux échelles du 1/63 360 et du 1/10 000 ont été préparées pour l'étude comparée des variations morphologiques avec les derniers relevés datant de 50 ans. Le glacier paraît avoir diminué considérablement mais sa pleine extension n'a pu être déterminée par suite des données antérieures insuffisantes. Le Shigri Stream émerge maintenant d'une partie différente du front du glacier. On a installé 3 stations photographiques pour favoriser les observations à venir.

Zusammenfassung. In der Monsunzeit des Jahres 1956 entsandte der Geological Survey of India eine Expedition zum Bara Shigri-Gletscher (32° 16′ nördl. Breite, 77° 40′ östl. Länge), Kangra District, in den grossen Himalaya-Ketten des Punjab. Diese Expedition bildete einen Teil des indischen Programmes für das Int. Geophysikalische Jahr 1956/57. Topographische Karten in den Massstäben 1 : 63 360 und 1 : 10 000 der untersten 8 km des Gletschers wurden aufgenommen, um durch deren Vergleich mit der letzten Aufnahme des Gletschers vor 50 Jahren morphologische Veränderungen feststellen zu können. Der Gletscher zeigt starke Rückgangserscheinungen, deren genaues Ausmass aber wegen mangelhafter früherer Vergleichsdaten nicht bestimmt werden konnte. Der Shigri-Fluss entspringt jetzt an einer anderen Stelle der Gletscherzunge. Für zukünftige Vergleichsaufnahmen wurden 3 photogrammetrische Messstationen errichtet.

Introduction

During the months of July and August 1956 an investigation of the Bara Shigri Glacier (lat. 32° 16′ N., long. 77° 40′ E.) in the Lahaul Tehsil, Kulu Sub-division, Kangra District, East Punjab was carried out with a view to discovering whether there had been any morphological changes in this glacier since it was first surveyed in 1906 by H. Walker and E. H. Pascoe of the Geological Survey of India. The author was accompanied by Dr. F. Ahmad, geologist of the Geological Survey of India, and a small contingent from the Geodetic and Research Branch of the Survey of India, which was led by Mr. C. M. Sapru. The surveyor-in-charge prepared topographical maps of the terminal five miles of the Bara Shigri Glacier on scales of 1 : 63,360 and 1 : 10,000.

Previous Investigations

Before the 1906 survey by H. Walker and E. H. Pascoe [1] the only description of the Bara Shigri Glacier was that by J. Calvert [2] in his book. The gazetteer of the Kangra District also contains a brief reference to this glacier, and an interesting description of it with a large photograph of the ice cave is given by P. H. Egerton.[3] Egerton mentions the existence of a lake formed by the damming of the Chandra River by the terminal moraine of the Bara Shigri Glacier upstream of the confluence of the Chandra and Shigri Rivers. This lake is also mentioned by Colonel Tyacke.[4]

During their survey Walker and Pascoe took some compass bearings on to certain prominent peaks in the vicinity of the glacier, and they set up several marked and painted

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photographic stations. As all the painted cairns have been destroyed by frost action comparative studies of glacier movement could not be undertaken from the original stations in the recent survey.

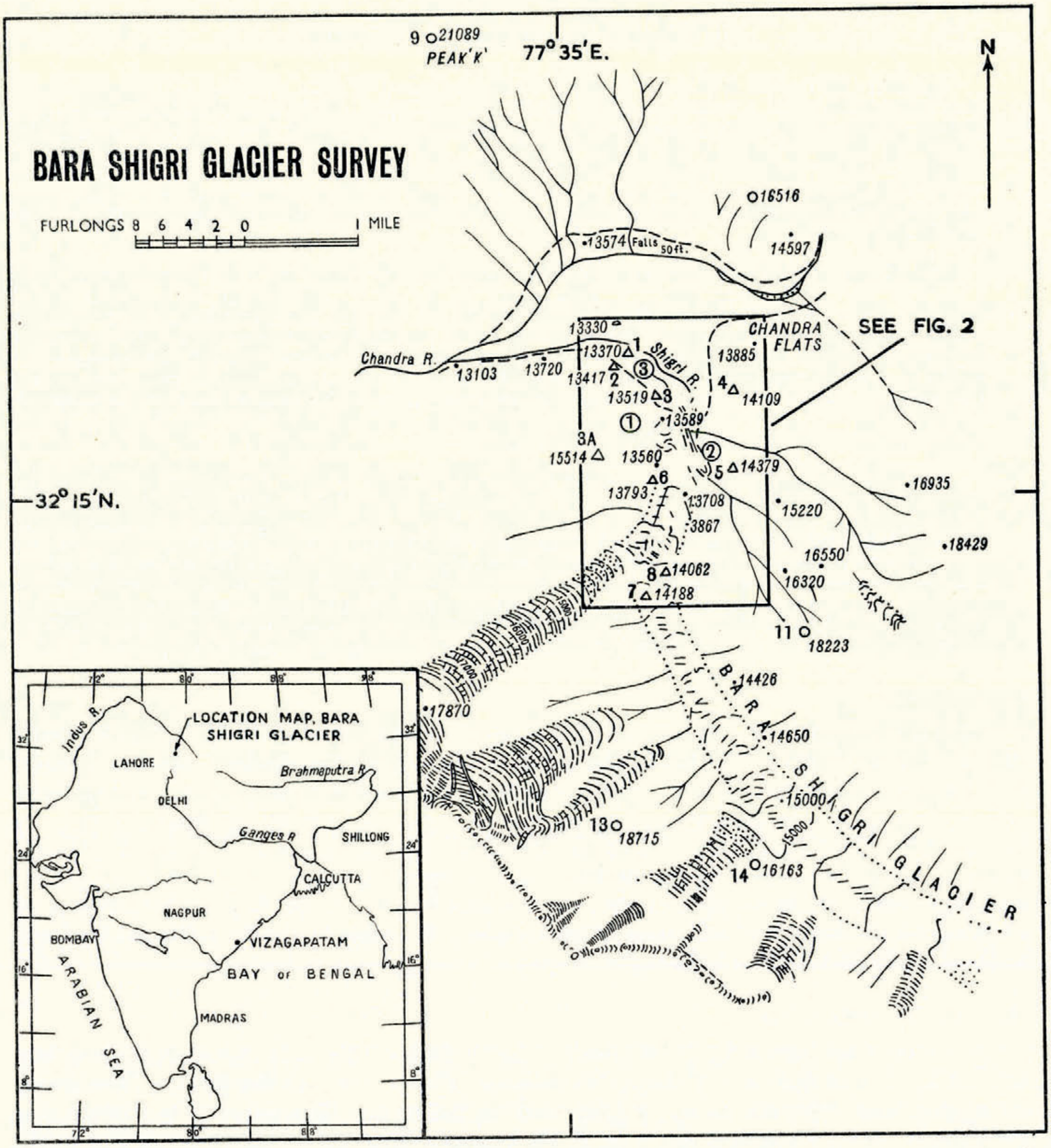

Fig. 1. Map of the Bara Shigri Glacier and the surrounding country. From an original survey on a scale of 1 : 63,360; heights in feet

Morphological Observations

Both in the Beas and Chandra Valleys the mountains bear unmistakable signs of recent alpine glaciation. Above the level of fluvial erosion the valleys are U-shaped and at other places the valley bottoms bear evidence of glacial erosion. In the Chandra Valley, between

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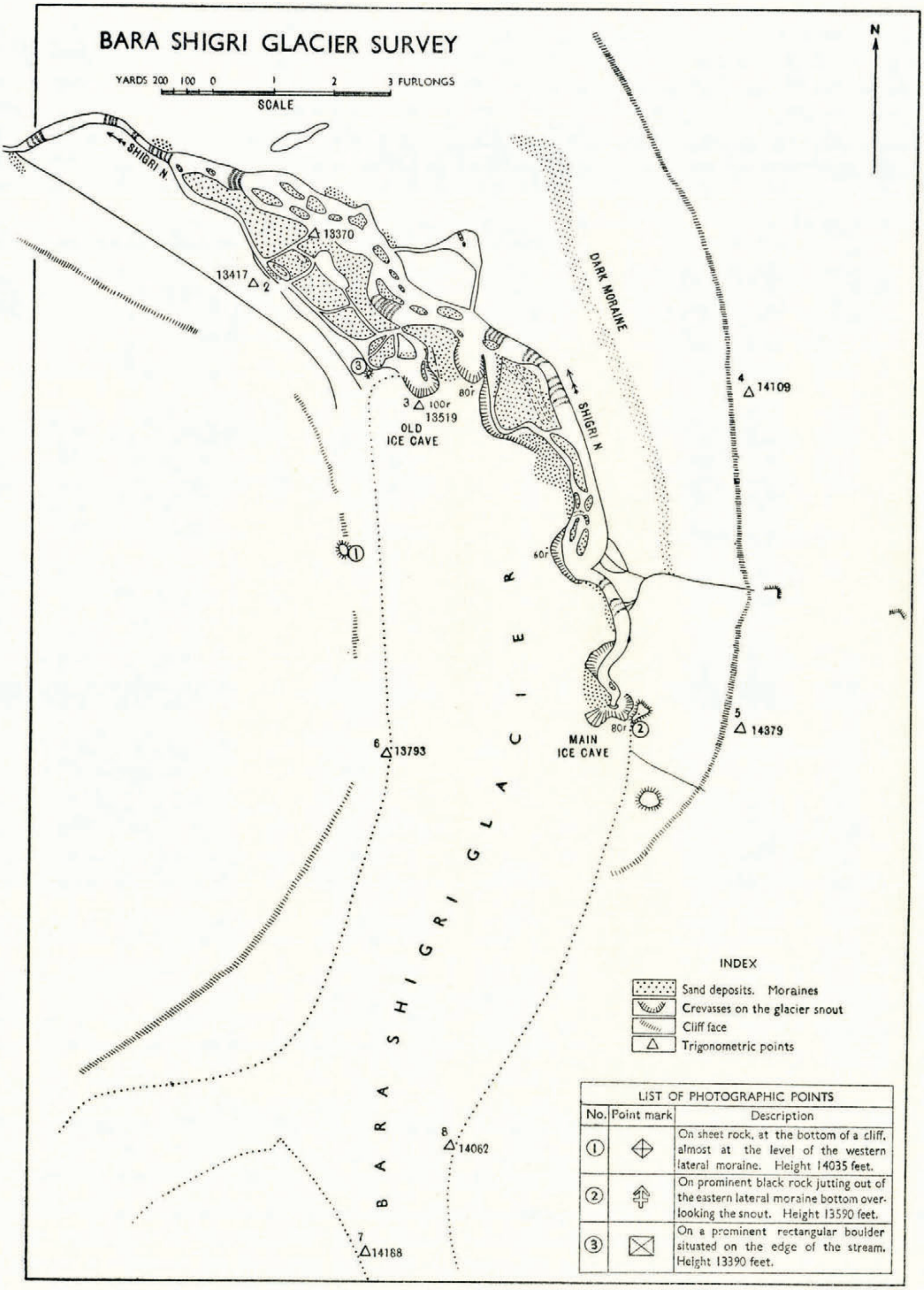

Fig. 2. Map of the terminal area of the Bara Shigri Glacier showing the distribution of the morainic deposits and the respective positions of the three marked photographic points. From an original survey on a scale of 1 : 10,000; heights in feet

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Rohtang and Spiti, which for the most part lies above 11,000 ft. (3,355 m.), except for some local modification by recent scree deposits, the U-shaped valley consistently retains its form. In some places the terminal moraine of the valley glacier descends into the Chandra River, while at other places wide terraces bear testimony to former morainic dams. The most important lake in this area, the Chandra-Tal (Fig. 3), lies on the site of an ancient glacier. The glacier west of Chandra-Tal had deposited a conspicuous terminal moraine on the east bank of the Chandra River and previously the glacial stream had joined the Chandra River across this moraine, but now it runs to the west of this morainic hill and joins the Chandra River about 1 mile (1·6 km.) farther south. There is a similar ancient terminal moraine at Karchha.

The Bara Shigri Glacier

The site of the Bara Shigri Glacier is shown as a dry stream on the Survey of India 1 : 253,440 topographical map (No. 52H, 4th edition). The confluence of the Shigri glacial

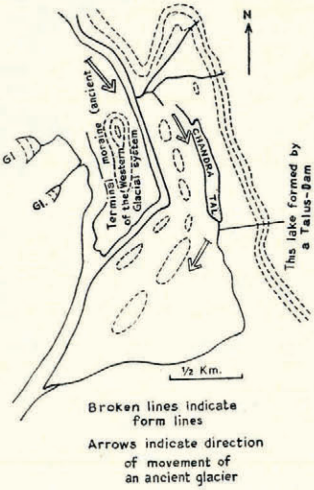

Fig. 3. Sketch map of the area around Chandra-Tal (lat. 32° 29′ N., long. 77° 40′ E.) showing the talus-dammed lake, ancient moraines and glacial striations

stream with the Chandra River is shown about 2 miles (3·2 km.) east of the actual confluence. At present the Shigri Stream, instead of joining the Chandra River directly from the south, detours to the west shortly after it leaves the ice cave and runs almost parallel to the course of the Chandra River up to Puti Runi (lat. 32° 17′ N., long. 77° 32′ E.).

A picturesque ice fall enters the Bara Shigri Glacier about 1 mile (1·6 km.) south-west of the ice cave. The impact of this ice fall, and of several others on the west side of the glacier, has caused an offsetting to the east of the active medial moraine.

Ancient moraines. As its name implies in the Spiti dialect, the Bara Shigri Glacier is so heavily covered with surface moraine that ice is not visible for long stretches, except along the crevasses and in the ablation areas. Across the valley of the Chandra River opposite the glacier snout, conical pillars of sand and boulders stand out as remnants of the ancient terminal moraine which existed there during the earlier part of the nineteenth century. These, as well as the dead eastern lateral moraine, are very conspicuous on this glacier. The terminal moraine is thicker on the eastern side than on the west, having a maximum width of nearly 0·5 miles (0·8 km.). From the evidence of this terminal moraine it is safe to conclude that this glacier has retreated more than 0·5 miles (0·8 km.), and in some parts farther, during the past 150 years.

Ancient lateral moraines occur near the Shigri Flats and about 2 miles (3·2 km.) farther west. Near the Shigri Flats they are quite common and they form narrow, parallel north–south ridges, having a maximum height of 20 ft. (6·1 m.), which protect the flats from the bitter westerly winds. The parallelism of the ridges indicates that they were deposited during the periodic movement of the glacier. One such ridge has been derived from one of the eastern lateral moraines of a tributary glacier which in the past joined the main Bara Shigri Glacier from the east a short distance below the ice cave. All these eastern valley glaciers have now retreated more than 0·75 miles (1·2 km.).

Immediately east of the ice cave the eastern lateral moraine of the Bara Shigri Glacier forms a steep scarp of boulders and sand, rising to a height of about 500 ft. (153 m.) above the level of the glacier near the snout. This moraine has been traced for more than 6 miles (10 km.) from the snout, although its relative height with respect to the glacier surface decreases progressively in the upper reaches of the valley.

The western lateral moraine occurs as a narrow parallel ridge about 0·75 miles (1·2 km.) east of the confluence of the Shigri and Chandra Rivers and it swings south-easterly near the western face of the glacier snout. The westerly deflection from its original northerly course perhaps occurred as a result of the bursting of the lake at Shigri. As already stated, this moraine is less conspicuous than the eastern one. Wherever the moraine occurs as isolated patches the hillside shows evidence of glacial erosion in the form of striations and grooves.

Cause of the lake burst. The breaching of the morainic dam was effected either by a flood due to an unusual rate of melting of the glacier system upstream of the Chandra River or by overflow of the lake caused by a landslide. A photograph by Walker and Pascoe [1] of the area below the snout indicates that the site which is now covered mainly by sand and relatively small boulders was covered by many large boulders 50 years ago. It is apparent that most of the boulders shown on the earlier photograph have disappeared as a result of the heavy discharge of melt water from the Bara Shigri Glacier.

Change in position of the ice caves. Another significant change in the glacier snout is that the principal source of the Shigri Stream is from a prominent ice cave near the eastern bank of the glacier (Fig. 6, p. 1013). Walker and Pascoe [1] indicated that in 1906 this stream emerged from an ice cave near the west side of the glacier, which at the time of the present survey appeared to be totally inactive. Perhaps the water emerges through interconnected underground channels, the courses of which are roughly indicated by indefinite longitudinal depressions on the surface.

Crevasses. Circular and crescent-shaped depressions on the surface of the glacier have been formed by the intersection of two crevasse systems, one running across the glacier (transverse crevasses) and the other running parallel to the direction of the movement of ice (longitudinal crevasses). In the ablation zone the transverse crevasses are crescent-shaped exposing dirt-covered ice. The longitudinal crevasses are formed on the moraine ridges in the ablation zone along north–south or north-north-east–south-south-west directions. Since the glacier was surveyed during the hottest period of the year (134° F. (57° C.) at 08.30 hr. on 7 August 1956) the movement along the main flow direction of the glacier was at its minimum. The change in the shape of the glacier snout has been principally due to melting of the ice by solar heat. A short distance below the ice cave the glacier melted up to a horizontal distance of 10 ft. (3·05 m.) in a five-week period. The melting of the ice takes place mainly along the direction of the longitudinal crevasses (Fig. 7, p. 1014) and melting near the ice cave has been more rapid than in the western part of the snout, because this particular face receives the full heat of the morning sun.

The plastic flow of ice. Another interesting feature observed near the most advanced part of the glacier snout is the phenomenon of plastic flow in the ice. Here the bottom of the glacier has moved farther down-glacier in relation to the upper surface. Presumably, as a result of the insulation by a thick mantle of sand and boulders, the surface of the glacier has moved less.

Subglacial features. The base of this glacier is nowhere exposed but observations on other valley glaciers in this area indicate an absence of a basal load. Judging from the way the small green lakes and pools of water down-stream of the glacier snout augment the supply of water without any visible surface link with the main glacier, it seems probable that the base of the glacier extends to deeper levels than is apparent from its surface extent. In this way alone the green lakes could escape contamination by glacier surface dirt.

Glacial Deposits

The glacial drift deposits can be divided into wind-blow detritus, surface and subglacial moraines, crevasse filling and fluvio-glacial sediments.

Wind-blown deposits. Throughout the entire period of the author's stay there was a steady north-westerly wind, which carries sand and gravel, twigs and plant fragments, including pollen and spores, on to the glacier surface. In the accumulation area at the head of the glacier the detritus becomes embodied in the ice and travels beneath the surface to become visible again only in the walls of the crevasses or at the snout.

Near the western side of the glacier snout at about the position of the old ice cave the dip of the dirt bands is 10° towards S. 60° E. (Fig. 7). In the ablation zone about 200 yd. (183 m.) north of the present ice cave the bands dip at 20° towards N. 70° W. but about 200 yd. (183 m.) north-west of the ice cave the glacier dirt bands are sharply folded into an asymmetrical syncline.

The dirt found at the base of the ice fall, 1 mile (1·6 km.) south-west of the ice cave, indicates that the central part of the glacier ice has moved faster relative to that at the sides of the glacier. Complex movements in the ice have resulted in the formation of recumbent folds and even thrust faults in the dirt bands.

Surface moraines. The active moraines of the Bara Shigri Glacier are the medial and lateral ones. Near the snout the former is slightly east of the centre of the glacier. The rocks comprising the moraines are mainly dark brown mica-schists with occasional Haimanta (Cambrian?) conglomerates, which only occur *in situ* near the ice cave; farther up-glacier for a distance of many miles the country rock is granite. The material forming the medial moriane (Fig. 8, p. 1014) seems to have entered the main glacier from a small valley glacier about 12 miles (19 km.) from the snout.

The published quarter-inch map shows the presence of many side glaciers entering the west flank of the glacier but in fact these are nothing more than ice slabs and ice falls, over one of which is a recently explored track to the Kulu Valley. At the confluence of each of these ice falls with the Bara Shigri Glacier the medial moraine has been offset slightly towards the eastern flank. In the past this moraine had perhaps extended about 0·5 miles (0·8 km.) down-stream of the glacier snout.

Near the snout the active lateral moraine has no obvious boundary and it often grades into talus and scree deposits from the valley sides. In general, these indefinite morainic boulders are more angular and larger in size than those comprising the medial moraine.

Crevasse filling and fluvio-glacial deposits. Along the flanks of the crevasses boulders have tumbled down the ice slopes into hollows and kettle holes. The crevasses are occasionally so close to each other that the small intervening areas stand out as conical boulder-covered mounds. Both the circular and crescent-shaped crevasses possess ice faces which are well exposed towards the margin of the glacier. The crevasses change direction in various parts of the glacier and there are usually four sets of directions near the intersections of the main glacier with its tributaries.

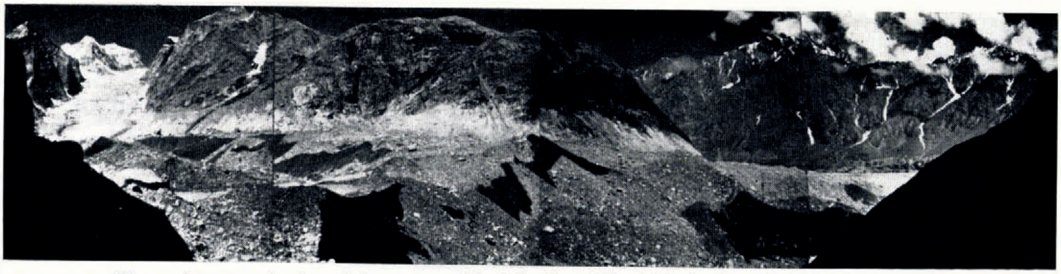

Fig. 4. A panoramic view of the western side of the Bara Shigri Glacier from photographic station 2

Fig. 5. The snout area of the Bara Shigri Glacier viewed from the ancient terminal moraine

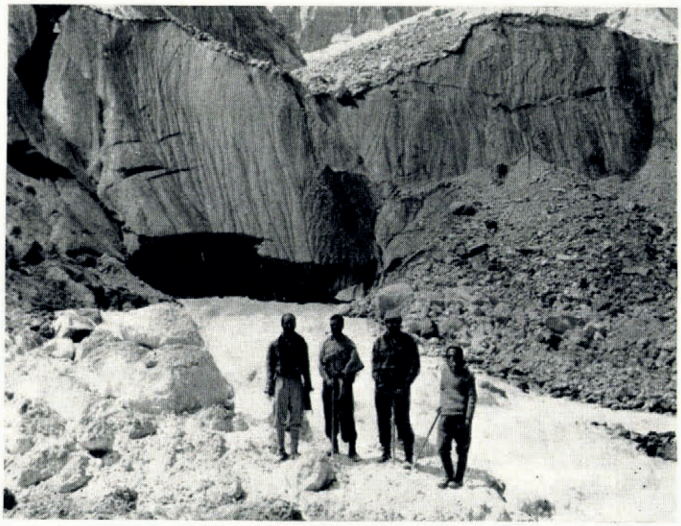

Fig. 6. The main ice cave at the snout of the Bara Shigri Glacier showing the source of the Shigri Stream

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Fig. 7. Part of the snout of the Bara Shigri Glacier illustrating the longitudinal crevasses in the ablation zone and the prominent dirt bands

Fig. 8. A general view of the Bara Shigri Glacier about 3 miles (5 km.) up-glacier from its snout. The dark medial moraine can be seen on the glacier surface

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Up-glacier from its snout no visible surface streams extend for more than 400 yd. (366 m.). Some of them originate from side-valley glaciers but they soon disappear below the ice surface into underground channels only to reappear with great force at the main ice cave. Alternate freezing and thawing have caused the disintegration of the material forming the ablation and ancient moraines. This material has intermixed with river gravel and sand to form a wide tract of country between the glacier snout and the course of the Chandra River.

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