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VOL. XXXV, PART 2.

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CONTENTS.

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RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

Part 2.] 1907. [May.

NOTES ON SOME INDIAN AEROLITES. BY L. L. FERMOR, A.R.S.M., B.SC., F.G.S., *Assistant Superintendent, Geological Survey of India.* (With Plates 4 to 15.)

CONTENTS.

I.—GENERAL REMARKS.

THE object of this paper is to put on record an account of the circumstances of the fall and external characteristics of specimens of four Indian aerolites or stony meteorites, concerning which only preliminary notices have appeared.[1] No attempt has been made to investigate the mineralogical and chemical composition of these aerolites. Two of these, Karkh and Bholgháti, fell in the year 1905, whilst the other two, Haraiya and Delhi, fell in the years 1878 and 1897 respectively, but have only recently been acquired by the Geological Survey of India.

[1] *Rec. Geol. Surv. Ind.*, XXXIII, pp. 72, 73, (1906); *Journ. and Proceedings, Asiatic Soc. Beng.*, *II*, pp. *xlix*, *l*, (June 1906).

An account is also given of the fall which took place at Andhára in 1880, although this meteorite is lost to science, as it has been made an object of worship by the inhabitants of the part of Bengal in which it fell.

It will be convenient to give in this place a list, as far as possible in chronological order, of all the falls known to have taken place within the bounds of the Indian Empire. It is possible, of course, that by a search of old astronomical and historical works records of other falls might be obtained. The list is as follows:—

List of Indian Meteoric Falls.

Year of fall.	Name of fall.	Year of fall.	Name of fall.
1798	Benares.	1857	Parnallee.
1808	Moradábád.	1860	Khairagarh.
1814	Gurram Konda.	1860	Kusiali.
1814	Chail.	1860	Dharmsála.
1815	Durala.	1861	Batsura.
1822	Kadonah.	1860-62	Meerut.
1822	Fatehpur.	1863	Pulsora.
1822 or '23	Ambála (Umballa).	1863	Shaital.
1827	Mhow (Mau).	1863	Mánbázár pargana.
1834	Chaharwala.	1865	Supuhi.
1838	Akbarpur.	1865	Gopálpur.
1838	Chandakapur.	1865	Sherghotty.
1843	Mánegáon.	1865	Maddur táluk.
1850	Shalka (Sáluká).	1865	Udipi.
1852	Yatur.	1866	Pokhra.
1852	Basti.	1866	Jamkhair.
1853	Segauli (Segowlie).	1867	Khetri.

List of Indian Meteoric Falls—contd.

Year of fall.	Name of fall.	Year of fall.	Name of fall.
1868	Lodhrán.	1886	Nammianthal.
1868	Moti-ka-nagla.	1887	Lalitpur.
1870	Nedagolla.	1890	Kakangarai.
1872	Dyalpur.	1890	Nawapali.
1873	Jhang.	1893	Bherai.
1873	Khairpur (and Maili).	1894	Bori.
1875	Sitatháli.	1895	Bishanpur (and Parjabat-pur).
1875	Nagaria.	1895	Ambapur Nagla.
1875	Queng-gouk.	1897	Gambat.
1876	Judesgherry (Judesegeri).	1897	Delhi.
1877	Bhágur (Dhulia).	1897	Kángra Valley.[1]
1878	Haraiya.	1898 (found)	Kodaikánal.
1878	Dandapur.	1899	Donga Khurd (Kohrod).
1879	Kalambi.	1901	Sindhri.
1880	Andhára.	1903	Dokáchi.
1882	Pirganj.	1905	Karkh.
1884	Pirthalla.	1905	Bholgháti.
1885	Chandpur.	Unknown	Goalpára.
1885	Sabet Mahet.		

The total number of falls recorded in this list is 71, of which all but three (Nedagolla and Kodaikánal) are stony meteorites or aerolites. Of these, 66 took place during the nineteenth century, or an average of 2 every three years. During the second half of the century,

[1]This is a meteorite recently described by Professor W. N. Hartley in *Proc. Chem. Soc., London*, Vol. 22, p. 251.

in which, in all probability, a larger proportion than previously of the falls which occurred were brought to the notice of science, 52 falls were recorded in 50 years or roughly 1 every year. Hence it can be expected that on the average at least one meteoric fall a year within the limits of the Indian Empire will be recorded during the twentieth century. The actual number of falls is probably considerably larger than the recorded number; for if the falls be arranged according to provinces, thus:—

United Provinces	21
Panjáb	10
Bengal	8
Madras	8
Bombay	7
Central Provinces	5
Eastern Bengal and Assam	4
Rájputána	3
Central India	2
Mysore	2
Baluchistán	1
Burma	1
	72[1]

it becomes evident that meteoric falls are most frequently reported in areas where the population is densest. Meteorites probably fall just as often in the less densely populated areas, where, however, they have less chance of being observed. Similar considerations, no doubt, explain why India, being, on the average, a very densely populated country, is apparently one of the most favoured parts of the earth's surface for meteoric falls. They do not explain, however, why the 71 falls recorded for India consist of 68 aerolites, 2 siderites or irons (Nedagolla and Kodaikánal), and 1 siderolite (Lodhrán), while out of 24[2] supposed meteorites recorded from Australia, 19 are siderites or irons, 2 are siderolites, and only 3 are aerolites or stones.

Specimens of all the falls given in the list on pages 80 and 81 are in the Museum of the Geological Survey of India, with the exception of Gurram Konda, Chail, Bherai, and Kangra Valley, portions of all of which we should like to acquire by exchange, and of Andhára of which no portion has reached any museum.

[1] One fall, Khairpur and Mailsi, took place in both the Panjáb and Rájputána.

[2] According to the 1904 "Catalogue of the Ward-Coonlay Collection of Meteorites," by the late H. A. Ward.

II.—THE BHOLGHÁTI METEORITE (No. 241).[1]

This meteorite fell at about 8-30 A.M., on 29th October, 1905, at Bholgháti village (22° 5′ N. and 86° 54′ E.), Deoli pargana, Morbhanj State, Bengal. According to a statement of Karu Majhi, son of Anupa Majhi, of Bholgháti, forwarded under cover of a letter from His Highness the Maharaja of Morbhanj,

"The sky was not cloudy. The meteorites fell almost simultaneously. His attention was first attracted by the noise resembling the roaring (dho—dho—) of the clouds. He looked up and saw two stones approaching the earth. They were not luminous. When they approached further the noise resembled that of rocket (sar-r-r). One of the meteorites fell a few paces off his verandah where he was sitting at the time of the occurrence, and the other in the jungle about 150 yards off his house. He took away the first one as soon as it fell down."

This is the meteoric stone (241·A) which was forwarded and presented to the Geological Survey of India by Mr. P. N. Bose, Geologist to the Morbhanj State, on behalf of the Maharaja. The second piece (241·B), which fell in the jungle close by, was also recovered and is the property of the Morbhanj Museum, but has been lent to the Geological Survey for examination.

These two pieces weighed respectively 1,000·6 and 1,578·9 grammes, giving a total of 2,579·5 grammes for the fall.

The first meteorite (241·A) received weighs 1,000·6 grammes, and is almost a complete aerolite, except for a few pieces chipped off. Its general appearance and shape are well shown in Plates 4 to 6.[2] If the portions chipped off were restored to the stone its shape would be roughly that of a tetrahedron, of which one side forms the base on which the meteorite rests in Plates 4 and 5. The other three sides of the tetrahedron may be designated A, B, and C, as indicated on the plates. In Plate 6, the meteorite is inverted so as to show this base uppermost. The crust is brownish-black, in some places dull, but in others shining black. The shiny parts form little glossy specks and patches, the latter being in places quite large, as is well

[1] The number of the meteorite in the register of the Geological Survey collection.

[2] I must express my thanks to Mr. H. B. W. Garrick for the fine set of photographs with which I am able to illustrate this paper.

seen in Plate 4, fig. 1. There are a few shallow pittings shown in Plate 4, fig. 1.

Where fractured the aerolite shows a dark-grey matrix in which are set many white greenish and brownish, angular and rounded, patches, shown well in Plate 4, fig. 2, which is somewhat enlarged, the photographic plate having been exposed for the contrast in the fractured part of the meteorite instead of for the detail in the crust, as was the case in fig. 1.

Some of these patches are $\frac{1}{4}$ or even $\frac{3}{8}$ inch long, and while some of them are seen to be composed entirely of one mineral, others resemble rather fine-grained rock fragments, and together they cause the meteorite to resemble a volcanic rock containing phenocrysts and angular fragments of rock in a dark fine-grained matrix. There are also some included black patches up to $\frac{1}{4}$ inch in diameter, one of which is shown in Plate 5 in the fractured part. A small chip of this heated on platinum became pale greyish in colour, so that it is probably partly composed of carbonaceous matter.

The second aerolite (241·B) weighs 1,578·9 grammes and is figured in Plates 7 and 8. The stone is roughly rectangular in shape and is covered with crust on five sides. The remaining one, the top side as seen in Plate 7, is made up of fracture-surfaces, of which the left hand portion is quite free from crust; whilst the right hand portion is a fracture which must have formed by the splitting off of a piece of the aerolite whilst still in air, for the fracture has since been partly covered with a new crust. This new crust is well shown in Plate 8, on the fracture-surface seen to the left. The front face of the meteorite (Plate 7) is beautifully curved and is covered with a dull blackish crust, on top of which are patches and networks, especially towards the edges, of a shining dark brown slag-like vitreous crust. The right hand end seen in Plate 8 shows parallel fluidal ridges of shiny brownish-black crust with some of the same smooth angular black patches of shiny crust as are seen in the other aerolite. In only one place on either stone does one of these smooth black patches of crust come against the edge of a fracture, and here it is seen to correspond to one of the whitish angular rock-like fragments which are included in the dark grey ground-mass; the probability therefore is that all these shiny smooth parts of the crust correspond to underlying breccia-like or porphyritic inclusions in the dark-grey ground-mass. This indicates that at least some of the light angular patches are more easily fused than the main part of the aerolite. The back side of the aerolite is similar to the right hand end, whilst the left hand end and base of the stone are formed by fracture-surfaces, formed long before the stone reached the earth, as they have been almost completely recovered by crust.

III.—THE KARKH METEORITE (No. 239).

The first indication that a meteoric fall had taken place in the Jhálawán Agency, Baluchistán, was an extract from the diary of Major H. L. Showers, Political Agent, Kalat, forwarded to the Geological Survey Office by the First Assistant to the Agent to the Governor-General and Chief Commissioner in Baluchistán. This extract contained an extract from the diary of the Native Assistant, Jhálawán, relating to phenomena noticed on the 27th April, 1905. The Native Assistant was passing near the Nar spring in the Mula Pass about 1 P.M. when he heard what he thought was the report of a gun on the adjacent hills. This was followed by another "echo" of the same sort, soon followed by a "thundering noise." The sky was cloudless. This noise resembling thunder is reported to have been heard all round the Mula Pass up to Naulang and several people are said to have seen "a flaming star like a ball running about during the middle of the day. Before the thundering noise ended the ball became extinguished and left clouds of smoke after it. The flaming ball is said to have had a long tail of smoke."

The Native Assistant's diary further states:—

"It is reported from Karkh that the noise rose in the Wehari Hills near Karkh and a star was seen rising from the top of a hill and some big stones were heard falling from the hill."

It seemed probable that this last passage indicated the fall of a large meteorite near Karkh, and this probability was confirmed when, in response to a request from the Director of the Geological Survey that a search should be made, the fine mass of meteoric stone shown in Plates 9 to 11 was received from Karkh, having been obtained by Major Showers.

Mr. Vredenburg of the Geological Survey of India subsequently visited Karkh and obtained from the Native Assistant, Jhálawán, a second piece of the meteorite, shown in Plate 12. He was unable however, to obtain any trustworthy details as to the exact circumstances of the find, or to trace what had become of the remainder of the meteorite, for the two masses obtained were evidently only portions of a very large meteorite.

Subsequently, however, as the result of further enquiries, Major Showers gained some additional information, according to which the meteorites fell at two different places, 15 miles apart, on the same date. The large piece (239·A), and probably also the second piece (239·B) mentioned above, was found on the banks of a dry nullah below the Sumbáji Hills. Many small fragments (239·C and 239·D) were collected at this locality where they "were found in a small oval-shaped hollow about two feet in diameter and one foot deep." "The second meteorite fell in the Michára hills on a flat piece of sheet rock. In falling it fractured the rock and was itself broken into four pieces." Two of these, 239·E and 239·F, have reached the Geological Survey collection through the Second Assistant to the Agent to the Governor-General in Baluchistán, and Mr. G. H. Tipper.

The Sumbáji Hills (highest point △ 6,448 feet) lie about 14 miles W. N. W. of Karkh and the Michára Hills about 5 miles W. N. W. of this place, so that the distance between the two spots is about 9 miles. The line joining these two sets of hills lies about W. N. W. to N. W. and this line should correspond with that of the flight of the meteorite. If the fact[1] that a much larger total weight (18,896 grammes) of meteorite was received from the Sumbáji Hills than from the Michára Hills (2,939 grammes) can be taken to indicate that a larger weight fell in the former place, then it seems probable that the direction of flight was from S. E. to N. W. or from E. S. E. to W. N. W. For we can suppose that the original meteoritic mass fractured at a considerable height above the earth's surface into two main pieces, of which the heavier travelled farther than the lighter. The piece which fell in the Sumbáji Hills may not have suffered further disruption till impact with the earth's surface or until broken by human agency. But the Michára portion must have disrupted before impact with the earth's surface, for the two pieces received from these hills had evidently become separate before they reached the earth's surface, as the fracture-surfaces of one piece are covered with a thin crust.

[1] On page 89 it is noticed that there has evidently been some mistake made with regard to the place of origin of C, D, E, and F. But even if we suppose C and D, as well as E and F, to have come from the Michára Hills, it still gives a much larger total weight from the Sumbáji Hills

The weights of the various pieces of this fall as received in the Geological Survey Office are shown in the following table:—

Place of Origin.	Number.	Weight.	Total weight for each locality.	Total weight of fall received.
		Grammes.	Grammes.	Grammes.
The Sumbáji Hills	239·A	14,546		
	239·B	3,087		
	239·C	878		
	239·D	385	18,896	
The Michára Hills	239·E	2,196		
	239·F	743	2,939	21,735

21,735 grammes is about 47·7 lbs.

The largest mass (239·A) is evidently but a portion of a much larger mass, but the fractured surfaces do not look very fresh so that the meteorite may have broken at the time of hitting the hill. It is covered by crust over about one-half its superficies. This crust is nearly all dull black, but at one end has adherent to it a number of rather soft white patches which effervesce with dilute acid and probably indicate that the meteorite fell on a limestone formation.

Plates 9 and 11 show the shape of this mass. There are abundant pittings or thumb-marks on the crust; these are seen in Plate 9, which is only half natural size. In Plate 10 a portion of the crust is shown natural size. This shows the groove-like character of some of these pittings. It is evident from the beautiful flow-structures shown by the crust on one side of these grooves that they must have been scooped out of the fused exterior of the aerolite by the air as it rushed over the surface of the meteorite during its rapid flight through the earth's atmosphere.

This flow-structure indicates the orientation of the meteorite in the line of flight during the time in which these grooves were cut out, the molten crust flowing, of course, towards the rear end of the stone. One portion of the crust shows a little slickensiding striation.

The fractured surfaces are of a dark ash-grey colour and where freshest show a few very light-grey chondri usually about $\frac{1}{16}$ inch in diameter. There are also scattered pale yellowish metallic points.

The smaller piece (239·B), though evidently a part of the same fall, does not fit the larger piece anywhere. One side of it, shown in Plate 12, fig. 1, is completely covered with a rather dull black crust, showing groove-like pittings and flow-structures where the molten crust has flowed over the top edge of the side shown. There is also a certain proportion of crust on the top side of the meteorite. This is shown in fig. 2 in which we are looking down on the fragment placed as in fig. 1. The crust on this surface has in places a scoriaceous or cindery appearance. Besides this fig. 2 also shows, in the S. E. corner, the thickness of the crust which is somewhat variable but seems to average about 0·5 mm. The back surface of the fragment as placed in fig. 1 consists entirely of fracture-surfaces, while the base on which it rests is largely covered with a thin dull (in places rather shiny) black coating and is possibly a fracture, produced by the disruption of the meteorite during flight, over which a very thin coating of crust formed before the stone reached the ground. On account of this old fracture-surface it seems probable that this piece and the large mass are portions of two separate sections of the meteorite which were disrupted from one another during flight and reached the ground separately.

239·C and 239·D were received together and consist of a weight of 1,264 grammes of chips. These were separated into 122 larger pieces weighing 878 grammes, of which the largest weighed 25·7 grammes, and some 200 to 300 smaller chips. Many of the chips are bounded entirely by fracture-surfaces, but a certain proportion have a little crust on one side. The fractures are evidently old, being now somewhat rusty, and many of them have on them a little soft buff-grey calcareous matter which is probably of the nature of tufa deposited on them as they lay on the ground. From this it must be concluded either that they were broken off at the time of impact of the meteor with the ground, or, and more probably, that they were broken off by the natives in their curiosity to see what the stone was. In either case they must have been left lying on the ground for a sufficient length of time for surface waters to have deposited on them calcareous tufa derived either from immediately underlying or from neighbouring limestone. Most of the fragments were of the same character as 239·A, but there were a few chips of a fine-grained pale grey rock, one piece having a layer of nickel-iron attached. Of 14 of these pieces, 12 had crust attached, and the remaining 2 had a secondary crust. In fact, it is evident that these chips are a portion of a similar layer of stone forming part of 239·E, and consequently that the information about the localities, according to which C and D fell on the Sumbáji Hills and E and F on the Michára Hills, is open to some doubt. If meteoritic matter did fall at these two separate places, then the specimens from these two localities must have been mixed before they reached Major Showers.

239·E is not figured here. It is about 6½ inches long by 4½ inches broad and 4 inches high, and is perhaps ⅛ covered with a dull black smooth crust (which may be called primary crust), whilst there are five fracture planes on which the rock has been re-fused so as to form a thin black, slightly shiny crust. The fresh fracture is of the usual dark grey. The most interesting point about this stone is that at one end there is a layer of much finer grained and much paler (light brownish grey) meteoritic material than forms the main mass of this stone and the whole of all the others except 239·F. This layer is ⅜ inch thick, 2½ inches long, and 2 inches broad. It is so fine-grained and structureless in appearance that it looks like a very fine-grained limestone at first sight. It is joined to the remainder of the meteorite along a flat surface which has been partly uncovered, owing to the chipping off of pieces of the lighter rock, so as to show signs of a shiny black crust-like layer separating the two portions of the stone. There is also a slight difference in the texture of the crust covering the two portions of the stone. In the fine-grained portion there are areas of yellowish nickel-iron in thin layers up to half an inch across.

239·F, which is also not figured, is about 3¾ inches long, 3 inches broad, and 2½ inches deep. Over one-half of it is covered with a black crust, rather shiny in places. On the fracture-surfaces are abundant tiny yellow specks of nickel-iron striking up. At one end is a little of the fine-grained light grey material similar to that in 239·E, but the junction between the light and the dark portions is obscured.

Composition of the meteorite.

Dilute hydrochloric acid applied to a fresh fracture-surface of any of the pieces of this fall gives rise to the emission of a strong smell of sulphuretted hydrogen. Microscope sections indicate that the stone is a rock composed mainly of olivine, enstatite, nickel-iron, an opaque constituent suggesting pyrrhotite by its bronzy lustre, and an opaque black mineral. Both the latter are probably sulphides. The specific gravity of the large pieces 239·A was roughly determined as 3·60. That of 239·F is 3·55.

IV.—THE DELHI METEORITE (No. 238).

According to a letter, dated 19th February, 1898, from Mr. J. Greson, Inspector of Railway Police, Allahabad, to the Reverend Father Francotte, S.J., of St. Xavier's College, Calcutta, some natives who were working in the fields in the evening of the 18th October, 1897, saw at about 7-30 P.M. a meteor of unusual brilliancy; a few seconds after, a noise similar to thunder was heard, and about the same time two stone-like bodies (each weighing about a pound) were heard to fall. They were black on the outside, but when broken were light blue or greyish.

Unfortunately this occurrence was not brought to our notice till 1903, and it was then impossible to trace these stones, partly on account of a change of the district officials, but no doubt partly due to the reluctance of the owners of the pieces, into which the stones had broken, to admit their possession. Hence the only specimen of this fall in the Geological Survey Museum is a tiny fragment sent with the above-cited letter by Mr. Greson to Father Francotte, who kindly presented it to our collection. It weighs only 0·79 gramme and has a little crust on one side. The fractured surfaces are light grey and show abundant tiny specks, probably of nickel-iron in a whitish matrix through which are scattered brownish and greyish granules. The place of the fall was a village some 5 miles from Delhi near the famous Kutb Minár.

V.—THE HARAIYA METEORITE (No. 237).

This meteorite was recently obtained from Mr. R. B. Reid of Allahabad, and the following is an abstract of the particulars furnished by him:—

It fell in the Basti district (United Provinces), about 14 miles west of the Sadr station in the afternoon during August or September, 1878, and was secured by Mr. Reid, who, on account of an exceptionally violent crash of thunder and brilliant flash of lightning, which he saw from his verandah during a thunderstorm, sent out a messenger who returned three days later with the meteorite. It appears that three people were weeding a field about a mile out of the village close to a mahua tree. It was raining hard at the time, and according to one of the survivors "suddenly a crashing peal of thunder resounded, he heard a whirring sound above him, like unto a kite descending then, as if a body came down with a thud on the ground." He and the second man were rendered insensible, and on coming to he saw that an old woman, one of the three weeders, was charred and dead. Close by her was a large mark on the ground, where the earth had been splattered up, giving the appearance as if something had entered the ground. The spot was dug up and at a depth of about 5 feet from the surface the meteorite was found buried.

The above account is given for what it is worth. The chief point is that Mr. Reid no longer remembers the name of the village, nor did he record the exact date of the fall, although he is sure of the year. As the large village of Haraiya (latitude 26° 48′ N.—longitude 82° 31½′ E.) is situated in the position indicated (14 miles west of the town of Basti) this name has been attached to the fall. It is just possible that this aerolite is only another portion of the Dandapur fall of 5th September, 1878. This, however, is not very probable (1) because Haraiya and Dandapur (26° 55′—83° 58′) are 88 miles apart, (2) because the Haraiya fall is said to have taken place in a thunderstorm while the sky at Dandapur was comparatively cloudless.

The specimen is a nearly perfect aerolite weighing 1,078·8 grammes. It is almost completely covered with a shiny black crust which has got knocked or peeled off in a few places as can be seen from the photographs of this meteorite (Plates 13 to 15). Plates 13 and 14 show the front side of this meteorite, and it will be seen that the crust exhibits a beautiful series of delicate ridges radiating from about the centre of this side of the stone. They indicate, of course, that this was the front side of the stone when in flight, and were caused by the rapid passage of the air over the molten crust. The symmetry of these radiations is spoilt by the prominent pittings or thumb-marks occupying part of this side. That these finger-like depressions were formed before the radiating flow-lines of the crust is shown by the fact that these lines continue through the pittings and out again on the other side.[1] The other side of the meteorite is shown in

[1] The remarkable likeness of these pittings or depressions to finger-marks is illustrated by the following passage from Mr. Reid's letter giving the details of the fall:—"The meteorite was found buried, apparently not quite hardened, as it has admitted of the finger prints and palm of the hand being impressed on it, when pulled up by the digger."

Plate 15, and although the crust has cracked off over a considerable part of this surface, yet the delicate radiating flow-lines (finer and closer together than on the front side) are well seen. They indicate the flow of the molten crust from the edge towards the centre of this side.

The fracture of this meteorite differs from that of the two preceding in its almost white colour. It shows numerous little dark specks in a white matrix.

VI.—THE ANDHÁRA METEORITE.

On the 2nd December, 1880, a meteoric fall took place at Andhára in the Muzaffarpur district, Bengal, which seems to have escaped notice on the part of students of meteorites. An account of it was given at the time by Major-General A. Cunningham in the Archæological Survey of India Reports, Vol. XVI, pages 32-34 (1883), and as this publication is not generally accessible in geological libraries, I have thought it desirable to reproduce here Cunningham's account of this fall. Some notes on this fall were also given by Mr. H. B. W. Garrick, who brought this fall to my notice, on pages 98 and 99 of the above-cited volume; but as they do not contain anything not in Cunningham's report, they are not repeated here.

"Andhára or Ujyân is a small village on the bank of the Parewâ, or Parwâ Nala, on the bed of the Bâgmati, 4 miles to the west of Sitâmarhi, and 30 miles to the north of Muzaffarpur. Here, on the *amávasi* of Agrahan (the conjunction or new moon of Agrahayan—2nd December, 1880) at 4 o'clock in the afternoon, a sound like that of a gun was heard, and two Brahmans of the village saw a dark ball fall in a field to the south-west of the village. It is described as having come down almost perpendicularly, but the sound was heard in the west, and a small cloud of dust rose up where it struck the ground. On picking it up it was quite warm and appeared to be white, but it was only covered with dust, and on washing it, its colour became quite black. I heard of its fall a few days afterwards when on my way to Muzaffarpur, and I visited the place on the 30th December.

" My chief object in going to Andhára was to witness the rise of a new worship, which may serve to throw light on the history of several of the *lingams* of Siva, which are very probably only stones that fell from heaven, like the Diana at Ephesus. 'What man is there that knoweth not how that the city of the Ephesians is a worshipper of the great goddess Diana, and of the image which fell down from Jupiter.'[1]

"Immediately after its fall the meteorite of Andhára became an object of worship. Two Brahmans at once established themselves as its ministering priests, one of them of course belonging to the village, but the other was a wandering Brahman or *Jogi* from Benares. I heard that it had been visited daily by crowds of people, latterly by as many as 500 a day. At the time of my arrival, about 8 o'clock in the morning, there was a continuous stream of people from all quarters. During the forenoon the stream became less continuous, and about midday was intermittent. I saw parties of 5, 10, 15, and 20 still coming from all sides. I counted one party of 23 people. During the early morning there could not have been less than 300 people present between 8 and 10 o'clock, and nearly as many more came before 2 o'clock. I counted roughly 400 persons up to 11 o'clock. On Sundays, they are said to be many more, certainly more than 1,000, and probably not less than 2,000. On the following Sunday, when I was encamped at Kura, 2 miles to the south-west of Parsoni, and 7 miles to the south-south-west of Andhára, the people were flocking to see the meteorite in a continuous stream. I estimated that not less than 4,000 people must have passed my tent; and as there were three other roads as much frequented as the other three sides, there could not have been less than 10,000 visitors on that Sunday.

"The people at Andhára asserted that the offerings made at the shrine amounted to as much as Rs. 20 a day, and that Rs. 400 had been collected up to the time of my visit, that is, in 28 days. The Jogi, however, denied this, and admitted only Rs. 4 or Rs. 5 a day. But as almost everybody gives something, however small, say from one *paisa* to two annas (a two-anna piece was seen by my servants on the 27th) 600 *paisa* or 150 annas, or nearly Rs. 10, would be a minimum daily collection.

"A brick temple had already been begun, and at the time of my visit the walls were about 2 feet high. The votaries crowded in to make their offerings of flowers, sweetmeats, milk, rice, water, bel-leaves, besides money, both silver and copper. Two bel-trees close by had already been stripped of their leaves. After making their offerings the people knelt down in front and with joined hands

[1] Acts of the Apostles, XIX, 35.

muttered some prayers. One old woman, who seemed to be particularly earnest, even clasped the stone.

"When the crowds of votaries had somewhat lessened, I got a good view of the stone. It was about the same size and shape as a common loaf of Indian bread, flattish below, and rounded above, and 4½ inches in height; its colour was apparently quite black. On one side there was a deep indentation as if a piece had been broken off. During the course of the day I heard that the missing piece had been found the day before in a field near the village of Rusâri, half a mile to the west of Andhára. When brought, the two stones were found to fit exactly. After 3 o'clock, when the crowds of votaries had gone off to their homes, I examined the stone quite close. It was quite black, flattish below and rounded above. I did not touch it, but it was measured before me by one of the attendant Brahmans. Its shape was oval, 6¼ inches by 4½ in length and breadth, and 4½ inches high. Its weight was said to be about 3 seers, or 6 pounds. The circumference was 16⅞ inches. By this measurement the diameter is 5·366 inches, and by that of the two diameters the mean is 5·37 inches.

"This new *avatar* of Mahâdeva has received the name *Adbhuta-Náth*, 'the miraculous or wonderful god,' and its fame has spread all over the districts of Tirhût and Champâran."

In response to an enquiry on the subject the Officiating Collector of Muzaffarpur has recently replied that there is no possibility of procuring for the museum any portion of this meteorite, as a temple has been built over the place where the stone fell and a *mela* and fair have been started in connection with the worship of the stone by which means the temple receives a considerable annual income.

VII.—THE KALAMBI, BHÁGUR, JAMKHAIR, AND PIRGANJ METEORITES.

These four Indian aerolites have long been known to science, but until this year (1906) they have not been represented in the Geological Survey collection. We are indebted, for their addition, to the generosity of the Trustees of the British Museum and of the Director of the K. K. Naturhistorisches Hofmuseum, Vienna.

The Kalambi meteorite (No. 243).

Of this meteorite, which fell on the 4th November, 1879, at the village of Kalambi, Wai taluq, Sátára district, two small pieces weighing respectively 6·40 and 4·58 grammes were received during the present year from the Hofmuseum, Vienna. Judging from "Die Meteoriten in Sammlungen" by Dr. E. A. Wülfing, p. 177, (1897), the original notice of this meteorite has escaped inclusion in the literature of this subject. It is to be found on page *lvi* of the Abstract of the Proceedings of the Bombay Branch of the Royal Asiatic Society which is appended to Vol. XIV of the Journal of that Society, 1880. The village at which the stone fell is probably that marked as Kalambha (17° 49½′—73° 59′) on Standard Sheet No. 201, Bombay Survey. The main mass of the stone seems to be still in the possession of the above Society.

The Bhágur (Dhulia) meteorite (No. 244).

A small fragment, weighing 2·5 grammes, of the meteorite which fell on November 27th, 1877, at Bhágur near Dhulia in the Khandesh district, Bombay Presidency, has recently been presented by the Trustees of the British Museum, to the Geological Survey Museum. The original account of this fall is given in *Jour. Bomb. Branch Roy. Asiatic Soc., XIV*, Abstract of the Society's Proceedings, pp. *iii-vi*, (1878). The main mass, the weight of which is unknown, seems to be buried in the collection of this Society.

The Jamkhair meteorite (No. 245).

A small fragment, weighing 1·7 grammes, of the meteorite which fell on the 5th October, 1866, at Jamkhair, Ahmadnagar district, Bombay Presidency, was also received in 1906 from the British Museum.

The Pirganj meteorite (No. 246).

Of this meteorite which fell on the 29th August, 1882, at Pirganj, Dinajpur district, Eastern Bengal and Assam, (formerly Bengal), a small piece weighing 16·2 grammes has also been received from the British Museum.

LIST OF PLATES.

Note—The titles of plates 14 and 15 have unfortunately been interchanged.

NOTE ON THE BRINE-WELL AT BAWGYO, NORTHERN SHAN STATES. BY T. D. LA TOUCHE, B.A., F.G.S., *Superintendent, Geological Survey of India.* (With Plate 16.)

THE brine-well at Bawgyo, a large village on the bank of the Myitnge or Nam Tu river, six miles east-south-east of Hsipaw, the capital of the state of that name, is situated in latitude 22° 35′, longitude 97° 16′ 15″, about half a mile slightly east of north from the railway station of Bawgyo. It lies at the northern edge of the valley, which is here broad and level, at the foot of a precipitous scarp of limestone, marking the line of a fault with up-throw to the north.

The well was visited on the 8th of June, 1890, by Dr. Noetling, Palæontologist, Geological Survey of India, who published a short paper on the subject in the *Records*, Vol. XXIV, Pt. 2. The date of my visit was almost exactly six months later in the year 1905, on the 19th December, and as Dr. Noetling says that he was assured by the natives that the output of salt varies with the seasons, it is now possible to arrive at an estimate of the average production with some degree of accuracy. It will be seen from what follows that my estimate of the production is very largely in excess of that of Dr. Noetling, who put it at only 12½ viss, or 45½ lb., a day in the rainy season, and 20 viss, or 73 lb., in the dry season. The present enquiry was undertaken mainly for the purpose of ascertaining the amount of sulphate of soda that is available from this source, since a possible demand for this substance may arise in connection with the proposal to establish a wood-pulp industry in Burma, with which end in view experiments are now being made to test the suitability of the various timbers grown in the province. The analysis of a sample of the brine collected by Dr. Noetling had already shown that sulphate of soda forms a large proportion of the solid matter contained in it.

There is only one well at present in use, but, as Dr. Noetling remarks, the villagers say that there was formerly a second well, the site of which was pointed out to me as about 50 yards to the north-east of the existing well. No trace of this second well now remains. The reason given to Dr. Noetling for its abandonment was that it yielded so large a quantity of brine that the villagers were unable to work it, but I was informed that it was on account of the red colour of the salt, which rendered it unsaleable.

The existing well is square in section, measuring 4 feet by 3 feet 8 inches, and is about 45 feet deep. At the time of my visit, in December, the level of the brine stood at about 7 feet below the surface of the ground. The brine is baled out with an ordinary bucket at the end of a balanced pole, enough being taken out at a time, and stored in troughs made of hollowed-out logs, to keep the boiling pans at work, with intervals for rest, etc., till the well fills again, an amount that has been found by experience. When I saw it, the surface of the brine was lowered about 11 feet after 9 hours' baling, and this, I was told, was the usual quantity taken out at a time. This would be about 1,000 gallons.

At intervals during the baling, several buckets-full of the brine are poured back into the well with as much force as possible, in order to mix up that which remains below. This process would counteract to a certain extent the effect of dilution during the rains, which, in Dr. Noetling's opinion, causes the weaker brine to float to the surface; but that there is a decided difference between the strength of the brine in the rainy and dry seasons appears to be evident from the amount of solid contents in Dr. Noetling's sample and in the one collected by me. These are—

	Sample collected, 8th June, 1890. Per cent.	Sample collected, 19th December, 1905. Per cent.
Water	87·47	74·42
Total salts	12·53	25·58
	100·00	100·00

It is possible that Dr. Noetling's sample was taken when the brine had been undisturbed for some time, when the surface layers would naturally be comparatively weak. Since, however, the well stands in what is practically a swamp, and is not particularly well protected at the top, there must be a considerable influx of surface water into it during heavy rains.

The boiling is carried on in a shed situated near the well. The brine is placed in shallow iron pans, each holding about 6 gallons, which are set in pairs in a furnace built of clay, of the shape shown in the figures attached. I found that it took just two hours for the contents of each pan to evaporate to the extent required. This is not to dryness, but to a point at which the residue is of the consistency of wet mortar, and a crust begins to form on the surface. The wet mass is then scraped out into a cloth, and allowed to drain and cool, after which it is packed in baskets containing 200 viss ($=6\frac{1}{2}$ cwt.) each, and well rammed into a solid mass with wooden mallets.

During the operation of boiling, the pan is well scraped from time to time with an iron-shod stick to loosen the scale, consisting largely of sulphate of soda, which is continually forming on the bottom. This is done probably to avoid loss of heat. A few chips of resinous pine wood are also placed in the pan, and are said to prevent the formation of scale to a certain extent. But shortly before the boiling is finished the scraping is stopped, and the scale allowed to collect. This is removed as soon as the fresh brine, which is added the instant that the salt has been taken out, has become warm, and so loosened it. This is the only attempt made to refine the salt. The scale is stored separately, and is sold for feeding cattle.

The salt obtained from each pan of brine, 6 gallons at a time (*i.e.*, in two hours), weighed $4\frac{1}{2}$ viss, or 16·42 lb. But as Dr. Noetling says that during the rainy season not more than $2\frac{1}{2}$ viss is obtained, and as the quantity of salt shown in the analysis of the sample collected by him bears out this statement, I think that 3 viss per pan may be taken as a fair average throughout the year, as a basis for calculation. This is almost exactly 11 lb. With 12 pans at work, as there were at the time of my visit, the average output would therefore be $\frac{12 \times 11}{2} =$ 66 lb. per hour, or 14 cwt. a day. The workmen told me that they turn out an average of 400 viss, or 13 cwt. a day, but this is probably the maximum, obtained when they are getting $4\frac{1}{2}$ viss at a time from each pan. This would mean about 15 hours' work a day and would allow sufficient interval for rest and food.

The well is being worked to quite its full capacity, for I found that the level of the brine rises at the rate of 3 inches an hour, after the baling has ceased. It would therefore take 44 hours to fill up the 9 feet that is taken out at a time. This amount of brine, approximately 1,000 gallons, would produce, at the rate of 11 lb. salt to each 6 gallons, 1,833 lb. of salt, which would take 28 hours' or nearly two days' work to boil down.

The possible average annual production, if the well were worked continuously, may be calculated as follows:—The amount of brine available may be taken as $3\frac{2}{3} \times 4 \times \frac{1}{4} = 3{\cdot}66$ cubic feet, or 23 gallons per hour. This would produce, at the rate of 11 lb. of salt to each 6 gallons, $\frac{23}{6} \times 11 \times 24 = 1{,}000$ lb. approximately, or 9 cwt. per day, which amounts to an output of 164 tons per annum. To this has to be added the amount of scale produced which varies considerably in each pan of brine, and cannot be estimated accurately. It would perhaps bring the total up to 200 tons per annum.

Two analyses of the solid contents of the brine have been made, one in Rangoon from the sample collected by Dr. Noetling, and the other in the Geological Survey Laboratory. The results as given below are very closely in accordance:—

	ANALYSES MADE AT	
	Rangoon.	Calcutta.
	Per cent.	Per cent.
Sodium chloride	60·30	60·48
Sodium sulphate	34·64	36·24
Calcuim sulphate	1·00	0·21
Magnesium sulphate	0·86	0·65
Undetermined (potassium, etc.)	3·30	2·42
TOTAL	100·10	100·00

Taking the average amount of sodium sulphate, as shown by these analyses, as 35·44 per cent., and presuming that the whole of this salt could be separated from the chloride, the total amount procurable during the year would be 70 tons.

This is the total amount that could be procured from the existing well; but if there is any truth in the statement that a second well produced brine that was even more rich in salt than the one now worked, there seems to be no reason why the production should not be largely increased. In any case as the brine rises through a fault fissure, it is exceedingly probable that other wells put down along the line of the fault would yield a greater or less amount of it, and if a demand for the sulphate of soda arises, it would be well worth while to sink other wells in the neighbourhood. If the sulphate could be utilized in any way, either in the manufacture of wood pulp, or otherwise, it would be of great advantage to the salt industry of the locality, for, as the salt is sold in its crude state and commands a ready sale among the hill people as far east as the Wa country beyond the Salween, it cannot compete in price with the ordinary bazaar salt in places where this is sold, on account of its bitter taste, due to the admixture of the sulphate of soda. It is sold at Rs. 5 a hundred viss, or a little over one rupee a maund. The proceeds, after deducting cost of firewood, wages, etc., go to the Bawgyo pagoda. The Sawbwa of Hsipaw derives little or no revenue from the industry.

REPORT ON THE GOLD-BEARING DEPOSITS OF LOI TWANG, SHAN STATES, BURMA. BY T. D. LA TOUCHE, B.A., F.G.S., *Superintendent, Geological Survey of India.*

Geology of the district.

SOME 50 miles to the south-east of the town of Hsipaw, the capital of the state of that name, a lofty mass of hills, attaining an elevation of 6,672 ft. above the sea in Loi Pan, rises abruptly from the undulating plateau of Palæozoic limestone which constitutes the whole of the intervening country. The northern end of this massif is formed of ancient micaceous slaty rocks, of which the exact age is at present unknown, though there is not the least doubt that they are older than the Ordovician period. They resemble, speaking generally, the slaty and quartzitic series to the south of the Mogok gneiss in the Ruby Mines district, to which the name Chaung-Magyi series has been given. These rocks are traversed by thick intrusions of granite, to which their present altered condition may be due, and in consequence their strike is somewhat irregular, but it appears to be generally from N. W. to S. E. A small quantity of gold is found among these rocks on the eastern flank of the range and has been washed on a small scale by the natives near the village of Hwe-pen (22° 15′ : 97° 48′).

Proceeding southwards from Loi Pan in the direction of the town of Möng Tung (22° 1′ 30″ : 97° 44′), the hills gradually become lower, and a series of quartzose and felspathic sandstones, with thick bands of yellow shale, is met with. These rocks are as a rule very poorly exposed, and it is very difficult to find outcrops of them, even in the ravines. The hill sides are covered with a thick deposit of sandy clay, and one may walk over them for miles without seeing a single fragment of solid rock. It is impossible to say therefore where the boundary occurs between this series and the slaty rocks to the north, but I first met with the sandstones *in situ* near the village of Se-heng, between 4 and 5 miles due north of Möng Tung, and it is probable that the boundary runs somewhat further to the north. Onthe latitude of Möng Tung the prevailing strike of these beds is W. N. W.—E. S. E., but further south it becomes due north and south, and they form the whole of the Loi Twang range, the principal axis of which runs in the same direction. Loi Twang itself, at the southern end of the range, rises to an elevation of 5,752 ft. Where these rocks are found *in situ* they are quite unaltered, and in some cases the surface of the beds is covered with well defined ripple marks. But neither in the sandstones nor in the shales has the slightest trace of any organism been found. Occasionally the sandstones contain small scattered cubical crystals of iron pyrites, which also occur in some very similar sandstones to the north-west of Hsipaw, where they overlie the Chaung-Magyi series. They also contain numerous veins and nests of white quartz. This sandy series may be known for the present as the Loi Twang series.

Along the eastern flank of the range is found a narrow band of highly fossiliferous shales, which is shown by its characteristic fossils, *Rafinesquina*, cystidean plates, etc., to be identical with the Naungkangyi shales (Ordovician) of the Maymyo area. These rocks have been traced for about 24 miles from N. E. to S. W., generally occupying a narrow valley between the Loi Twang series and the overlying beds. In places they appear to rest conformably on the former, but in other cases the strikes are quite discordant, and although it would be difficult, in the absence of fossils, to distinguish the Naungkangyi from the Loi Twang shale, the abundance of organic remains in the former probably indicates a considerable lapse of time between the periods of deposition of the two series.

The Naungkangyi shales are followed by a great thickness of purple and grey micaceous shales, which are also highly fossiliferous, containing fine specimens of trilobites in places, as well as detached plates of cystideans. They do not, however, contain the *Brachiopoda* characteristic of the Naungkangyis, but resemble closely a narrow band of purple shaly limestone which is commonly found at the top of the latter series in the northern area. For the present, and until the trilobites collected from them have been determined, I propose to call them the Hwe Mawng series, from the village close to which I obtained the finest collection of fossils. These rocks form a broad belt of hilly country to the east of the Naungkangyi band, and have been traced for the same distance.

To the east of these, forming a succession of low foot-hills, bordering the plain of Kehsi Mansam, comes a series of soft sandy marls, of which outcrops are very seldom obtainable. In one of these, however, I found specimens of trilobites with a Silurian facies, and I have little doubt that these marls represent the Namhsim sandstones of the northern area. These soft marls are in turn covered by the Plateau Limestone of the Kehsi Mansam valley, which sweeps round the foot of the high range from the north, and occupies all the low ground.

The western side of the range differs from that just described in the absence of the Hwe Mawng and Naungkangyi series. Here the soft sandy marls containing Silurian trilobites rest directly upon the sandstones of the Loi Twang series, or more probably are faulted against them. They are in turn overlaid by the Plateau Limestones, which form the small plateau of Loi Keng (21° 58′ : 97° 39′).

Mode of occurrence of the gold.

The gold of this district is derived entirely from the sandstones of the Loi Twang series, but judging from the capricious nature of its occurrence in the streams draining the sandstones, its distribution in the rock must be very irregular. I could find no trace of igneous intrusion which would account for the mineralisation of the sandstones, and it seems to me very probable that the gold was introduced during the deposition of the latter from some outside source, perhaps from the crystalline rocks to the north. The gold is usually found in thin flat spangles with very irregular outlines and a pitted surface, as if it had segregated in the interstices between the sand-grains, and the only "nugget" found during my investigation shows that the matrix was of a sandy nature. It is found in all the streams which radiate from the Loi Twang ridge, except those whose valleys are mainly confined to the shales associated with the sandstones. The fact that the gold occurs in this sandy series is of considerable interest, for rocks of the same appearance and probably of the same age are found in several parts of the N. Shan States and it is not unlikely that the gold reported to occur in many localities in those States is derived from them. In any case the streams that drain these rocks, wherever they are found, would be worth prospecting. From all I can gather the gold now being mined at Namma is probably derived from similar rocks.

The streams were examined in order, beginning at the north end of the range, and working round by the east to the south-west. In most cases very little gold was found in the gravel now brought down by the streams, in fact as a general rule they are too feeble to transport gravel of any size more than a very short distance from the mouths of the narrow ravines cut through the solid rocks of the range. The only exception is the Nam Ka, which drains the western side of the range, and is a fair-sized stream. In this case coarse gold is found in the present bed of the stream as far down as Hamngai, about six miles from its source. In the other cases the gold was found in the older alluvium underlying the stream beds, evidently laid down, judging from the size of the boulders usually found in it, at a time when the streams had far greater transporting power than they now possess. In taking samples pits were dug as far as possible into the gravel deposits, and 6 cubic feet were measured out in each case and washed under my personal supervision. The resulting concentrates were preserved for assay in the laboratory. In most cases the influx of water was so great on reaching the gravel that the pits could not be carried more than 3 feet or so into it, and it was very seldom that the bed rock was reached. The samples collected therefore only give a rough idea of the value of the gravels, but they are sufficient to show that the field as a whole is of no value from a commercial point of view.

Results of assays.

The results of the examination of the concentrates in the laboratory have proved to be very disappointing in view of the hopes raised by the coarseness and quantity of the gold in the samples originally collected by the Sawbwa of Hsipaw. In only five instances did the value of the gold per cubic yard amount to more than one grain of gold, and in the great majority of pits only a trace of gold was found, in exceedingly fine particles. The coarsegold was found in only a few of the pits, and it is because these spots were known to the natives that the Sawbwa was able to obtain so much gold with so little labour. Even if these spots were much richer than they are the field would be not worth working as a mining proposition, and the gold that does exist may safely be left to the natives, for extraction by their primitive methods of washing.

The streams examined were :—

Möng Tung Sub-State.

I. *Hwe-long* (Plan A). This stream issues from the hills 2 miles to the S. S. W. of Möng Tung, and drains the northern end of the Loi Twang range. Four pits were sunk along the course of the stream below the point, where it issues from a narrow ravine, of which Nos. 1 and 3 showed very slight traces of gold, but none was found in Nos. 4 and 5. Sample No. 2 was taken from a gravel spit on the bank of the stream, and showed a colour. Two pits were also put down on a terrace of older alluvium bordering the stream, and gravel was met with in both, but only the lower stratum in No. 7, 7 ft. 6 ins. from the surface, gave a colour. About a quarter of a mile higher up stream the valley opens out, and a deposit of coarse gravel and boulders was found with a cover of 3 to 4 ft. of soil and clay. Three pits were sunk into this, but none of them showed the slightest trace of gold. Nearly all the pebbles in this gravel were of shale. The gold lower down was apparently derived from a band of the sandstones which crosses the stream between the two gravel deposits.

II. *Namhkam* (Plans B and C). The Namhkam (Golden stream) issues from a narrow gorge close to the village of Wan Maü, 3 miles S. E. of Möng Tung. Two areas of auriferous gravel in this stream were examined.—

(1) *Lower Namhkam* (Plan B). The gravel deposit here is covered by from 3 to 8 ft. of soil and clay, and the whole of the ground is cultivated. Nine pits were sunk, of which eight produced gold. In the upper pits, Nos. 1 to 4 and 6, the gold was fairly coarse, but lower down it became progressively finer in grain, and in pit No. 9, the lowest, it occurred only in microscopic particles. It is probable that it does not extend much below this.

(2) *Upper Namkham* (Plan C). This is a small patch of coarse gravel and boulders occupying a slightly wider part of the gorge, where a band of shale crosses the stream, about half a mile above Lower Namhkam. Here there is no 'cover' to the deposit, or at most 8 inches or so of soil. Gold was found in 4 out of 5 pits sunk. The thickness of the deposit is about 2 ft. resting on decomposed shales. The only nugget found during the operations was obtained from the lowest pit, No. 1, in this deposit. Its weight is 4·86 grains.

III. *Hwe-pan-hak.* This stream drains the S. E. side of the same ridge as the Namhkam, but no trace of gold was found either in the bed of the stream, or in the older gravel deposited by it. The eastern branch also of this stream contained no gold.

Passing now to the eastern side of the range, four streams were examined, with the following results:—

Kehsi Mansam Sub-State.

IV. *Hwe Patayap.* One of the pits put down on this stream showed a very thin stratum of fine gravel containing a few extremely minute specks of gold. The others met with either quicksand or clay. The valley appears to be excavated mainly in shales.

V. *Hwe Nying.* In two pits sunk near the stream coarse gravel with boulders was found containing a small quantity of gold in fine particles. The coarseness of the gold was not found to increase higher up the valley, and the average value of the deposit is very small.

VI. *Hwe Mawng.* The same remarks apply to this stream as to the last. Gold was found only in one pit near the point where the stream issues from a deep narrow gorge, in small quantity and only in very fine particles.

VII. *Hwe Aw* (Plan D). This is the stream referred to in the correspondence on this subject as the Hwe Mawng, from which the Sawbwa of Hsipaw is said to have obtained a nugget weighing 117·55 grains. It drains the southern end of the Loi Twang range, and is the only stream on this side which carries gold in any quantity. Twelve pits were sunk along the course of the stream, ten of which produced gold, but its distribution is somewhat capricious. The most productive pits were those on the lower part of the stream below the point marked A on the plan, where it flows through a narrow gorge formed of sandstone. In the lowest pit, No. 1, a few fine particles only were found, but in the four pits, Nos. 2-5, above this, it occurred in comparatively large flakes or spangles, showing no signs of being waterworn. A pit sunk in the middle of the gorge mentioned above met with very large boulders and sand, but no gold. The two pits above this, Nos. 6 and 7, gave only fine particles, but in No. 8 fairly coarse gold was again found. Higher up again in pits 9 and 10, there was very little gold, and that only in minute particles.

VIII. *Namkat.* Four pits were put down in the valley of this stream, which is a tributary of the Hwe Aw, but none of them showed any trace of gold.

The valleys of all these streams are of the same character, narrow, rather highly inclined, and, with the exception of the Hwe Aw, nearly straight. They are all cultivated, with a very elaborate system of terracing, and the amount of waste ground is confined to a few feet on either side of the stream bed. The flow of water in the streams is inconsiderable, and none of them are able to transport even fine gravel to any distance from the points where they issue from the deep narrow ravines on the flanks of the main range. It is very doubtful whether there would be sufficient water in any of them to work the deposits, except on a very small scale, even if a far larger amount of gold were present than is actually the case.

Möng Küng Sub-State.

IX. *Nam Ka* (Plan E). This stream, with its tributaries, drains the whole of the western flank of Loi Twang, and differs from those already mentioned in possessing a wide level valley and a considerable flow of water. Gold was found both in the bed of the river and in the older gravels as far down as Hamngai, about six miles from its source, but in only one instance did it appear to be fairly abundant and in coarse flakes. Eighteen pits were sunk along or near the course of the river between Hamngai and Wan-tawng, about four miles up stream. In some of these nothing was met with but quicksand with a copious discharge of water, and the gravel deposit could not be reached with the appliances at my disposal. Gold was found wherever coarse gravel was reached as far up as the mouth of a small stream, about a mile south of Wan-tawng, draining the southern end of Loi Twang, but above this, in the main stream, either no gold at all, or only a few microscopic particles. A couple of pits, sunk along the small stream referred to, also showed no gold. The absence of gold above Wan-tawng may be accounted for by the fact that the course of the stream above this point lies mainly through limestone.

There is a fairly large flow of water in the Nam Ka at Hamngai, probably sufficient for dredging, but it is doubtful whether it could be obtained under sufficient pressure higher up stream for hydraulic mining, except at great expense. As in the case of the other streams examined, the whole of the ground overlying the deposit is terraced and cultivated.

Summary.

The general results of my examination of this gold-field are given in the following table, from which it will be seen that only in three of the streams, *viz.*, the Namhkam in Mōng Tung, the Hwe Aw in Kehsi Mansam, and the Nam Ka in Möng Küng, was coarse gold found, and that even in these it is confined to a very small area in each case. It is possible that further prospecting might reveal the presence of gold in larger quantities in the lower portion of the gravel deposits, which was not reached in most of the pits sunk by me, but so far as I could judge this was not the case in the few instances where the pits reached the bed rock. In any case I think that further prospecting might well be left to private enterprise. Even if the value of the deposits were proved to be greater than it seems to be, a serious objection to their being worked on a large scale is undoubtedly the fact that the gold-bearing gravels are in all cases covered by a fertile soil which is terraced and cultivated, and that practically the whole of this cultivation would be destroyed by the operations. In the Hwe Aw valley this terracing is carried to a considerable height up the hill sides, which are very steep, and even if the excavations were confined to the narrow strip of waste ground immediately adjoining the stream, there is little doubt that any interference with the base of the slopes would eventually result in the destruction of the terraces above. On the Nam Ka the damage done need not be so complete, for the valley is more open, but certainly more than half the present cultivated area would have to go. In these two cases the area cultivated has reached its possible limits and the villages dependent on it would have to be abandoned. These would be—on the Hwe Aw, Kong-mu, Ho-hkai, Kong-lang, and perhaps Ho-na: and on the Nam Ka, Hamngai, Hai-kun, Kyawng-pong, and perhaps Wan-tawng, all of which are large and thriving villages. Moreover, there is no waste land in the neighbourhood to which these villages could be removed. In the case of the Namhkam the problem is not so difficult, for only one large village, Wan Maü, would be affected, and there is a considerable amount of waste but cultivable land available in the neighbourhood of this village. It is, however, hardly probable that the question will arise, for the general value of the deposits is so low that it is not likely that any application will be made for working them on a large scale.

SUB-STATE.	Name of stream.	Area of deposit.	No. of pit.	Depth of gravel from surface.	Thickness of gravel.	Character of deposit.	Value of gold per cubic yard.
		Acres.		*ft. ins.*	*ft. ins.*		*Grains.*
MÖNG TUNG.	I. Hwelong . .	$2\frac{1}{3}$	1	1 0	3 6	Coarse gravel and small boulders	0·09
			2	...	1 0+	Coarse gravel	Trace.
			3	3 0	2 0	Do.	*Nil.*
			4	4 0	2 0+	Coarse gravel mostly shale pebbles.	Trace.
			5	4 6	2 0	Do. do.	*Nil.*
			6	7 6	2 0	Do. do.	*Nil.*
			7	6 0	2 0	Do. do.	*Nil.*
	II. Namhkam—						
	(i) Lower Namhkam	$17\frac{1}{3}$	1	8 0	2 0+	Coarse gravel with small boulders	0·09
			2	6 0	2 0+	Do. do.	0·135
			3	6 0	1 0+	Do. do.	0·09
			4	4 6 to 6 0	1 0 to 4 0	Coarse gravel with large boulders	0·225

Sub-State.	Name of stream.	Area of deposit.	No. of pit.	Depth of gravel from surface.	Thickness of gravel.	Character of deposit.	Value of gold per cubic yard.
	II. Namhkam—	*Acres.*		*ft. ins.*	*ft. ins.*		*Grains.*
Möng Tung—*concld.*	(i) Lower Namhkam —*concld.*	...	5	6 0	2 0+	Coarse gravel with large boulders	Trace.
			6	7 0	2 6+	Coarse gravel with small boulders	1·08
			7	3 0	2 6	Coarse gravel	Trace.
			8	7 6	2 0+	Do.	0·18
			9	9 0	2 6+	Do.	Trace.
	(ii) Upper Namhkam	1½	1	0 8	2 0	Do.	22·14
			2	0 8	2 0	Do.	0·36
			3	2 0	2 0	Do.	Trace.
			4	...	2 0	Earthy gravel	*Nil.*
			5	1 0	4 0	Coarse gravel	Trace.
			6	...	...	Do.	*Nil.*
	III. Hwe-pan-hak .	...	1	...	6 0	Sand and gravel . . .	*Nil.*

SUB-STATE.	Name of stream.	Area of deposit.	No. of pit.	Depth of gravel from surface.	Thickness of gravel.	Character of deposit.	Value of gold per cubic yard.
		Acres.		*ft. ins.*	*ft. ins.*		*Grains.*
KEHSI MANSAM.	IV. Hwe Patayap .	...	1	4 0	1 0	Fine gravel	Trace.
			2	10 0	No gravel	......	*Nil.*
	V. Hwe Nying .	...	1	3 6	1 6	Coarse gravel and boulders .	Trace.
			2	2 6	2 0	Do. do. .	Do.
			3	2 0	2 0	Do. do. .	Do.
	VI. Hwe Mawng .	...	1	3 9	2 0+	Do. do. .	Do.
			2	5 0	2 0	Do. do. .	*Nil.*
	VII. Hwe Aw . .	203	1	1 0	2 0 to 3 0	Coarse gravel	Trace.
			2	2 0	2 0+	Coarse gravel with small boulders	0·27
			3	0 6	2 0+	Do. do.	0·675
			4	2 6	2 0+	Do. do.	0·09
			5	2 6	2 0+	Do. do.	1·575
			6	2 0	2 0+	Do. do.	Trace.

Sub-State.	Name of stream.	Area of deposit.	No. of pit.	Depth of gravel from surface.		Thickness of gravel.		Character of deposit.	Value of gold per cubic yard.
		Acres.		*ft.*	*ins.*	*ft.*	*ins.*		*Grains.*
Kehsi Mansam—*concld.*	VII. Hwe Aw—*concld* .	...	7	3	0	2	0+	Coarse gravel with small boulders	0·09
			8	5	0	1	6	Do. do.	1·305
			9	3	6	2	0+	Do. do.	Trace.
			10	2	0	2	0+	Do. do.	Do.
	VIII. Namkat . .	...	1	3	0	1	0	Do. do.	*Nil.*
			2	2	0	2	0	Do do.	*Nil.*
Möng Küng.	IX. Nam Ka . .	776	1	8	6	3	0	Do. do.	0·315
			2	10	0	3	0+	Fine gravel	Trace.
			3	10	0	3	0	Coarse gravel with small boulders	1·89
			4	11	0	3	0	Do. do.	Trace.
			5	4	0	2	6+	Do. do.	Do.
			6	4	0	2	0+	Do. do.	Do.
			7	5	6	4	0+	Do. do.	0·135

NOTE ON THE OCCURRENCE OF *Physa Prinsepii* IN THE MAESTRICHTIAN STRATA OF BALŪCHISTĀN. BY ERNEST W. VREDENBURG, A.R.C.S., A.R.S.M., *Geological Survey of India.*

IN the absence of direct evidence, the Upper Cretaceous age generally attributed to the Deccan Trap in the publications of the Geological Survey of India has remained for a long time rather conjectural, and it is gratifying to find that of late years we have become acquainted with palæontological data confirming this conclusion, and defining with some degree of accuracy the horizon of the great volcanic formation. *Cardita Beaumonti* d'Arch. and Haime, one of the leading fossils of the strata associated with the Deccan Trap in Sind, has been obtained in Luristān by de Morgan in beds containing the genera *Omphalocyclus* and *Hippurites*,[1] while in Egypt, the same fossil, or one closely allied, described under the name of *Cardita Lybica* Zittel, occurs both in the Maestrichtian beds with *Ostrea Overwegi* Buch, *Indoceras Ismaelis* Zittel, *Baculites anceps* Lamk., etc., and in the overlying Danian beds with *Nautilus Danicus* Schloth.[2] The Maestrichtian beds of Luristān also contain *Cerithium Stoddardi* Hislop, and *Irania fusiformis* Hisl.[3] which characterise the Intertrappean beds of Rājāmahendri. A further piece of evidence is now supplied by the recognition, amongst beds of the same age in Balūchistān, of the characteristic Intertrappean fossil, *Physa Prinsepii* Sowerby.

This fossil was recognised amidst some specimens collected by Dr. Noetling in the Des valley of the Mari country in Balūchistān during the year 1898. The collection is very interesting on account of the great number of fossiliferous horizons that succeed one another in one continuous section. A short account of the stratigraphy and palæontology of the Des valley was published by Dr. Noetling in the General Report of the Geological Survey for 1898-1899,[4] and again

[1] Mission J. de Morgan, Paléontologie; Mollusques fossiles par H. Douvillé, Paris, 1904.

[2] A. Quaas: Die Fauna der Overwegischichten und der Blätterthone in der libycshen Wüste. *Palaeontographica*, XXX (2), pp. 153-336, (1902).

[3] *Loc. cit.*, pp. 304 and 321.

[4] Preliminary report on the Mari hills and part of the Zhob valley, pp. 51-63.

in the *Centralblatt für Min., Geol. und Pal.* for 1903.[1] The latter contribution is illustrated with a figured section in which the beds are numbered from 1 to 29, the 24 first zones being regarded as Cretaceous, the remainder as Tertiary. The opinion is expressed that there is a complete gradual transition from Upper Cretaceous to Eocene.

The lists of fossils published in Dr. Noetling's account have no pretence to be complete and only give the names of a few forms that were identified in the field. The *Physa* which I look upon as identical with *Ph. Prinsepii* is not mentioned in Dr. Noetling's lists. It occurs amongst the fossils of zone 20 in company with a number of interesting forms, amongst which may be mentioned *Sphenodiscus Ubaghsi* de Grossouvre, a characteristic species of the newest ammonite zones of Europe. The rock constituting zone 20 is an olive-coloured shale impregnated with volcanic material. It is mostly unfossiliferous except for some very thin bands of hardened calcareous somewhat porcellanic-looking material in which the fossils occur surrounded by concretions not unlike those enclosing the ammonites of the Spiti shales. Owing to its well-marked lithology and its stratigraphical relation to the underlying and overlying fossiliferous horizons, the same zone is readily identified in the State of Kelāt where I have found it crowded with specimens of *Sph. Ubaghsi* accompanied by other ammonites identified as *Pachydiscus Neubergicus* F. Von Hauer, *Pach.* n. sp., *Schlüteria Larteti* Seunes, and *Baculites* sp. In Dr. Noetling's collection *Sphenodiscus Ubaghsi* is represented by a single very well preserved specimen of which special mention is made in the General Report for 1898-1899, page 56, where it is erroneously referred to *Indoceras baluchistanense* Noetl. which it closely resembles when, as in the present case, the shell is well preserved. On closely examining the specimen I found the sutures clearly exhibited over a portion where the shell is missing, and they agree with those of the numerous specimens which I obtained at the same horizon in the neighbourhood of Kelāt. As already mentioned, Dr. Noetling's preliminary lists are founded on identifications roughly made in the field.

Dr. Noetling's collection from this zone contains three specimens of *Physa* measuring about 55, 50, and 28 millimetres in length,

[1] Uebergang zwischen Kreide und Eocän in Balūchistān, pp. 514-523.

respectively. The shape of the two larger specimens agrees in every particular with the specimens of *Physa Prinsepii* Sow. from the Intertrappeans of the Indian Peninsula, belonging to the form distinguished by Hislop as the "normal" one. (*Quart. Journ. Geol. Soc.*, Vol. XVI, p. 173, Pl. V, fig. 23*a*, 1859.) The two larger specimens show very clearly the distinctive specific character constituted by the large size of the last whorl enveloping the greater part of the younger portion of the shell, with the consequent development of an aperture of considerable height relatively to the spire. The smallest specimen agrees in the greater relative length of the spire with the immature individual figured by Hislop (*loc. cit.* Pl. V, fig. 23*c*) and referred to the variety *elongata*. The largest of the Balūchistān specimens does not attain the size frequently exhibited by those from the Peninsula. Either the Balūchistān ones belong to a smaller race, or the difference may be simply accidental in consequence of the small number of specimens obtained. The fauna of zone 20 is chiefly marine, and the individuals of *Physa* must have been washed into the sea from some neighbouring estuary. This probably happened only during exceptional floods, and the individuals of various sizes thus overwhelmed could not have survived the altered conditions to which they were accidentally subjected. We cannot expect therefore to find such a preponderance of full-grown specimens as where the conditions of life were so eminently favourable as they seem to have been in the Intertrappean swamps.

But for the unimportant difference in size, the Des valley specimens do not exhibit the slightest divergence from the peninsular Intertrappean ones, nor do they show any approach towards the European fossil forms of which I have been able to consult descriptions. The overlapping disposition of the last whorl is even better marked than in some peninsular specimens.

The zones distinguished by Dr. Noetling as the "Hemipneustes beds" constituting horizons 2 to 12 in the Des valley section, and recognisable in many parts of Balūchistān, do not contain any intercalations of volcanic material. It is only when we reach the horizon of the olive shales that contemporaneous volcanic action becomes evident. While examining Dr. Noetling's collection I was able to identify several foraminifera which are of assistance in estimating the age of the various zones. The species referred by Dr. Noetling to *Orbitoides socialis* Leym (Upper Cretaceous fauna of Balūchistān, *Pal. Ind.*, ser. XVI, Pl. I, figs. 1-4, 1897) is in reality *O. media* d'Arch. It occurs in zone 7 together with a small form of *Omphalocyclus*. Specimens identical with the true *Orbitoides socialis* also occur, but at a higher horizon in zone 11, in company with a rich fauna amongst which mention may be made of a *Sphenodiscus* closely allied to *Sph. Shiva* Forbes of the Valudayur beds of Southern India, and to *Sph. lenticularis* Meek of the "Fox Hills group" of North America. Typical specimens of *Omphalocyclus macropora* Leym occur plentifully in zone 16.

Dr. Noetling has classified all the beds of the Des valley, from 2 to 18, as Maestrichtian. If we consider that, in Europe, *Orbitoides media* is specially abundant at the limit of the Campanian and Maestrichtian, it seems possible that the lower zones of the Des valley section, from 2 to 4 or 6, may be referable to the Campanian. Zones 19 to 24 have been placed by Dr. Noetling in a special stage styled by him "Pathanian," and regarded as newer than the rocks usually classified as Maestrichtian. Their fauna, nevertheless, indicates an upper Maestrichtian age, at least up to zone 23. Should the uppermost bed, zone 24, turn out to be post-Maestrichtian, there is no need to apply to it any other name but the well-known term "Danian."

Instead of the somewhat vague reference to Upper Cretaceous or Lower Tertiary with which we had formerly to be content as regards the age of the Deccan Trap, we are now in possession of a certain amount of sound palæontological data fixing the age of a portion of the volcanic outbursts as Maestrichtian, the eruptions continuing, no doubt, into the Danian. We do not know of any undoubted instance of their having extended into the Eocene. In Sind, where the oldest Tertiary beds of India are exposed, there is a stratigraphical gap between the last eruptions and the very early Eocene beds at the base of the Ranikot.

Regarding Dr. Noetling's claim as to the presence of passage beds between Cretaceous and Tertiary in the Des valley section, it may be mentioned that in the State of Kelāt, the olive shales with *Sphenodiscus Ubaghsi* are succeeded by a vast thickness of sandstones which I propose to distinguish as the "Pab sandstones," and which correspond with the thick "*Cardita Beaumonti* group" of Sind. In the latter province this formation is unconformably overlaid by the Lower Ranikot whose age approximately corresponds with that of the Woolwich and Reading beds. This is succeeded by the Upper Ranikot corresponding with the London Clay and the nummulitic sands of Cuise, and this in its turn by the Laki series of Lower Lutetian age. In the Des valley section, the Pab sandstones are reduced to a thin layer (zone 24) probably corresponding with their lowermost beds. The next fossiliferous zone, 100 feet higher, corresponds with the Laki limestone, the intervening unfossiliferous beds being apparently connected with it. The greater part of the Pab sandstones, and the whole of the Lower and Upper Ranikot are therefore missing, and the claim to the Des valley section representing a gradual transition from Cretaceous to Tertiary cannot therefore be substantiated.

MISCELLANEOUS NOTES.

Further note on the Trias of Lower Burma and on the occurrence of *Cardita Beaumonti* d'Arch. in Lower Burma.

IN a preliminary note on the Trias of Lower Burma (*Rec. G. S. I.*, Vol. XXXIV, pt. 2, p. 134), I gave reasons for supposing that true Triassic rocks do occur in the Arrakan Yoma. Further investigation shows that the Axial (Triassic) group of Theobald is a complex one, and that he classed together beds of very different ages. Theobald (*Mem. G. S. I.*, Vol. X, pt. 2, p. 134) divided his Trias into two groups, which may be summarised as follows:—

Upper Axials . .	*a.* Cardita beds. *b.* Halobia limestones. *c.* Shales, sandstones and grits.
Lower ,, . .	Flaggy shales and sandstones.

The Halobia limestones were dealt with in part in the note referred to above. It is with the Cardita beds that this short note is concerned. The fossils from these beds were discovered in the Museum unregistered but labelled by Theobald himself as Triassic. They consist chiefly of fairly well preserved *Carditæ* and some poor gastropods (*Turritella*, etc.). The *Carditæ* are all of one species, and are easily recognised as identical with the well-known *Cardita (Venericardia) Beaumonti* d'Arch. of Sind and Baluchistán. Beds with *C. Beaumonti* have long been supposed to bridge over the gap between the Tertiary and the Cretaceous, but they are more probably Maestrichtian to perhaps Lower Danian in age. (Vredenburg, *Rec. G. S. I.*, Vol. XXXIV, pt. 2, p. 86.) Theobald was aware of the occurrence of Cretaceous rocks in the Arrakan Yoma from the discovery of a fragment of a Cenomanian ammonite (*Schlœnbachia inflata*) near Maū, but he did not suspect the Cretaceous age of these Cardita beds. It is very evident that Theobald's Axial (Triassic) group is a very mixed one, containing not only Triassic rocks, but also beds of Cretaceous age.

[G. H. TIPPER.]

Fossils in the Upper Miocene of the Yenangyaung Oil-field, Upper Burma.

Until quite recently, the only fossils found in the Upper Miocene or Yenangyaung stage in the Miocene outcrop at Yenangyaung, consisted of three species of *Batissa (Cyrena)* described by Dr. Noetling [1] under the names of *B. kodaungensis*, *B. crawfurdi*, and *B. petrolei*. The corresponding strata at Singu and Yenangyat contain a typical marine fauna, and it was therefore concluded by Dr. Noetling [2] that the Yenangyaung beds of Burma occurred in two facies, a marine type at Singu, Yenangyat and Minbu, and an estuarine type at Yenangyaung. He mentions the abundance of gypsum in the latter locality in support of this view, and considers that the one type of beds passes horizontally into the other.

The discovery of a number of marine fossils in this stage a short distance north of the village of West Twingon, Yenangyaung, shows that the change from estuarine to marine conditions—assuming that the southern part of the Yenangyaung outcrop does consist of estuarine beds—commences at least as far south as this village. The fossils were found in a hard limestone about 1 foot thick and of very limited horizontal extent: they extend sparingly for a short distance into the underlying soft sandstone and into the overlying mixture of sand and clay lenticles. The horizon of the bed is about 350 feet below the ferruginous conglomerate or Pliocene-Miocene boundary. The fossils, some of which show compressional distortion, are imperfectly preserved in the sands and clays, and difficult to extract from the limestone. It should be mentioned that gypsum is quite as abundant at Singu and Yenangyat as at Yenangyaung; but it is probably subsequent to the Miocene.

[E. H. PASCOE.]

Note on a cranium of *Boselaphus namadicus* Rütim. from the Narbada Pleistocene gravels of Jabalpur.

In the course of an examination of the collections of the Nagpur Museum some months ago, I came across a well preserved fragment of the cranium of *Boselaphus namadicus* Rütim. showing the occipital,

[1] Fauna of the Miocene Beds of Burma, *Palæontologia Indica,* New Series Vols. 1-3, page 183.

[2] *Ibid*, page 9.

parietal and frontal regions. The only known examples of this species exist in the British Museum, and were figured and briefly described by Rütimeyer[1] in 1878. Lydekker refers to these specimens in *Pal. Ind.*, ser. X, Vol. III, p. 48 (1885).

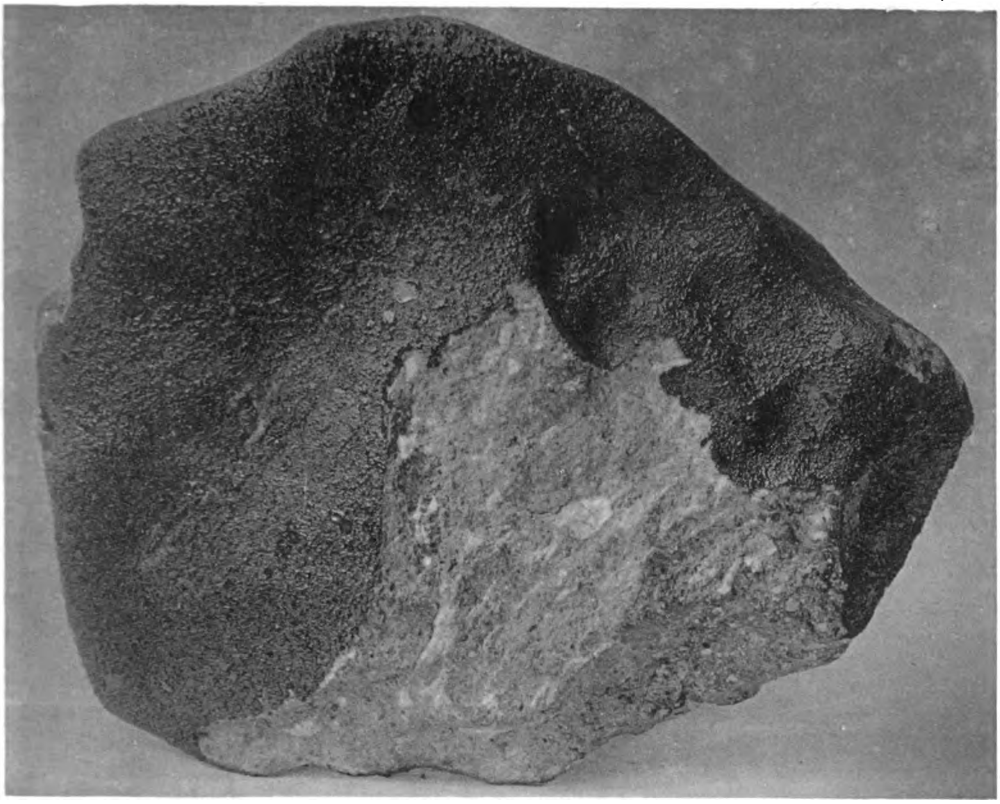
The present specimen is an almost exactly similar fragment to those in the British Museum, except for the absence of the horn cores. Both of them unfortunately lack the teeth, but there can be no doubt as to specific identity. They differ from the corresponding portions of the recent Nylgai, ***Boselaphus Pragscamelus***, chiefly in the greater approximation of the horn cores to the orbit.

This species has accidentally been omitted from the list of the Narbada pleistocene vertebrate fauna given in the Manual of Indian Geology, 2nd ed., p. 398 (1892).

The Nagpur Department of Agriculture have presented the specimen to the Geological Survey and it is now stored in the Geological Museum, Calcutta (Reg. No. K $\frac{9}{739}$.)

[GUY E. PILGRIM.]

[1] Abh. schwoiz. pal. Geo., Vol. V, p. 89 (1878).



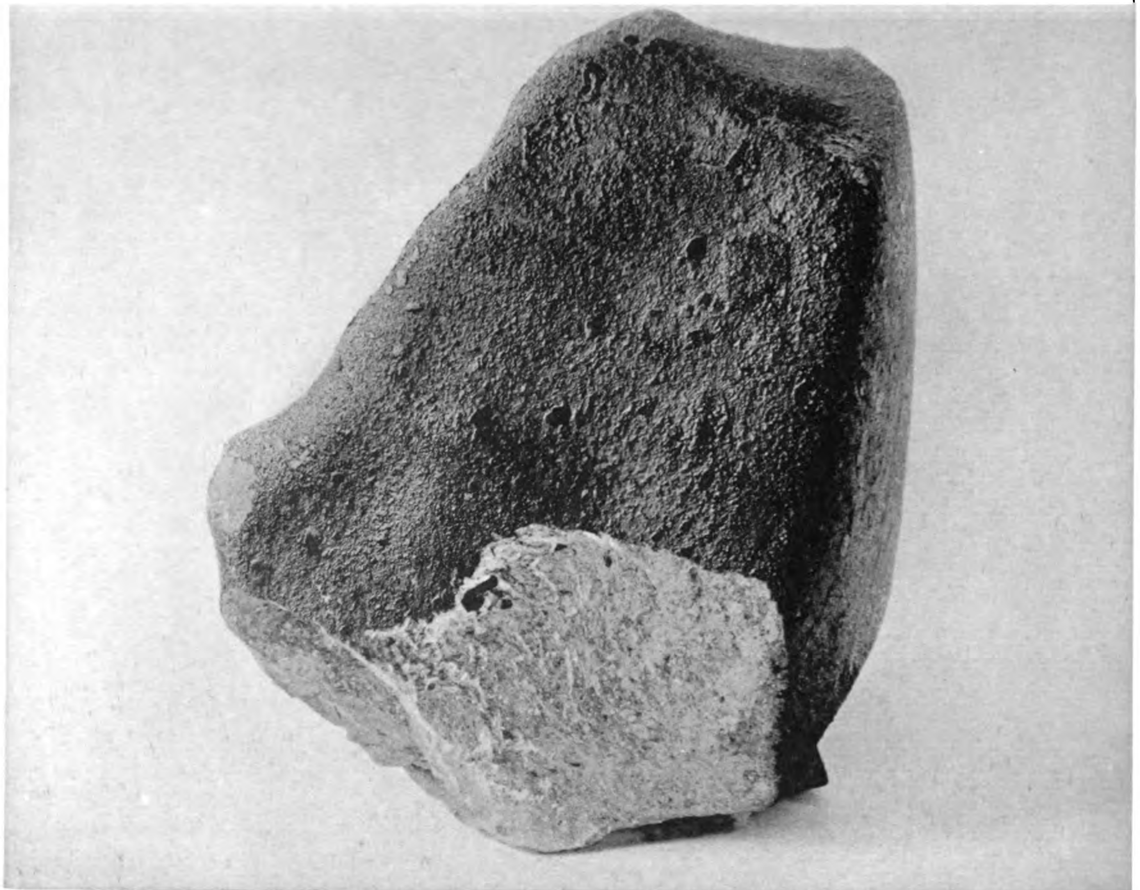
H. B. W. Garrick. Photo. Fig. 1.

H. B. W. Garrick. Photo. Fig. 2. *Bemrose. Collo., Derby.*

THE BHOLGHATI METEORITE (NO. 241).

Fig. 1 - Front view showing the face A — Natural Size.

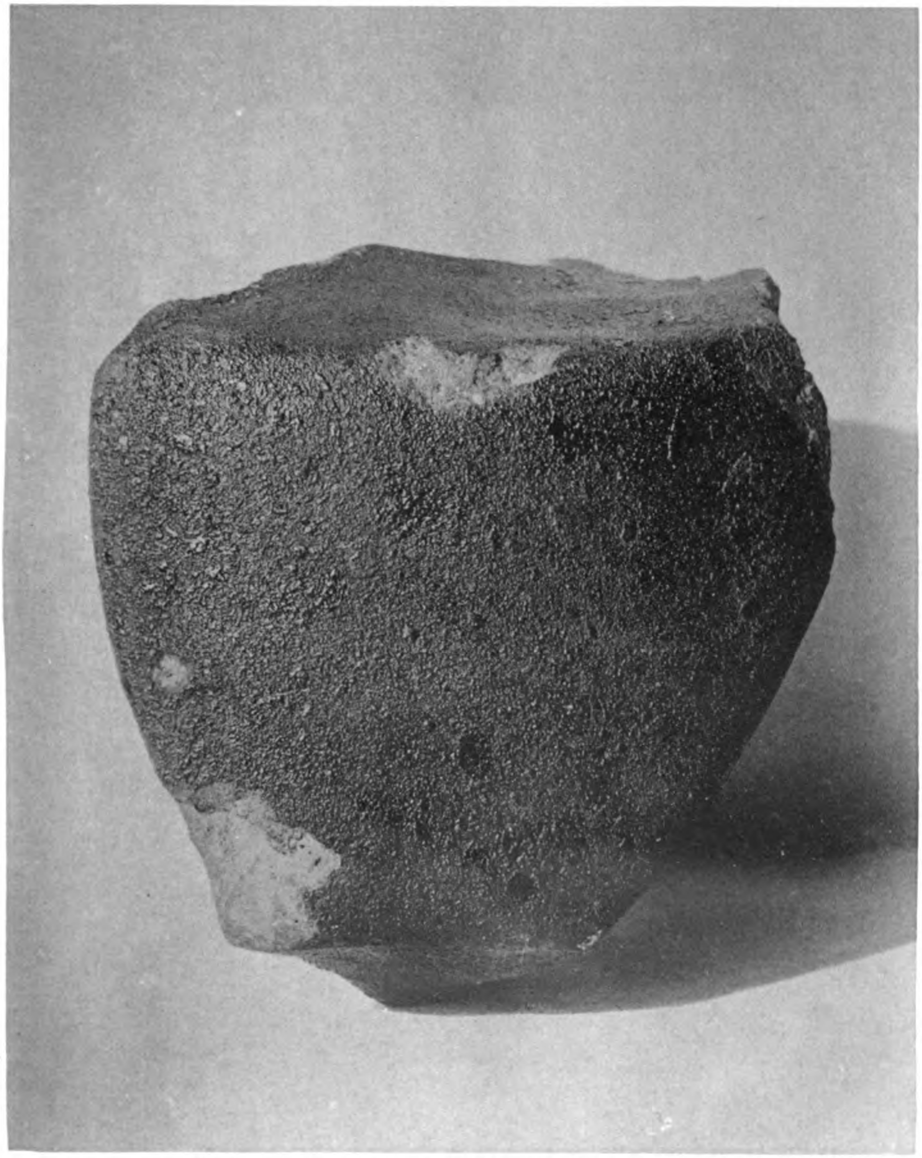
Fig. 2 — The fractured part of Fig. 1 — (Slightly enlarged, and exposed so as to show the white spots).



H. B. W. Garrick, Photo. *Bemrose, Collo., Derby.*

THE BHOLGHATI METEORITE (NO. 241).

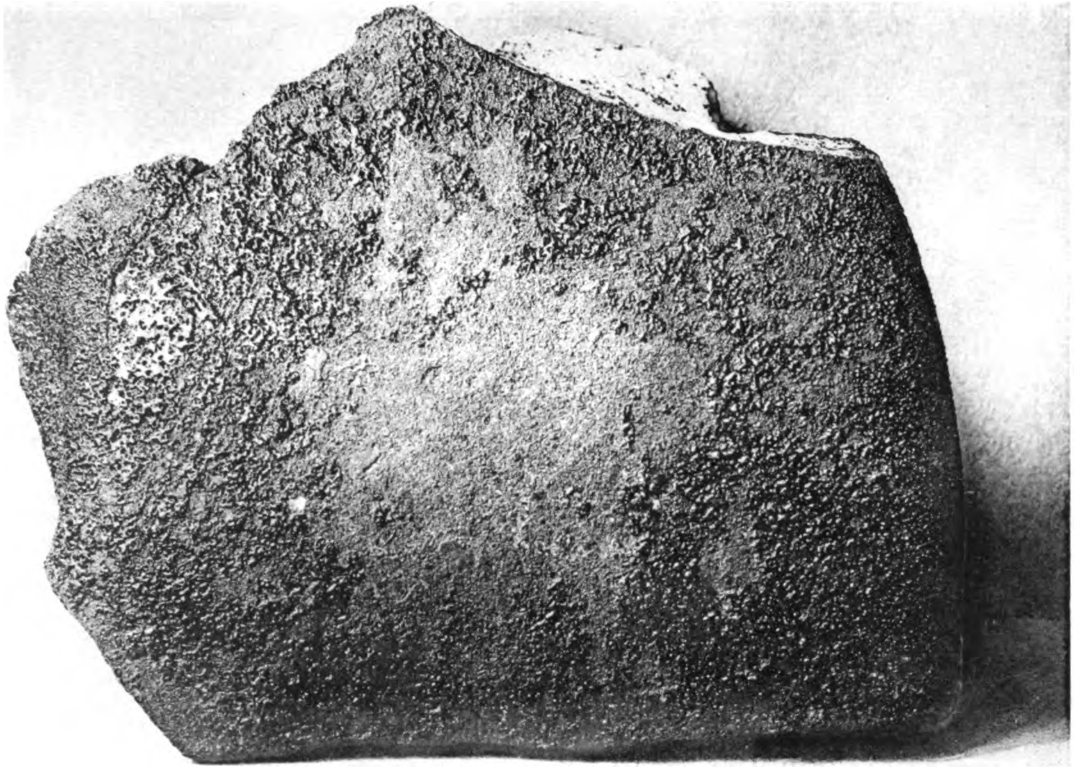
View showing the face C and a little of B (on the right).—Natural Size.



H. B. W. Garrick, Photo. *Bemrose, Collo., Derby.*

THE BHOLGHATI METEORITE (NO. 241).

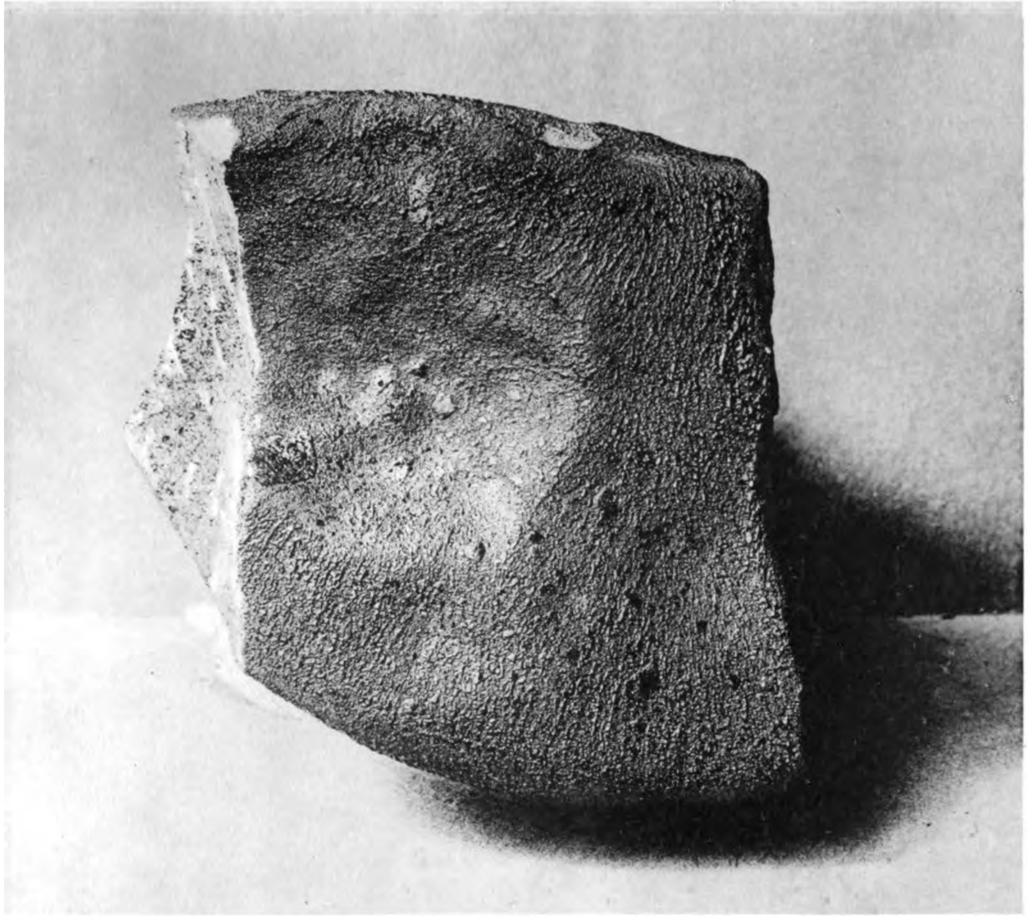
Inverted; shows the face B and the base of the tetrahedron.—Natural Size.



H. B. W. Garrick, Photo. *Bemrose, Collo., Derby.*

THE BHOLGHÁTI METEORITE (NO. 241 B).

Front view. Natural size.



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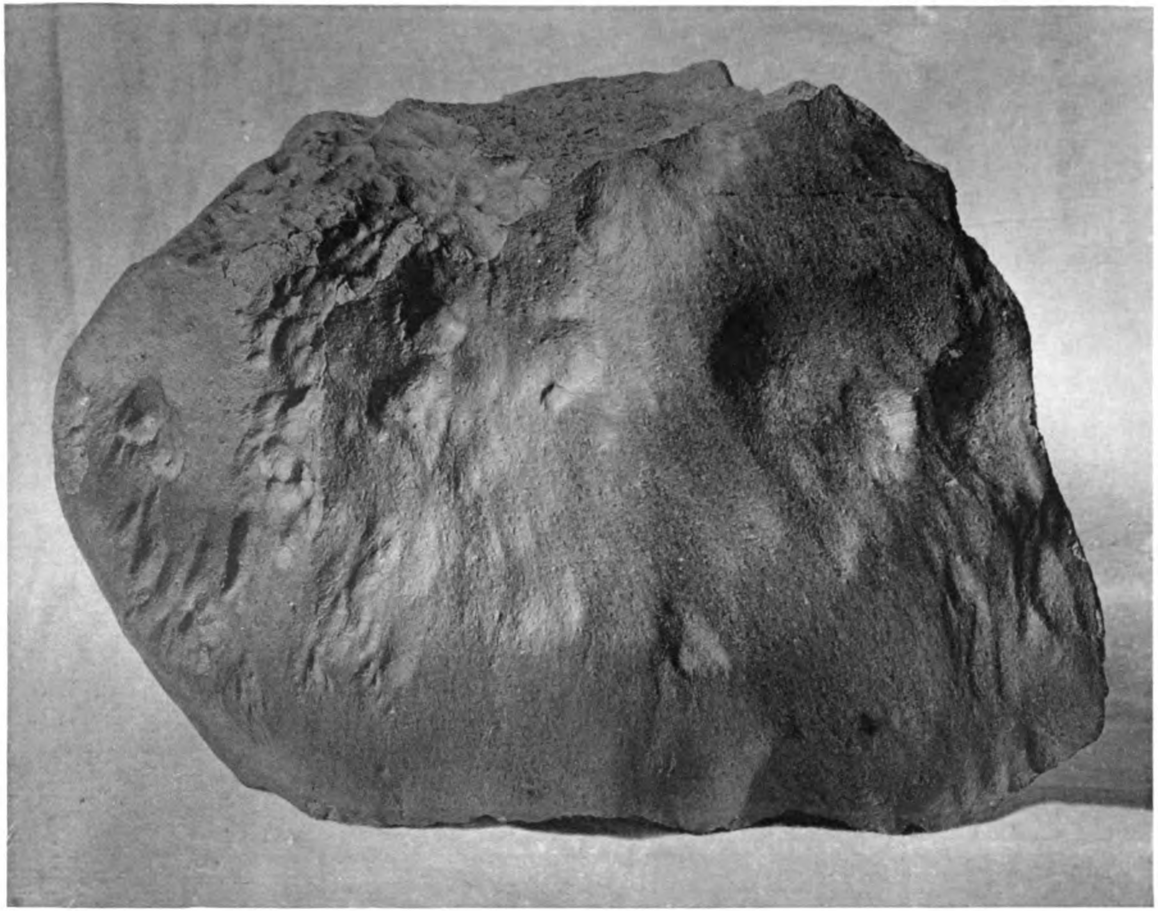
THE BHOLGHÁTI METEORITE (NO. 241 B).

End view of meteorite resting on its front face. Natural size.



H. B. W. Garrick, Photo. *Bemrose, Collo., Derby*

THE KARKH METEORITE (NO. 239 A). LARGE PIECE. HALF NATURAL SIZE.

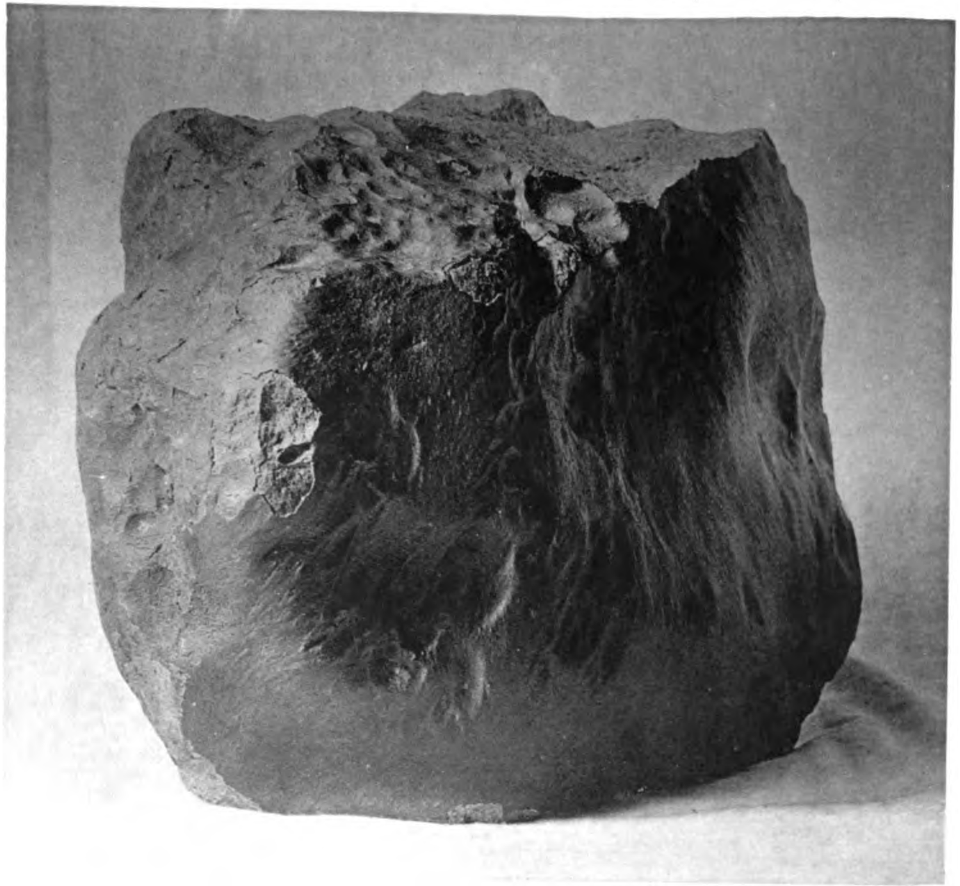
L. L. Fermor.

Records, Vol. XXXV, Pl. 10

H. B. W. Garrick, Photo. *Bemrose, Collo., Derby.*

THE KARKH METEORITE (NO. 239 A).

View of part of large piece showing pittings and flow-markings of crust. Natural Size.

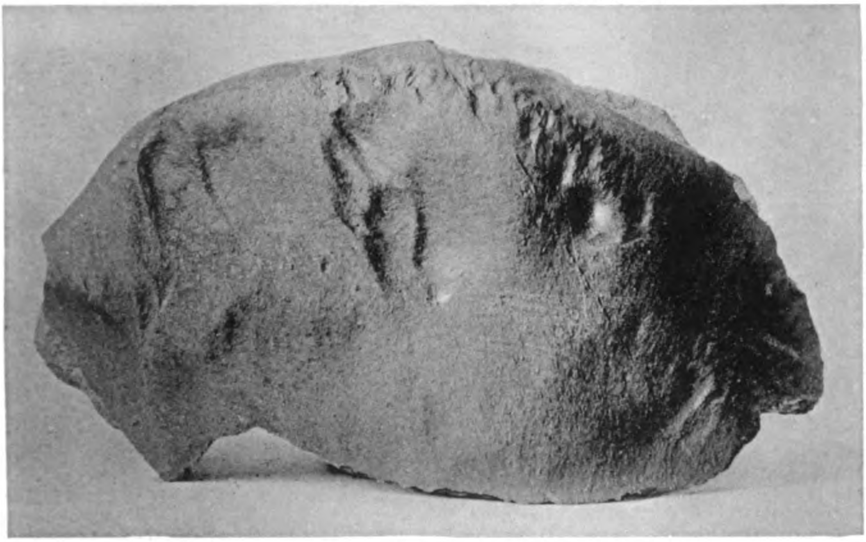


H. B. W. Garrick. Photo. Bemrose, Collo., Derby

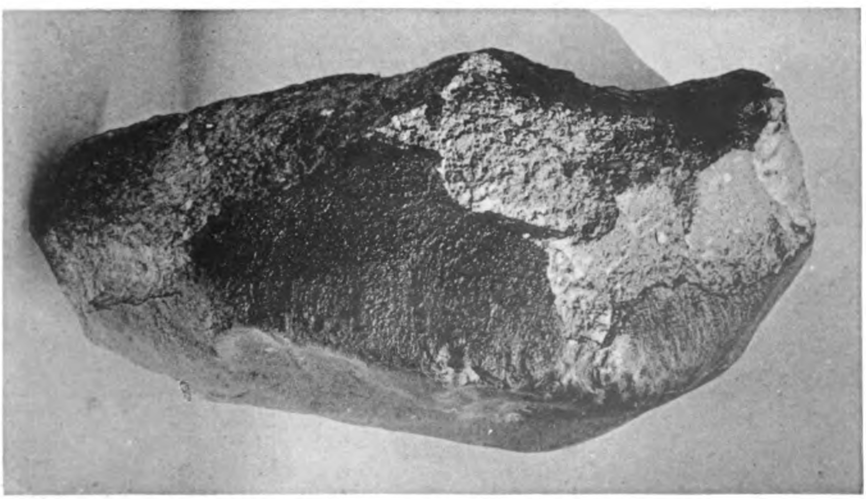
THE KARKH METEORITE (NO 239 A).

Large piece. View from left hand end. Half Natural Size.

L. L. Fermor. Records, Vol. XXXV, Pl. 12



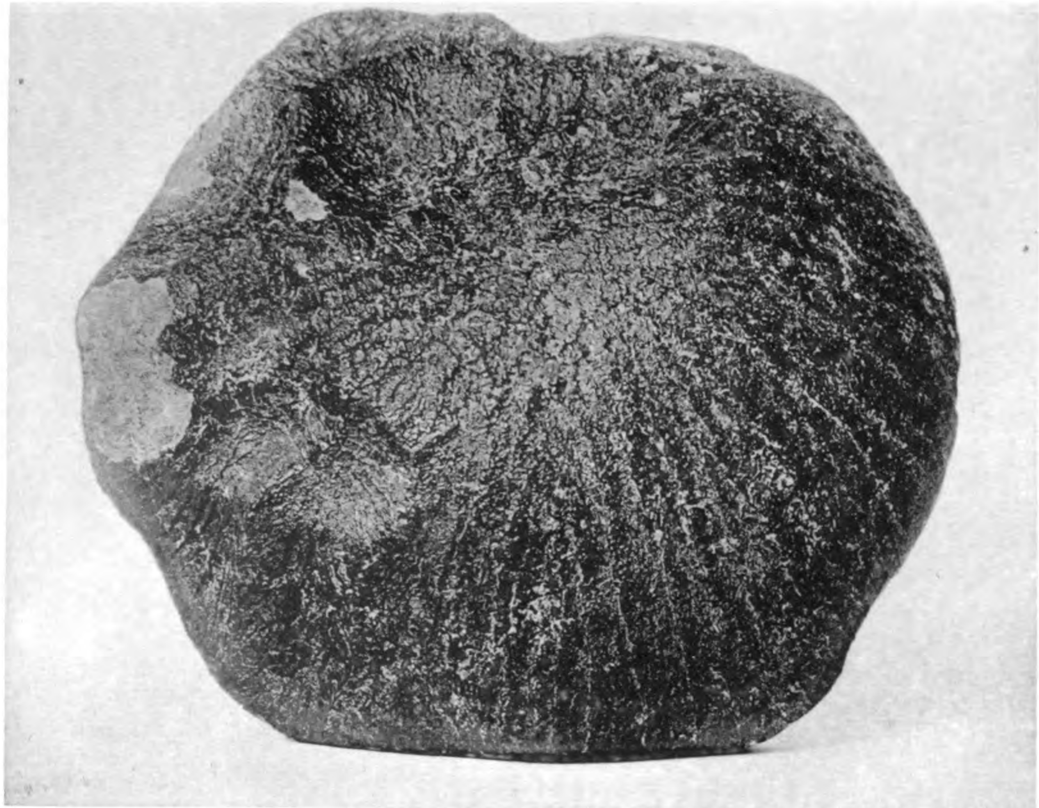
H. B. W. Garrick, Photo. Fig. 1



H. B. W. Garrick, Photo. Fig. 2. *Bemrose, Collo., Derby.*

THE KARKH METEORITE (NO. 239 B). SMALL PIECE. HALF NATURAL SIZE.

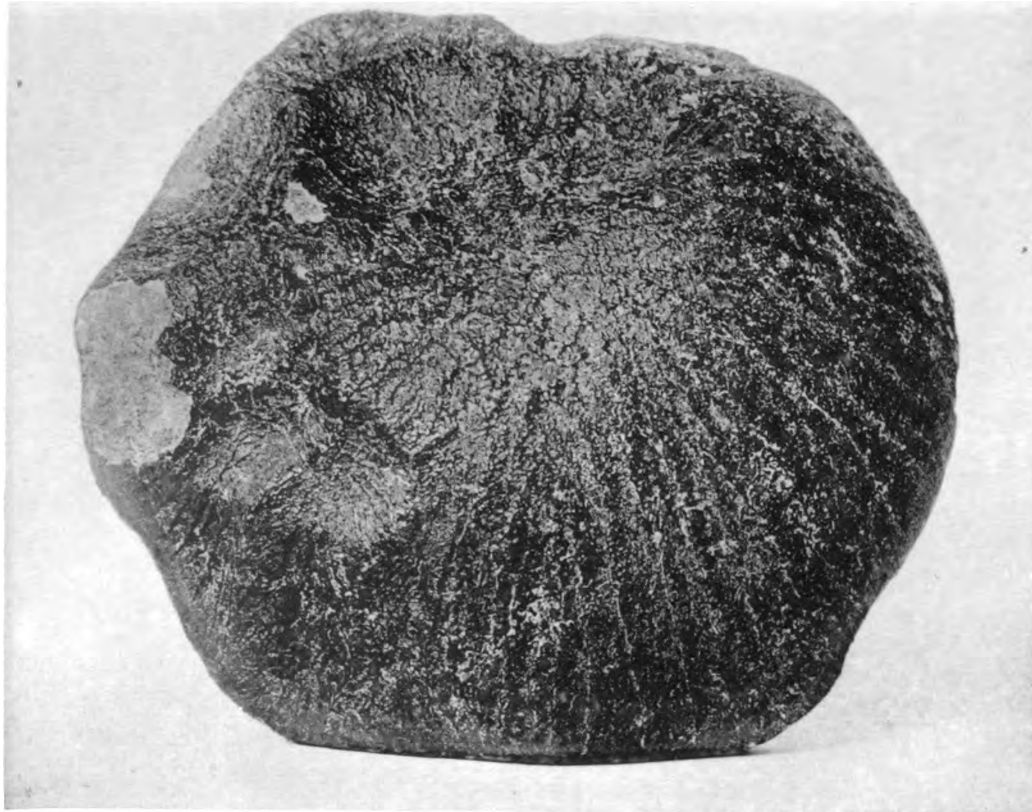
Fig. 1—Front view showing pittings. Fig. 2—View from above showing thickness of crust.



H. B. W. Garrick, Photo. Bemrose, Collo., Derby.

THE HARAIYA METEORITE (NO. 237). FRONT VIEW. NATURAL SIZE

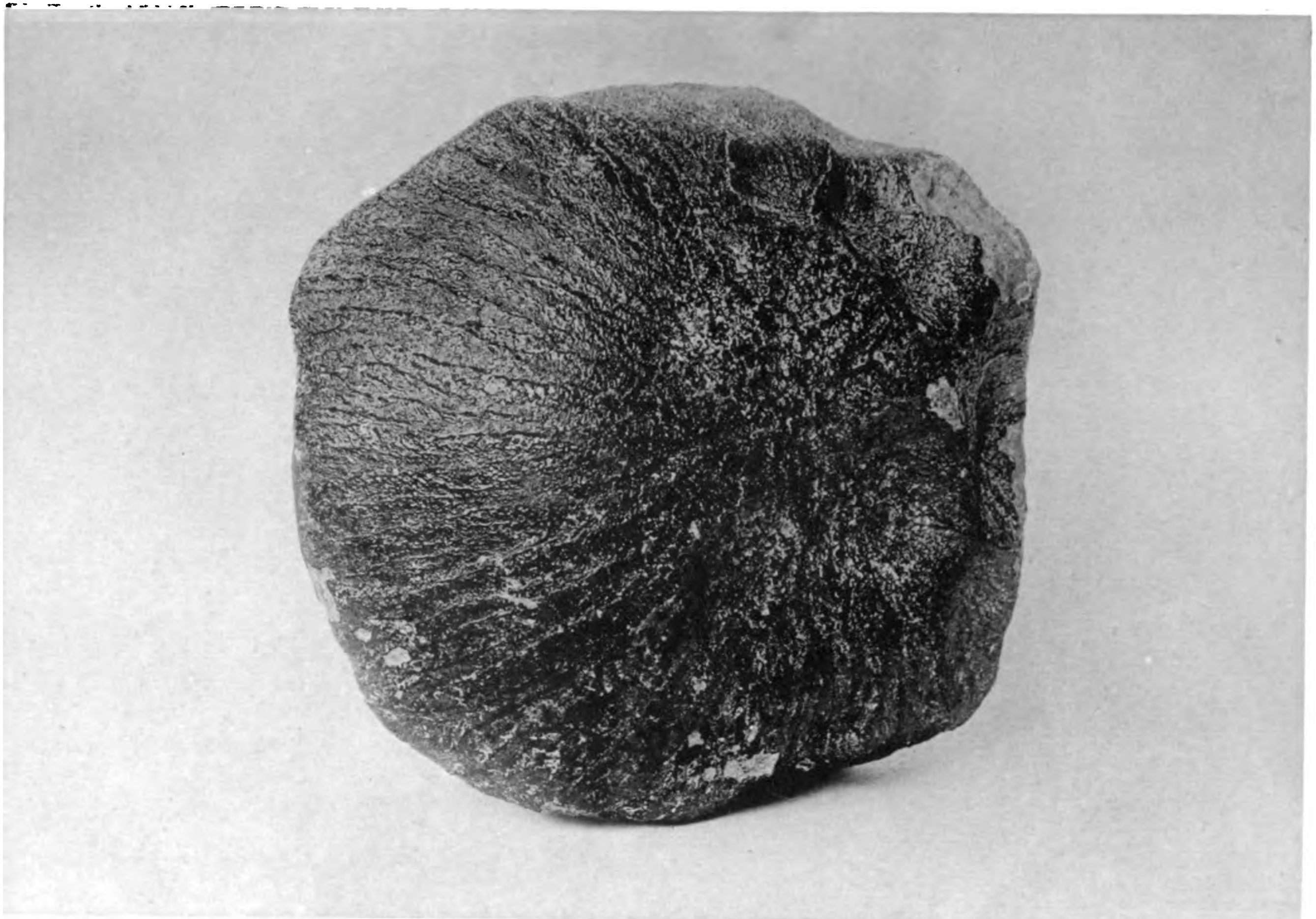
Shows pittings and radiated flow-lines of crust.



H. B. W. Garrick, Photo. Bemrose, Collo., Derby.

THE HARAIYA METEORITE (NO. 237). FRONT VIEW. NATURAL SIZE

Shows pittings and radiated flow-lines of crust.



H. B. W. Garrick, Photo. Bemrose, Collo., Derby.

THE HARAIYA METEORITE (NO. 237). BACK VIEW. NATURAL SIZE.

Shows radiating flow-lines of crust.

H. B. W. Garrick, Photo | Bemrose, Collo., Derby.

THE HARAIYA METEORITE (NO 237). THREE-QUARTER VIEW OF FRONT SIDE. NATURAL SIZE.

Shows radiating flow-lines of crust.

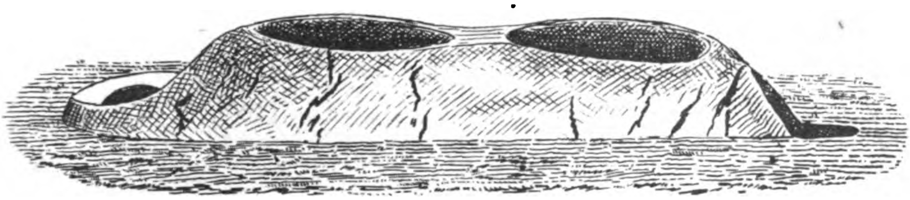


Fig. 1 Sketch of Furnace with pans removed.

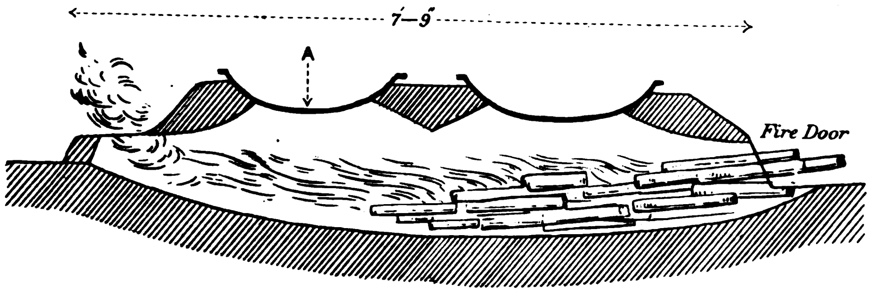


Fig. 2 Longitudinal Section.

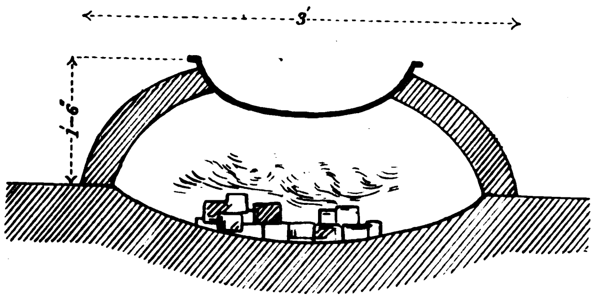


Fig. 3 Cross Section at A, fig. 2.

Drawn by T. H. D. La Touche.

SALT-BOILING FURNACE. BAWGYO.

RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

VOL. XXXV, PART 3.

1907.

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Part 3.] 1907. [July.

A PRELIMINARY SURVEY OF CERTAIN GLACIERS IN THE NORTH-WEST HIMALAYA. BY OFFICERS OF THE *Geological Survey of India.*

CONTENTS.

INTRODUCTION. BY T. H. HOLLAND, *Director.*

Himalayan glaciers.

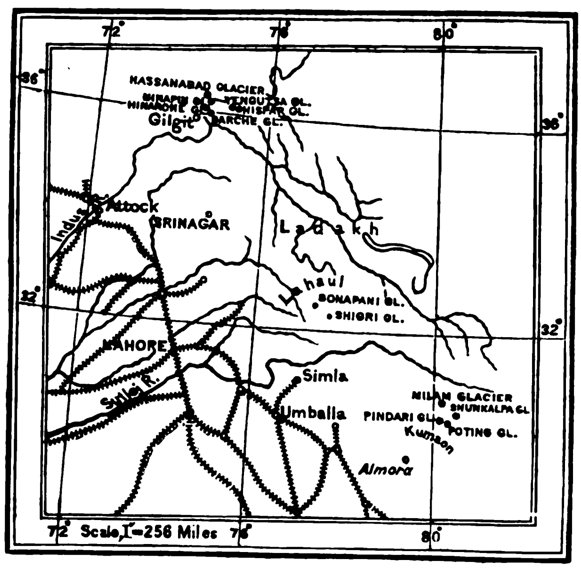
IN 1905, Mr. D. W. Freshfield, on behalf of the *Commission Internationale des Glaciers*, drew the attention of Lieutenant-Colonel S. G. Burrard, F.R.S., Superintendent of Trigonometrical Surveys, to the importance of recording data for determining the secular movements of the principal Himálayan glaciers. As the work required the co-operation of all officers and private travellers likely to visit the glacier regions of the Himálaya, Colonel Burrard referred the question to the Board of Scientific Advice, and, on the recommendation of a sub-committee composed of Colonel F. B. Longe, R.E., Surveyor-General, Dr. G. T. Walker, F.R.S., and myself, the Board agreed on a system of observations, recommending that the distribution of the necessary information and collection of data should be under the control of the Geological Survey Department. The proposals having received the sanction of the Government of India, the first step in the investigation was taken by the deputation of five Geological Survey officers during August and September to make a preliminary survey of the principal glaciers in the Kumaon, Lahaul, and Kashmir regions.

Altogether twelve glaciers were examined, as follows:—

Kashmir Region.—The Barche (lat. 36° 3′, long. 74° 42′) and Hinarche glaciers (36° 5′, 74° 36′) in the Bagrot valley which leaves the Gilgit R. at lat. 35° 52′, long. 74° 31′; the Minapin (36° 13′, 74° 40′), Hispar (36° 7′, 75° 15′), and Yengutsa (36° 9′, 75° 4′) glaciers in the Nagir State, and the Hassanabad glacier (36° 18′, 74° 37′) in Hunza. These six were surveyed by Mr. H. H. Hayden.

Lahaul.—The Bara Shigri (32° 16′, 77° 39′) and Sonapani (32° 25′, 77° 25′) glaciers were examined by Messrs. H. Walker and E. H. Pascoe.

Kumaon.—The Pindari (30° 15½′, 80° 2′), Milam (30° 27′, 80° 10′), Shan Kulpa (30° 19½′, 80° 2½′), and Poting (30° 12½′, 80° 12′) glaciers were surveyed by Messrs. G. deP. Cotter and J. C. Brown.



The above sketch-map shows the positions of these twelve glaciers with reference to better-known parts of Upper India. In all cases plane-table sketches were made, showing the exact positions of the ice-caves with reference to points cut and painted on rocks in the valley as well as with prominent and unmistakable peaks in the vicinity. In some cases cairns were built over the marks, and in the Kashmir area these were placed in charge of the nearest village headmen. The cairn built near the Milam glacier was placed in charge of Rai Bahadur Kishen Singh, who is well known to science as "A.-K."

Photographs were taken from various points of view carefully marked on the map and described in the report, showing the state of the glaciers and the principal masses of moraine material at the time of the visit. These photographs will enable subsequent travellers to form an idea of any changes that may have occurred in the interval, and will thus make the observations of value even if the fixed points cut in the rocks are destroyed by weathering or by being overwhelmed with loose material.

The reports are issued in two parts, the first, dealing with the Kashmir region by Mr. Hayden, is published in this part of this volume, while the descriptions and illustrations of the Lahaul and Kumaon areas are issued with Part 4.

The short time available rendered it necessary that observations should be confined to one aspect of the glaciers, namely, that of their secular advance or retreat. It was impossible, under the circumstances, to make more than passing observations on such questions as the rate of flow, the lamination of the ice, included dirt bands, and erosive action. These interesting questions must be left for future workers, as it was important in as many instances as possible to fix at once, for the purposes of the main problem, the positions of the snouts and general disposition of the ice with regard to fixed features in the ground around.

The first point that strikes one on examination of the reports is the fact that the glaciers of the Hunza valley and the Karakoram range generally descend to lower altitudes than in the Lahaul and Kumaon regions. In the former region the snouts of the glaciers proceed down to levels of 7,000 or 8,000 feet, while in the latter region they melt before descending below the level of about 11,000 feet. In the Hunza region, also, there are two classes of glaciers—

(*a*) those which flow transversely to the trend of the mountain range, and are relatively short, with a steep descent reaching down to elevations as low as 8,000 feet and under; and (*b*) those which lie in troughs parallel to the range, and also approximately parallel to the strike of the rocks of which the range is composed. These, having at their angles of slope a less rapid fall, rarely descend below 10,000 feet, and form long glaciers, in some cases making the most magnificent ice-flows in the Himalayas; the Hispar glacier is some 25 miles in length, while the Biafo, which commences on the opposite side of the same col, is even longer, being as much as 39 miles in length.

The second point most prominently displayed is the evidence of general retreat shown by the occurrence in nearly all cases of old moraines (sometimes grass-covered) at lower levels in the valleys. This point does not, of course, necessarily mean that the glaciers are now in retreat, and two well-authenticated cases of recent advance have been found in the Yengutsa and Hassanabad glaciers. The valleys below the glaciers being generally covered by moraine material and talus from the hills around, very seldom reveal the solid rock, and consequently the evidence with regard to the erosive action of the ice is very unsatisfactory. Only two instances have been recorded of the solid basement rock being exposed and showing marks of glaciation, namely, the Shunkulpa glacier in Kumaon, and the Minapin glacier in Nagir. These observations are insufficient to show whether the glaciers had eroded material in large quantity, or had only succeeded in striating and polishing the rocks over which they flowed. In the case of the Minapin glacier, the rock striated is a crystalline limestone, over which the glacier must have formed a considerable ice-fall, the rounded mass of rock being striated on the lee-side as well as above.

One of the most interesting features recorded in the reports is the occurrence of a large, dry lake-basin, about 1½ miles in length and nearly a mile in width, immediately below the Sonapani glacier. This was formed by the damming up of the glacier stream by an old terminal moraine. The waters of the lake have, since the silting of the basin, cut through the moraine barrier and escaped, leaving a desiccated plain along which meander numerous branches of the glacier stream.

A.—NOTES ON CERTAIN GLACIERS[1] IN NORTH-WEST KASHMIR. BY H. H. HAYDEN, B.A., B.E., F.G.S. (With Plates 17—39.)

BAGROT.

Hinarche Glacier.

THE Hinarche glacier, which occupies the upper reaches of the main valley, rises in the snow-fields of the south-eastern slopes of Rakipushi (25,550 feet) and the high snowy range running thence eastward and separating Bagrot from Nagir. The sources of the glacier have not been mapped in detail, nor so far as I am aware have they been visited by any European, and its total length is consequently unknown. For about eight miles up from its snout it was mapped in 1892 by Sir Martin Conway, whose description of the glacier enables us to form some idea of the changes that have taken place in the interval that has elapsed since the date of his visit.

Near its snout, the glacier separates into two branches, the larger occupying the centre of the main valley, and the smaller turning obliquely towards Sat in the tributary valley on the east. These are separated by an old, partially pine-clad moraine, and an extensive terminal moraine over-grown with scrub surrounds the snout of the smaller branch.

The main branch as will be seen from the sketch-map (Pl. 33) is very much the larger of the two, and on its left front impinges against the precipitous slopes of the Gasunar ridge; here the path from Sat to Chira is forced first up over the ice and then along the face of the

[1] These glaciers are conveniently approached from Srinagar as starting point. From this city it is necessary to march to Gilgit *viâ* Tragbal, Astor and Bunji. From Gilgit the Minapin glacier is reached in three marches, by way of Nomal and Chalt. The march to the Hispar glacier is *viâ* Askurdás, Nagir and Huru; and from this camp the Darapu glacier can be examined. On returning to Huru the Hassanabad glacier is approached *viâ* Baltit (Hunza) and Aliábad. In order to survey the Barche ("Burche") and Hinarche glaciers it is necessary to return to Gilgit and march *viâ* Sinakar to Dar.

cliffs, till beyond the ice-cave it descends again to the broad valley below the glacier (see Pls. 33 and 18). Here we have distinct evidence of advance since 1892, when Sir Martin Conway, on his way from Sat to Bulchi, passed through "narrows, between the ice of the glacier's snout and the angle of the Gargo valley."[1] The total advance, however, is not great and may have no significance as regards truly secular movement, for the glacier is said to undergo periodic fluctuation, going through a definite cycle extending over a period of six years, three of advance and three of retreat; this characteristic is vouched for positively by the natives of Phanpher, Bulchi and Sat, who all seem to be aware not only of the movement but also of its regularity. Some reservation in accepting this statement must be made on account of the vague ideas of time-intervals entertained by most primitive communities, and the peasants in these valleys are no exception to the general rule; but there is daily intercourse throughout the greater part of the year between Bulchi and Chira on the one side and Sat and Dar on the other, and observations relative to movements of the ice which are of sufficient importance to affect the position of the path between these villages may be accepted with some confidence.

At the time of my visit (September 30th—October 4th) the snout of the main branch was said to be at its position of maximum advance, and the position of furthest retreat was reported to coincide approximately with the dotted line shown on the sketch-map (Pl. 33): this points to a fluctuation of over 300 yards in three years. I am inclined to think, however, that this superior limit has been placed too far back, since at the time of Conway's visit—May 1892, corresponding to an intermediate stage in the period of advance—the ice was evidently not far from the cliffs of the Gasunar spur; the path apparently ran at that time along the valley bottom, but the stream from Sat passed, as at present, through a tunnel under the ice near the cliffs, and although the advancing glacier might no doubt carry the tunnel forward with it, yet when the period of retreat set in the tunnel must either disappear or the stream must cut it back laterally sufficiently rapidly to keep pace with the retreat of the ice; it seems much more probable, however, that if the retreat were as great as stated the tunnel would disappear and the stream pass round the snout of the glacier. The evidence,

[1] Climbing and Exploration in the Karakoram Himalayas, 1894, p. 206.

therefore, points to a considerable vertical, but relatively small horizontal, diminution of the glacier. The wall of ice now abutting against the Gasunar cliff appears to be over 100 feet high; in the periods of retreat this must melt completely to the level of the valley and retire from the cliffs to a sufficient distance to admit of a clear passage between them and the tunnel. This might no doubt be due to seasonal or rather periodic variation in the snowfall, but such variation is not likely to be regular.

Only the main stream of the glacier appears to be affected by this periodic fluctuation, the position of the small left branch being approximately stationary. This latter branch is completely surrounded with old terminal moraine, now overgrown with scrub, and there is ample evidence that this part of the glacier has retreated. In the main valley, on the other hand, the evidence of comparatively recent retreat is by no means so well-marked: low ridges of old moraine run down the valley, but they are relatively small and have been to a great extent re-arranged by water, whilst the presence of bushes right up to the ice of the snout shows that it is some time since the glacier occupied a position in advance of its present one.

Old lateral moraines are well-marked on both sides of the valley. In the valley below Diran there are at least three clearly defined parallel ridges of moraine, of which the outer two are partially covered with full-grown forest trees, whilst the innermost of the three has been only comparatively recently left by the ice. On the right-hand side of the valley, similar old moraines can be seen beyond the steep cliffs against which the glacier lies. It is thus clear that the glacier is contracting in volume, although there may be no actual secular retreat of the snout of the main stream.

On the accompanying sketch-map, stations (1) and (2) represent points on either side of the main valley: (1) on the right side and (2) on the left. At the time of my visit, a line joining these two points would have touched the most advanced part of the snout of the main ice-stream (see Pls. 18 and 19). At each point, a cross (×) was cut on solid rock, and marks were painted in black paint beside and around the cross (×): a list of these marks will be found on the sketch-map (Pl. 33).

A third station (3) was selected high up on the hill-side, about 1,500 feet above Chira and just above the path to Damaye, a forest grazing ground above Gasunar; from this point a good general view of the glacier is obtained (see Pl. 17): this station is also on solid rock, on which the marks were cut and painted.

A conspicuous cairn, between 4 and 5 feet in height, was built over the mark cut at each of the stations; the cairn was capped with a slab on which was painted the number and date of the station, and a cross (×) several feet in length was in most cases painted on the exposed rock-face near the cairn. The paint was similar to that used for marking the mile-stones on the Gilgit Road, and the marks will probably be found to last for some years.

Barche Glacier.

The remains of old moraines which are seen extending up the hill-sides far above the present glaciers show that at one time the whole of the upper Bagrot valley was filled with a continuous sheet of ice of which these glaciers are but the mere relics: thus the villages of Gasunar, Sat, and Dar all lie on old moraine materials. Near the Barche glacier this old moraine is covered with forest of pine, spruce and juniper of great age. The glacier now consists of two main streams, one coming from the snowy peaks above the grazing-grounds of Barche and flowing south till it meets the other stream which is derived from the snow-fields among the peaks to the east and north-east and flows past Gargo[1]; from the junction, the combined streams flow due west between vertical cliffs nearly 150 feet high of old moraine on the right hand (north) side and a high rocky ridge on the left. The snout of the glacier lies at about half a mile to the south-east of the small village of Dar and ends in a broad and boulder-strewn valley. On either side of and in front of the snout are remains of a former moraine (see 2 on Pl. 34), now sparsely studded with young pine trees: the moraine, however, is stated to be considerably older than the trees; it has been eroded and in places re-arranged by water; this effect as well as the absence of older trees is said to be due to floods which occur in this valley from time to time owing to the bursting of glacial dams; a particularly violent one is said to have taken place some few years ago and to have destroyed all the trees on the moraine. Small lateral moraines, however, on either side of the snout show that there has been a comparatively recent retreat of the

[1] These are shown on Conway's map as the Burche and Gargo glaciers respectively.

ice, but it is impossible to say whether such movement is truly secular or merely seasonal.

Two large erratic blocks (A, B, Pl. 34), one on either side of the snout, were chosen as stations: a line joining these, as will be seen from the sketch-map (Pl. 34), would pass in front of the ice-cave and cut through the left toe of the glacier at 100 feet behind its extreme western end. Photographs were taken looking across the snout in each direction (Pls. 21 and 22), and a general view of the glacier (Pl. 20) was taken from a large boulder in the broad river-bed at some distance below the snout. In each case a cross (×) was cut on the rock and name of station and date of observation were painted beside it: cairns were then built over the marks and capped with slabs: the marks at the respective stations A, B and C will be found on the plan (Pl. 34). In case a marked advance of the ice should take place resulting in the obliteration of these stations, two other points were chosen, in the same straight line as A and B; these were E, a pine-tree on the edge of the precipitous cliff of old moraine, and D a flat surface of rock 47 feet 8 inches to the south of A. The trunk of the pine-tree E was blazed on the side overlooking the glacier, a cross (×) was cut into it and an inscription painted on it.

NAGIR.

Minapin Glacier.

The Minapin glacier rises in the névés on the north-east flanks of Dumani (Rakipushi)[1] and falls rapidly towards the Hunza river; near the snout is an ice-fall, marked by broken and impassable sérac; here the glacier bends almost through a right angle and terminates in a steep snout filling a narrow valley and just visible from the bridge crossing the stream between the villages of Pisan and Minapin (see Pls. 35 and 23).

From the village of Minapin the lower part of the glacier is hidden by steep hills composed partly of solid rock and partly of old moraine The rock consists of garnetiferous sandy mica schist and crystalline limestone; its face is very steep and has been beautifully polished and grooved by ice, thus showing that at one time there was a steep ice-fall from the top of the ridge down to the valley below.

[1] The name "Rakipushi" is only known in Hunza and Nagir as the name applied by Europeans to the peak locally called "Dumani."

Evidence of retreat of the ice is afforded not only by the glaciated rock-surfaces, but also by two old moraines, one of which (1, Pl. 35) now forms an old grass-covered ridge some way from the present glacier. The second moraine (2, Pl. 35) is of the nature of a terminal moraine and is of comparatively recent date, having been left by the ice as it gradually shrank back off the limestone cliffs and became restricted to the narrow gorge in which it now flows. There is no well-marked terminal moraine in the stream-bed in front of the snout; this may be due to the fact that the glacier is now advancing, but is more probably attributable to the fact that any material dropped from the snout is at once distributed by the violent stream which issues from the ice-cave and, during the summer, completely fills the narrow gorge to which the snout is now confined.

According to local tradition, the glacier, five generations ago, extended almost down to the bridge, and even after making due allowance for the unreliability of local conceptions of time-intervals, it is evident that the total amount of retreat of the glacier in historical times must have been very appreciable.

For purposes of observation, two points were chosen—one on either side of the gorge—in such positions that a line joining the two touched the present snout of the glacier: these points are B and D on the plan (Pl. 35). At B, a cross (×) was cut on a large block, and the letters G. S. I. and date (24th September 1906) were painted on the face of the rock; over this a cairn was built. On the opposite, left bank, of the gorge, a cross (×) was also cut in the solid rock beside the path leading to the summer grazing grounds, and the usual marks were painted on the rock-face. On the same side of the gorge and immediately above the cliff of old moraine overhanging the stream, a rock (A) was chosen and a cairn built over it; from this point the photograph (Pl. 24) was taken of the snout of the glacier.

Plate 23 shows the snout of the glacier as seen from a large flat rock situated at 150 feet to N. 20° E. of the bridge on the main road from Pisan to Minapin and 20 feet S. 10° W. from the nearest point of the road; this station offers considerable facility for observation of the movements of the glacier, for subsequent photographs taken from the same point should offer evidence of advance or retreat.

The marks and cairns were shown to the headman of Minapin village, who was instructed to keep them in repair.

Hispar Glacier.

The Hispar glacier, which is one of the largest in the Himalayan region, has a length of about 25 miles and a breadth near its snout of nearly ¾ mile. It occupies a long trough, which is parallel to the strike of the stratified rocks, and is a typical example of the longitudinal type of glacier referred to below (p. 136). The snout of the glacier lies at about 1¼ mile from the village of Hispar.

The glacier was visited in 1892 by Sir M. Conway, who came to the conclusion that it had for a long time been practically stationary.[1] At the time of his visit, the path crossing the snout of the glacier to the grazing grounds of Bitermal left the left bank at some little distance below the loop-holed wall ("sangar") built across the path to Chokutens (3, Pls. 36 and 27). This sangar is still in a very good state of preservation, and serves as an admirable landmark, but the path across the glacier no longer takes off below, but at about 100 yards above, the sangar; it is evident, therefore, that, at the time of Conway's visit, the ice extended to some little distance further down the valley than in September 1906. The total retreat is only a matter of a few hundred yards, and might quite well be due to seasonal variation. Evidence of retreat in comparatively recent times, however, is afforded by a single narrow moraine (b, Pl. 36) extending for some distance down the valley from the right toe of the glacier: this moraine is narrow and only about 30 feet in height, but is fairly continuous up to the glacier (Pl. 25).

In order to determine the movement of the glacier, four stations were chosen; *viz.*, A, a large erratic block near the edge of the steep cliff on the left bank of the river and at a little over a mile from the snout of the glacier and about 800 yards from the village of Hispar. From this a photograph (Pl. 25) was taken giving a general view of the glacier. A cross (×) was cut in the stone, the date (17th September 1906) added in black paint, and a cairn was then built over the marks.

The next point is a steep and conspicuous hill of old moraine (B, Pl. 36) on the left side of the valley: from this a photograph (Pl. 26) of the snout and ice-cave was taken and the site was marked by means of a cross (×) cut on a block of white crystalline limestone on the top of the hill: this was also marked with a circle O and a large

[1] *Op. cit.*, p. 331.

cross (×) in black paint, and a cairn was built over the marks. The camera was set up at eight feet to north-west of this mark.

The next station selected (C) is a granite block on the old lateral moraine on the right side of the glacier: on this the usual cross (×) was cut and the date (16th September 1906) painted on the stone; a cairn was then built over the mark and capped by a flat stone similarly painted. From this point a photograph (Pl. 27) was taken looking towards the "sangar"(3) on the left side of the valley. The line joining the points (C) and (3) just touches the right toe of the glacier and cuts the left toe 350 feet behind its extreme point.

Yengutsa Glacier.

Between the villages of Hispar and Darapu a deep and narrow valley[1] is now occupied by a glacier, the snout of which abuts on the fields on either side. This and the glacier to be next described are in many respects the most interesting of those visited, for both are known to have advanced with startling rapidity in the course of the last few years.

In the year 1892, the path from the fields of Darapu to Hispar village descended into a precipitous gorge: "a deep nala . . . divides Darapu from Hispar. In its bowels some half-dozen mills find a footing. The path goes round by these and mounts to the fairer fields of Hispar."[2]

It is difficult to imagine a more striking contrast than that between the picture called up by Conway's description of the ravine and its present condition. Now the path, instead of descending, climbs arduously over a steep mass of black and slippery ice, the mills are gone and their ruins hidden under the snout of the advancing glacier, and many of the " fair fields " are now an uncultivated waste of boulder and moraine (see Pl. 37): what the total amount of advance has been it is not possible to say, but to judge from Sir Martin Conway's map, it must have been at least two miles. Nor does this appear to have been gradual, for according to local reports, the glacier moved forward suddenly some five years ago, and has since been practically stationary.

[1] On Sir M. Conway's map the glacier is named the Rung Pa, but the name locally used at the time of my visit was Yengutsa.

[2] *Op. cit.*, p. 325.

Pl. 28 shows a general view of the glacier taken from a large erratic block of granite (D) lying in a field to the east-south-east of Hispar village; this block was marked in the usual way and a cairn was built over the mark.

Two stations were also chosen, one on either side of the snout of the glacier, in such position that a line joining the two would touch the extreme snout of the ice in the valley-bottom. That on the Hispar side is a large flat stone at the south-east corner of the cemetery; this was marked with the usual cross (×) cut on the stone and the letters $\frac{D}{e}$ were added in black paint; similarly, the station on the Darapu side is a large boulder of granite, which was marked $\frac{D}{w}$. Pl. 29 represents a photograph taken from this latter station, looking up the Yengutsa valley, whilst Pl. 30 is a view of the snout and ice cave taken from the edge of the precipitous bank 40 feet to E. 20° S. of $\frac{D}{w}$. Cairns were built over each of these stations, and these, as well as the cairns at stations A, B and C of the Hispar glacier, are put in charge of the village headman (Gauhar by name) and a member of the local levy, named Shah Murad, who had accompanied Sir M. Conway in 1892.

HUNZA.

Hassanabad Glacier.

Like the Yengutsa glacier, that of Hassanabad has a well-authenticated history of recent advance, but in this case the advance has been much greater than in the case of the Yengutsa glacier. According to the statements of the Mir of Hunza and his Wazir, the advance took place about three years ago, when the glacier moved forward over a distance, variously estimated as from six miles to one day's march, in the course of 2½ months; owing to the danger involved to the villages in the valley, its progress was very carefully watched, and the above statements may therefore be regarded as reliable, although undoubtedly somewhat indefinite. The snout is now said to be stationary, no further advance having been recently observed. It is further stated by the Wazir that the glacier occupied its present position many years ago; it subsequently retreated very rapidly, but has now returned to its former site. The snout lies in a broad gravelly stream-bed (see Pl. 38) with no trace of recent moraine, either terminal or lateral. Three points were selected as stations, one being on either side of the snout and a third (3) on a large flat rock near the last (most northerly) group of bushes growing beside the Garukin irrigation-channel, high up on the steep slope on the right side of the valley.

Station (1) is a large erratic block of granite just above the right bank of the river, the point chosen on the opposite bank is a conspicuous cliff with intersecting veins of white granite ; the photograph of the snout (Pl. 31) was taken from station (1) looking towards station (2). A line joining stations (1) and (2) would just touch the toe of the glacier.

Plate 32 is a general view or the glacier taken from station (3) on the Gamkin irrigation-channel.

SUMMARY.

Six glaciers in Hunza, Nagir and Bagrot have been visited and sketch-maps and photographs of their snouts prepared with a view to determine the direction and amount of their secular movements. These glaciers are the Hinarche and Barche in the Bagrot valley, the Minapin, Hispar, and Yengutsa in Nagir, and the Hassanabad glacier in Hunza.

The glaciers fall into two classes, *viz.*, those which lie in troughs parallel to the mountain-ranges, and those which flow at right angles to the ranges: the former may be termed longitudinal and the latter transverse glaciers. Of those enumerated above, the majority, *viz.*, the Hinarche, Minapin, Yengutsa, and Hassanabad glaciers, are transverse ; the Hispar is a very typical longitudinal glacier; whilst the Barche glacier is in the main longitudinal, but one of its branches, the smaller of the two, is transverse. The longitudinal glaciers are characterised by their greater length, greater stability, gentler gradient and the higher elevation at which they terminate (about 10,000 feet as compared with elevations of less than 8,000 feet to which such glaciers as those of Minapin and Hassanabad descend). The longitudinal glaciers are therefore likely to give more reliable evidence as to the direction of truly secular movements than are the transverse glaciers, which appear to be more readily affected by seasonal and short-period variations. Thus the Hispar and Barche glaciers show no signs of rapid fluctuation, such as has affected those

of Hinarche, Yengutsa, and Hassanabad; they appear, on the other hand, to be almost stationary, with, however, a general tendency to retreat. Of the transverse glaciers, two, the Yengutsa and Hassanabad, have advanced remarkably in recent years; the Hinarche appears to fluctuate, advancing and retreating through short periods, although the numerous lateral moraines point to a general history of retreat, whilst the history of the Minapin glacier appears to be one of steady secular retreat.

(*Notes on Lahaul and Kumaon will be issued in Part 4.*)

Photo. by H. H. Hayden.

Bemrose, Collo., Derby.

HINARCHE GLACIER.

From Station 3.

[For index to letters, see sketch map of Glacier.]

Photo. by H. H. Hayden. Bemrose, Collo., Derby.

HINARCHE GLACIER.

Snout from Station 1.

Photo. by H. H. Hayden.

Bemrose, Collo., Derby.

HINARCHE GLACIER.

Snout from Station 2.

Photo. by H. H. Hayden.

Bemrose, Collo., Derby.

BARCHE GLACIER.

From Station C.

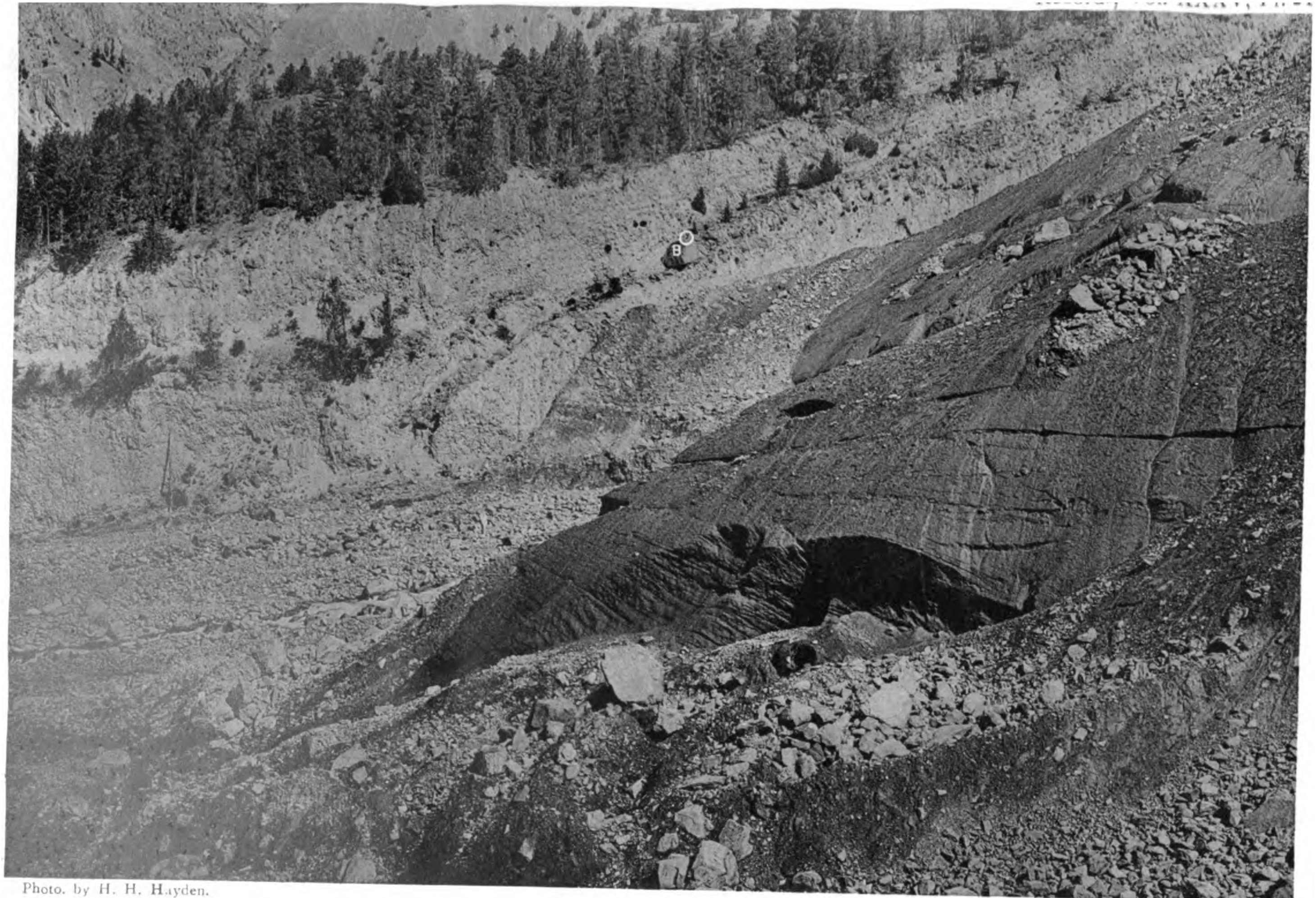


Photo. by H. H. Hayden.

Bemrose, Collo., Derby.

BARCHE GLACIER.

From Station A, looking towards Station B.

Photo. by H. H. Hayden.

Bemrose, Collo., Derby.

BARCHE GLACIER.

From Station B, looking towards Station A.

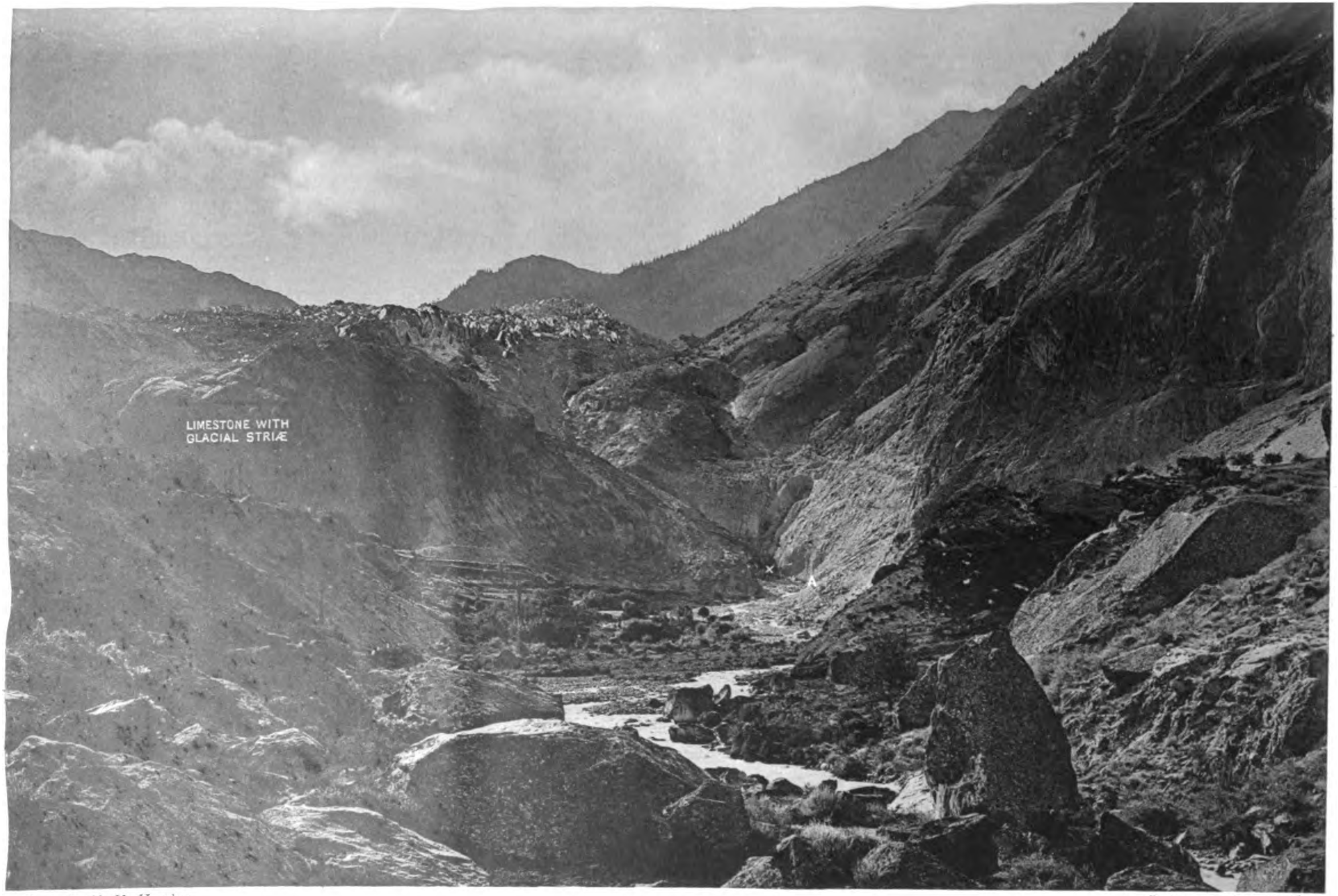


Photo. by H. H. Hayden. Bemrose, Collo., Derby.

MINAPIN GLACIER.

General view from bridge Station.

[×, Snout of Glacier.]

Photo. by H. H. Hayden. Bemrose, Collo., Derby.

MINAPIN GLACIER.

View of Snout from Station A.

Photo. by H. H. Hayden.

Bemrose, Collo., Derby.

HISPAR GLACIER.

From Station A.

Photo. by H. H. Hayden.

Bemrose, Collo., Derby.

HISPAR GLACIER.

Ice-cave from Station B.

[3, Sangar.]

Photo. by H. H. Hayden.

Bemrose, Collo., Derby.

HISPAR GLACIER.

Snout from Station C, looking towards Sangar (3).

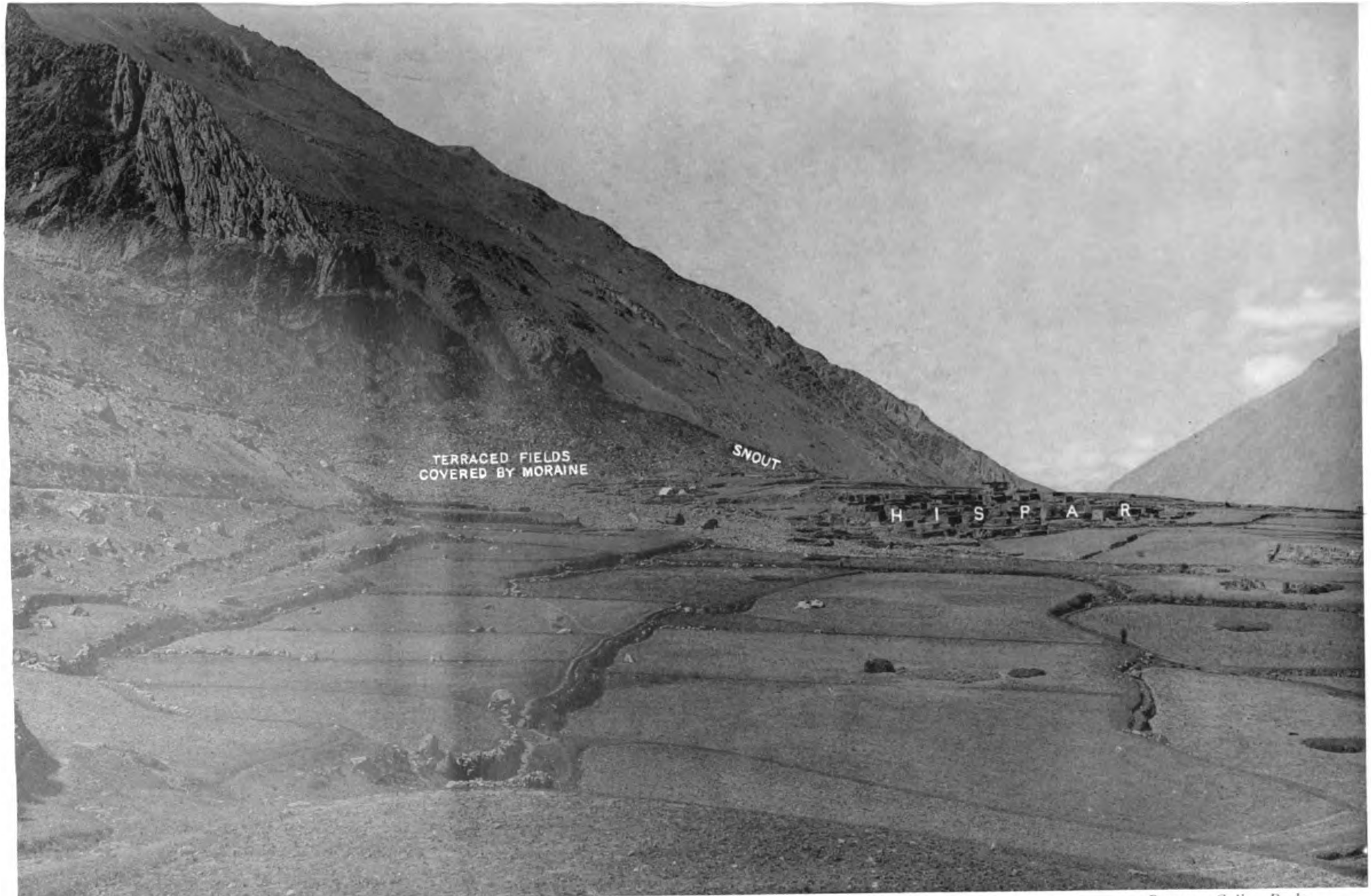


Photo. by H. H. Hayden. Bemrose, Collo., Derby.

YENGUTSA GLACIER.

From Station D.

Photo. by H. H. Hayden.

Bemrose, Collo., Derby.

YENGUTSA GLACIER.

Left front from Station $\frac{D}{w}$.

Photo. by H. H. Hayden.

Bemrose, Collo., Derby.

YENGUTSA GLACIER.

Snout from Station $\frac{D}{w}$, looking towards $\frac{D}{c}$.

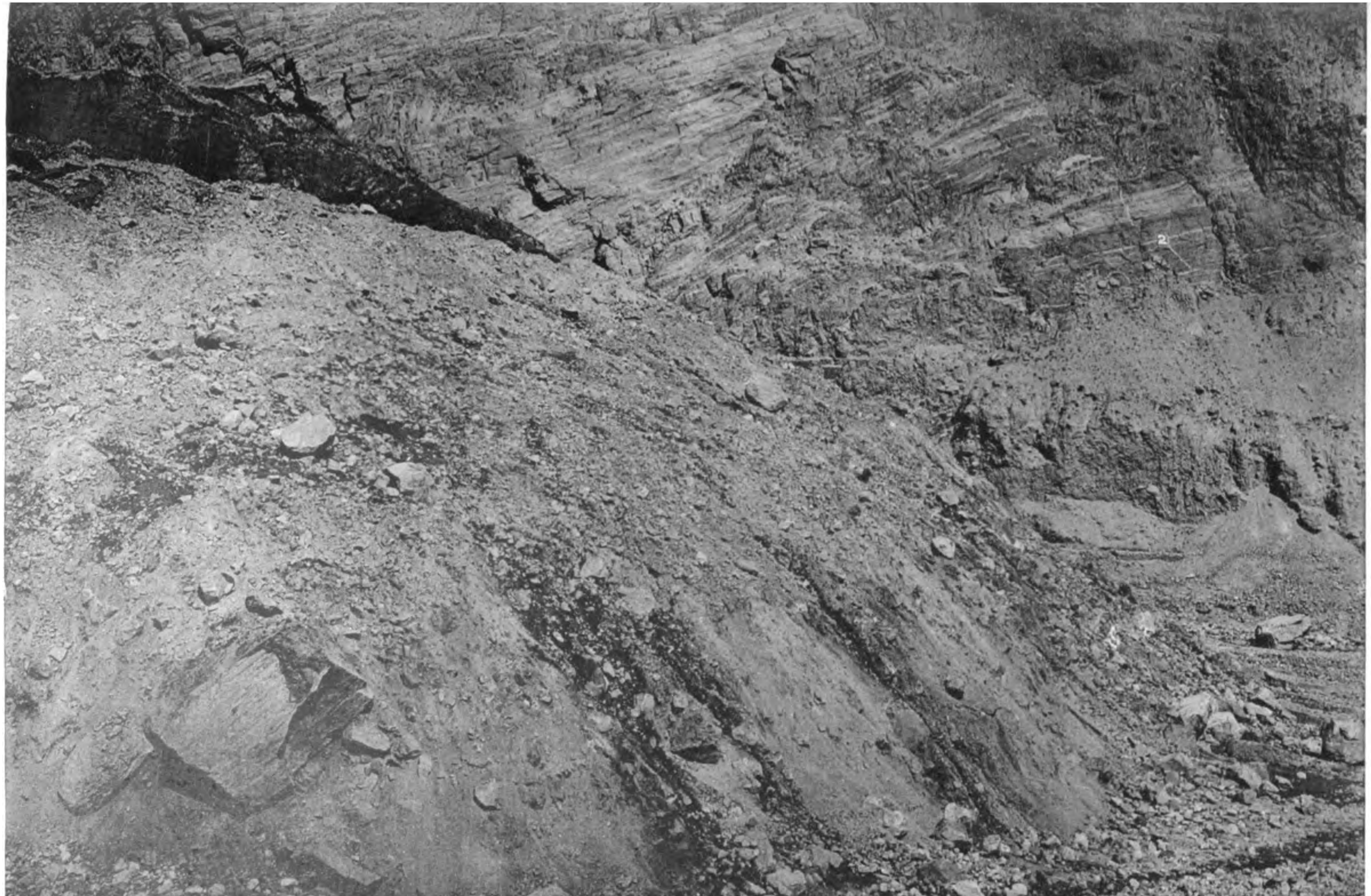


Photo. by H. H. Hayden.

Bemrose, Collo., Derby.

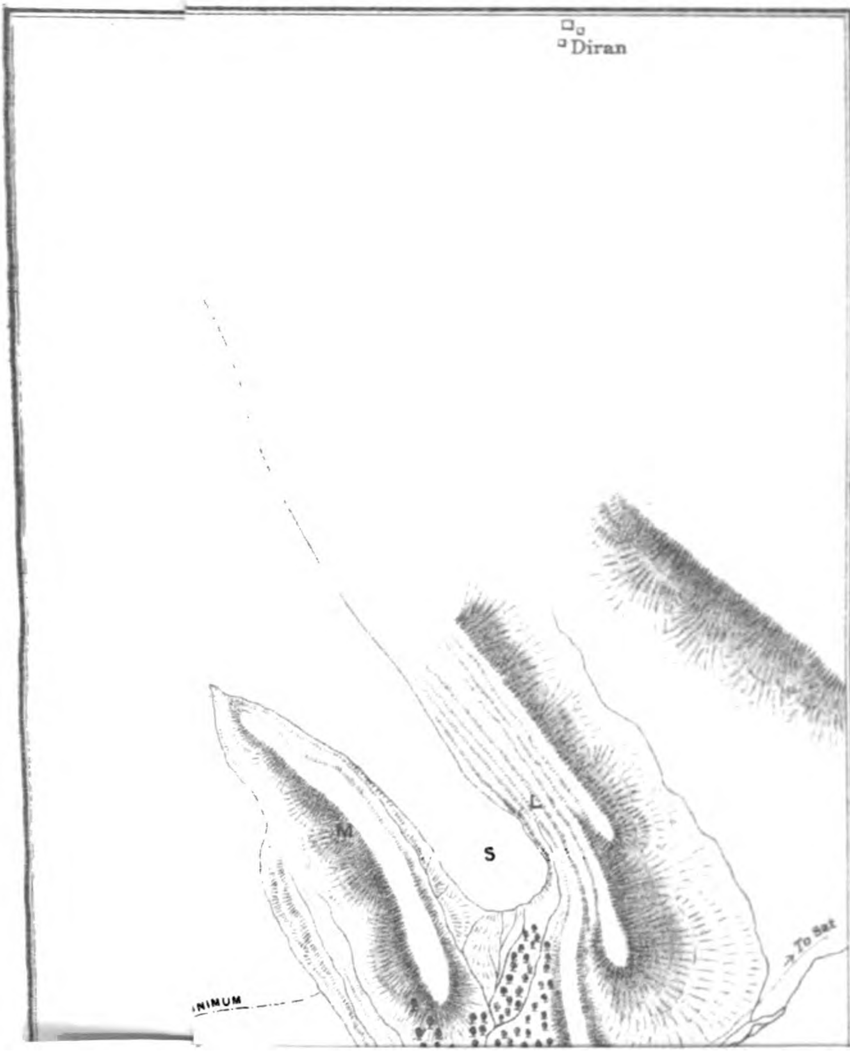
HASSANABAD GLACIER.

From Station 1, looking towards Station 2.

Photo. by H. H. Hayden. Bemrose, Collo., Derby.

HASSANABAD GLACIER.

From Station 3.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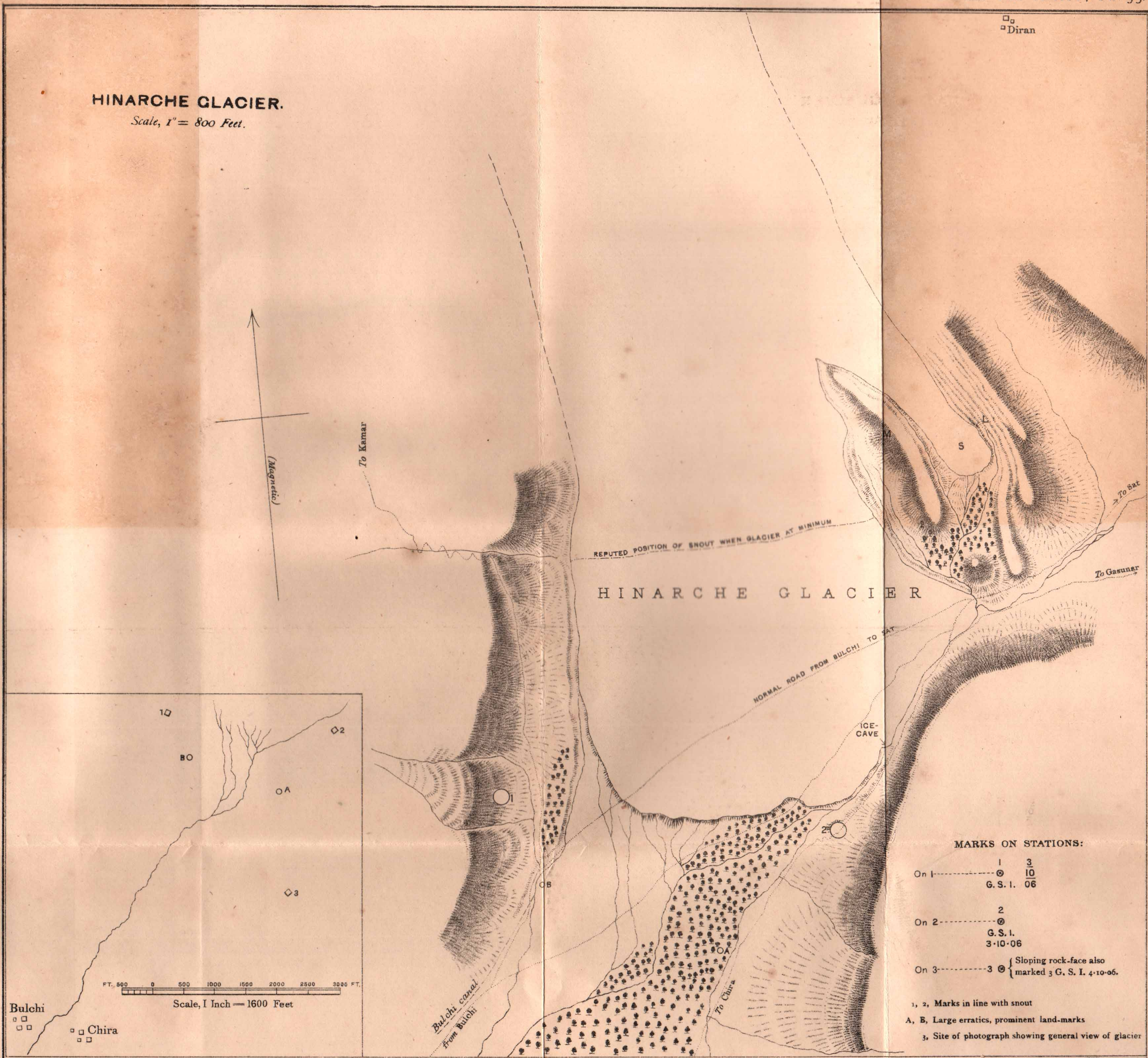
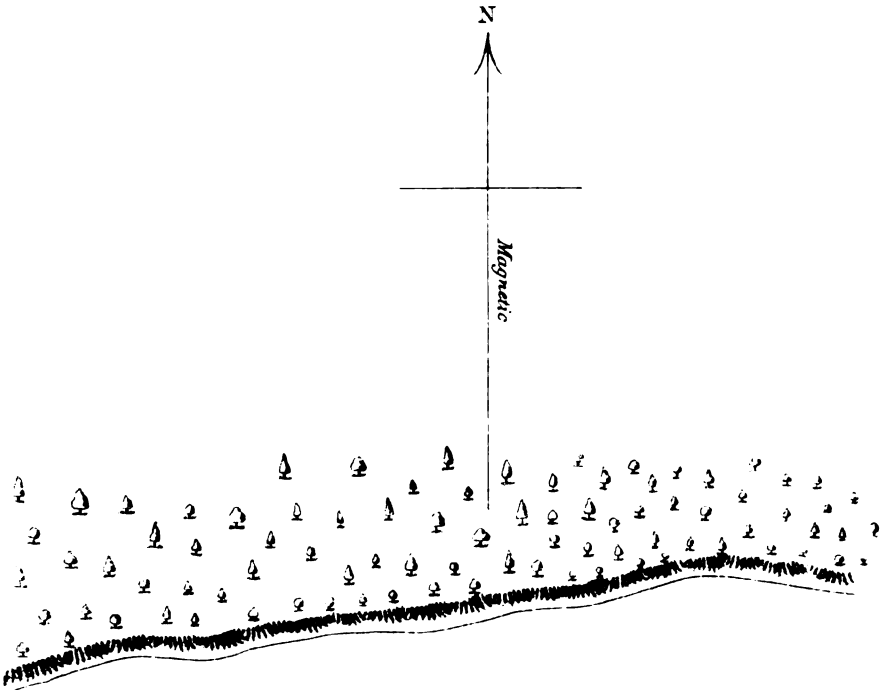
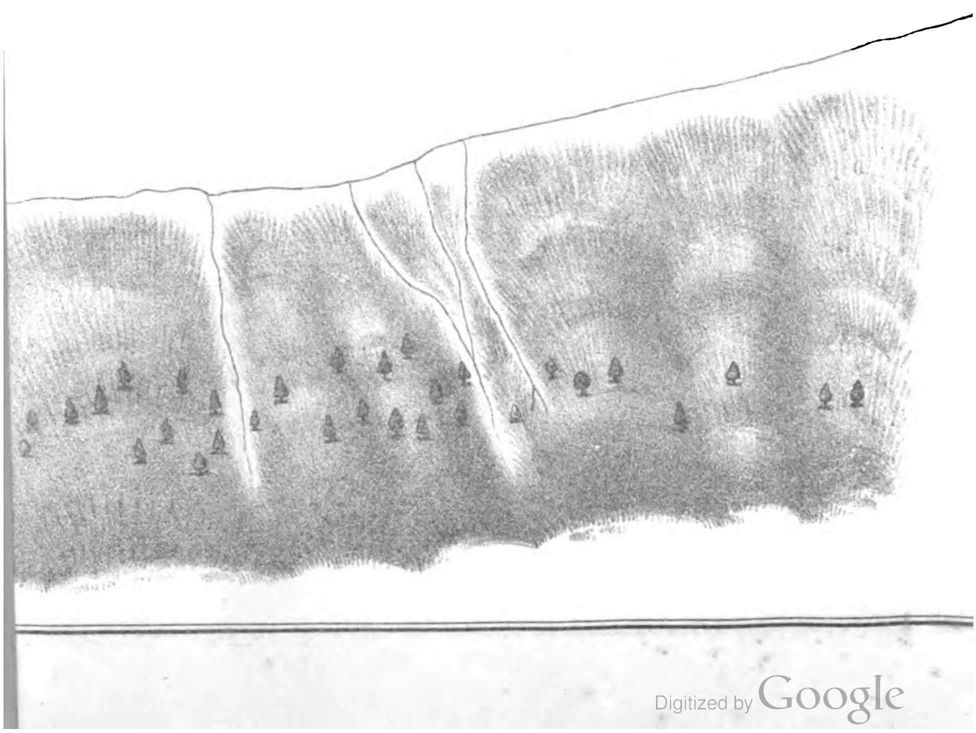
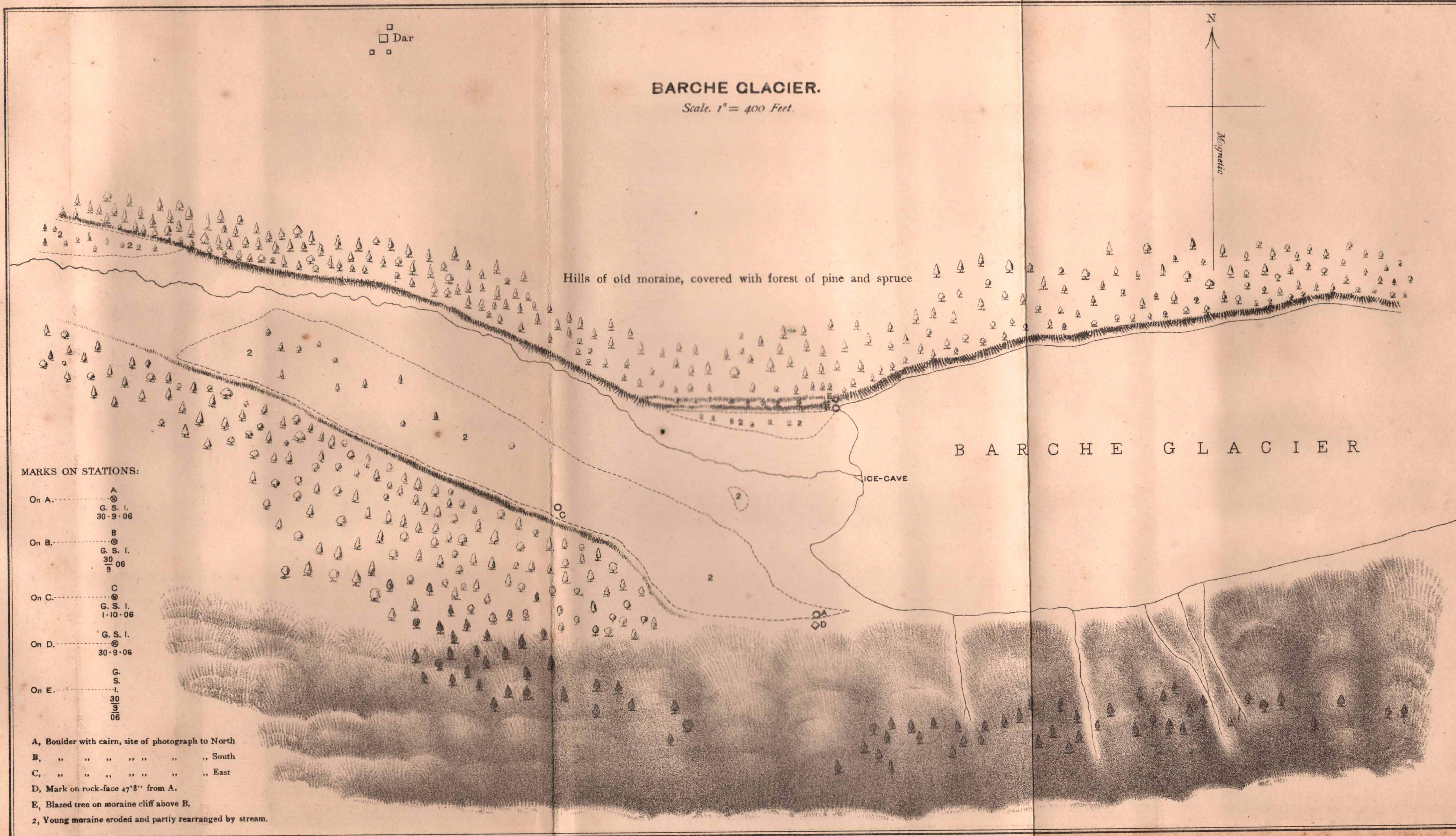
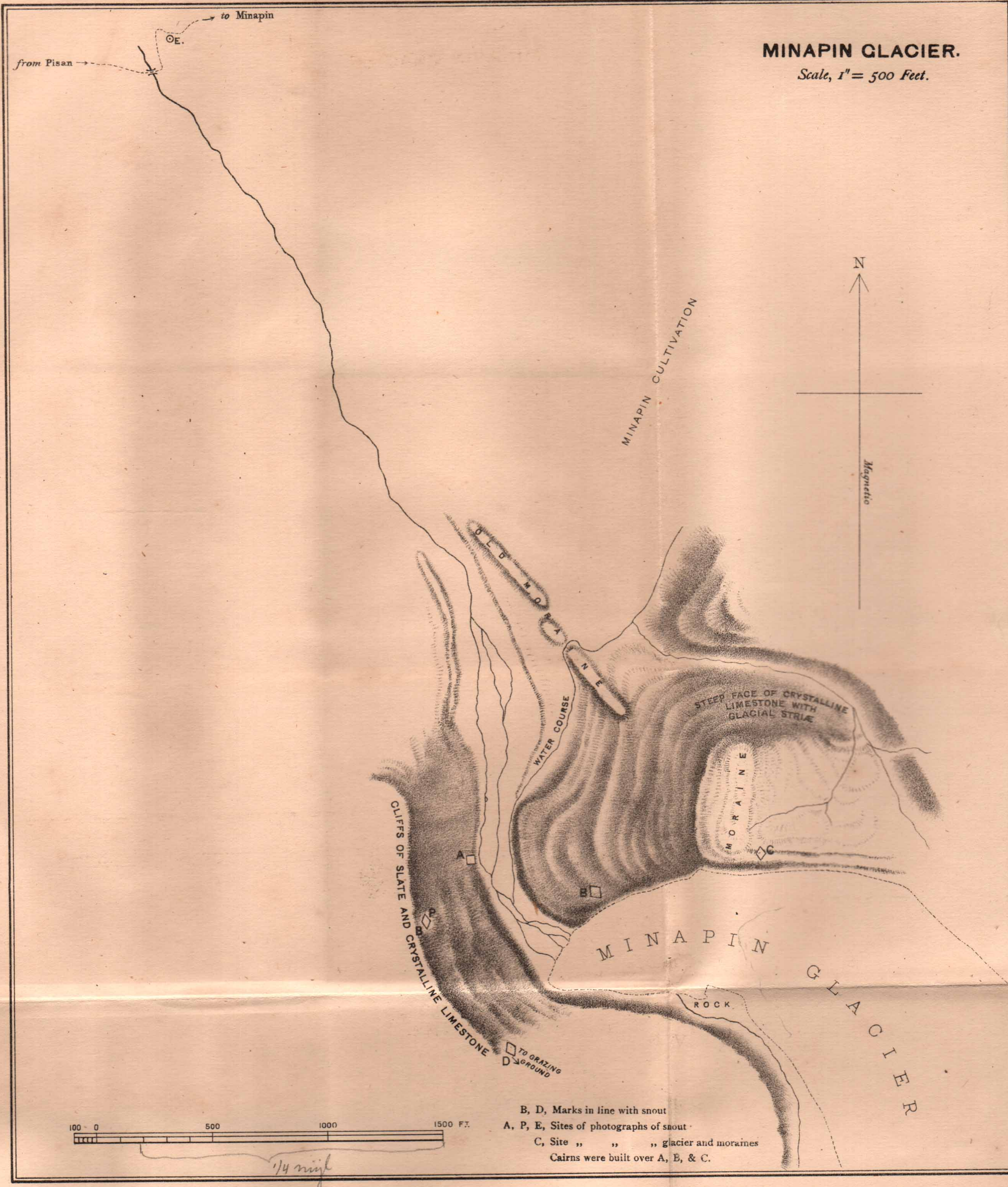

HINARCHE GLACIER.
Scale, 1" = 800 Feet.
(Magnetic)
To Kamar
Diran
REPUTED POSITION OF SNOUT WHEN GLACIER AT MINIMUM
HINARCHE GLACIER
NORMAL ROAD FROM BULCHI TO SAT
To Sat
To Gasuner
M
S
L
ICE-CAVE
1
2
B
A
Bulchi canal from Bulchi
To Chira
FT. 500 0 500 1000 1500 2000 2500 3000 FT.
Scale, I Inch = 1600 Feet
Bulchi
Chira
MARKS ON STATIONS:
On 1 ⊗ 1 G. S. I. 3/10/06
On 2 2 ⊗ G. S. I. 3·10·06
On 3 3 ⊗ Sloping rock-face also marked 3 G. S. I. 4·10·06.
1, 2, Marks in line with snout
A, B, Large erratics, prominent land-marks
3, Site of photograph showing general view of glacier



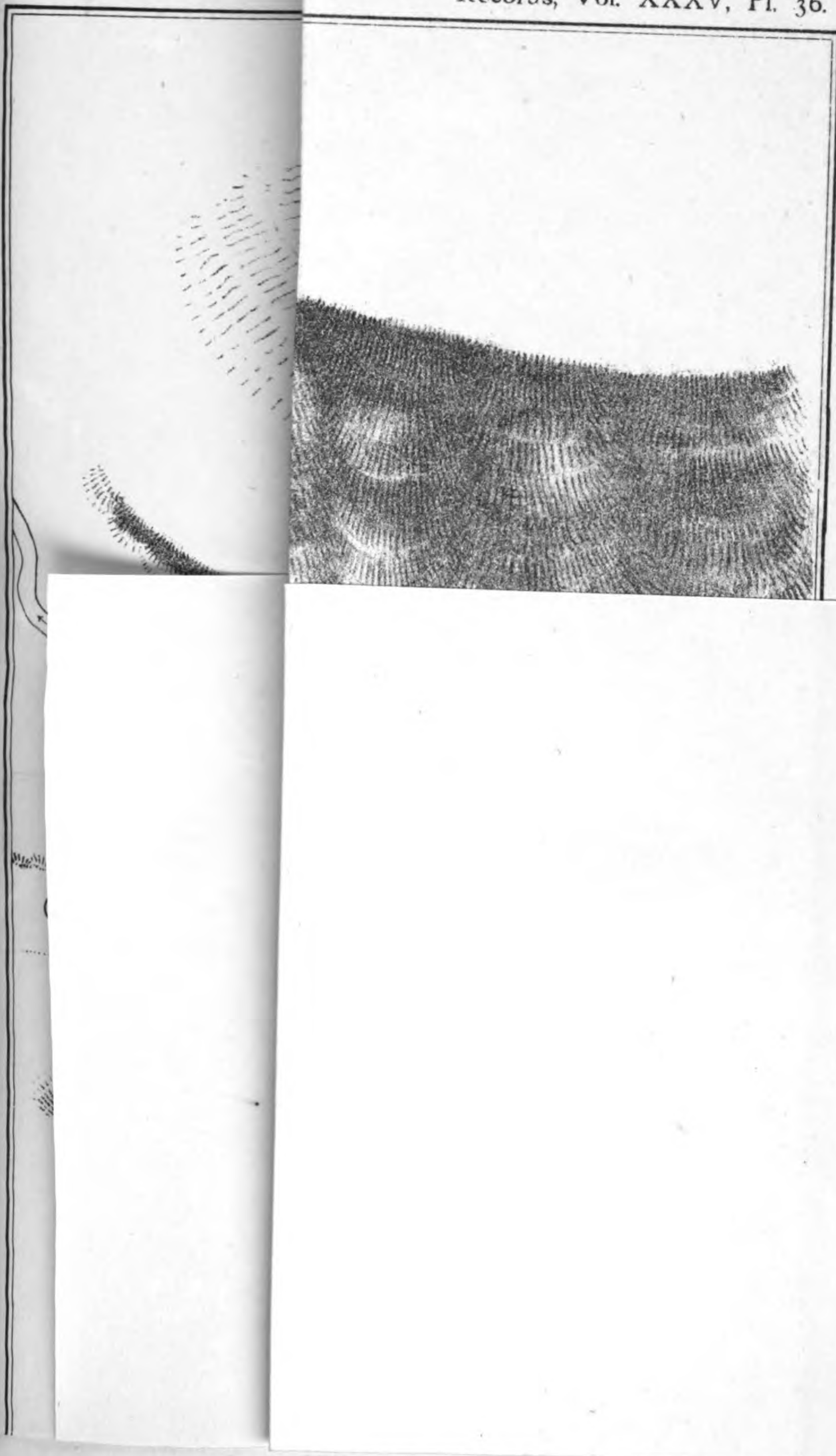
ARCHE GLACIER

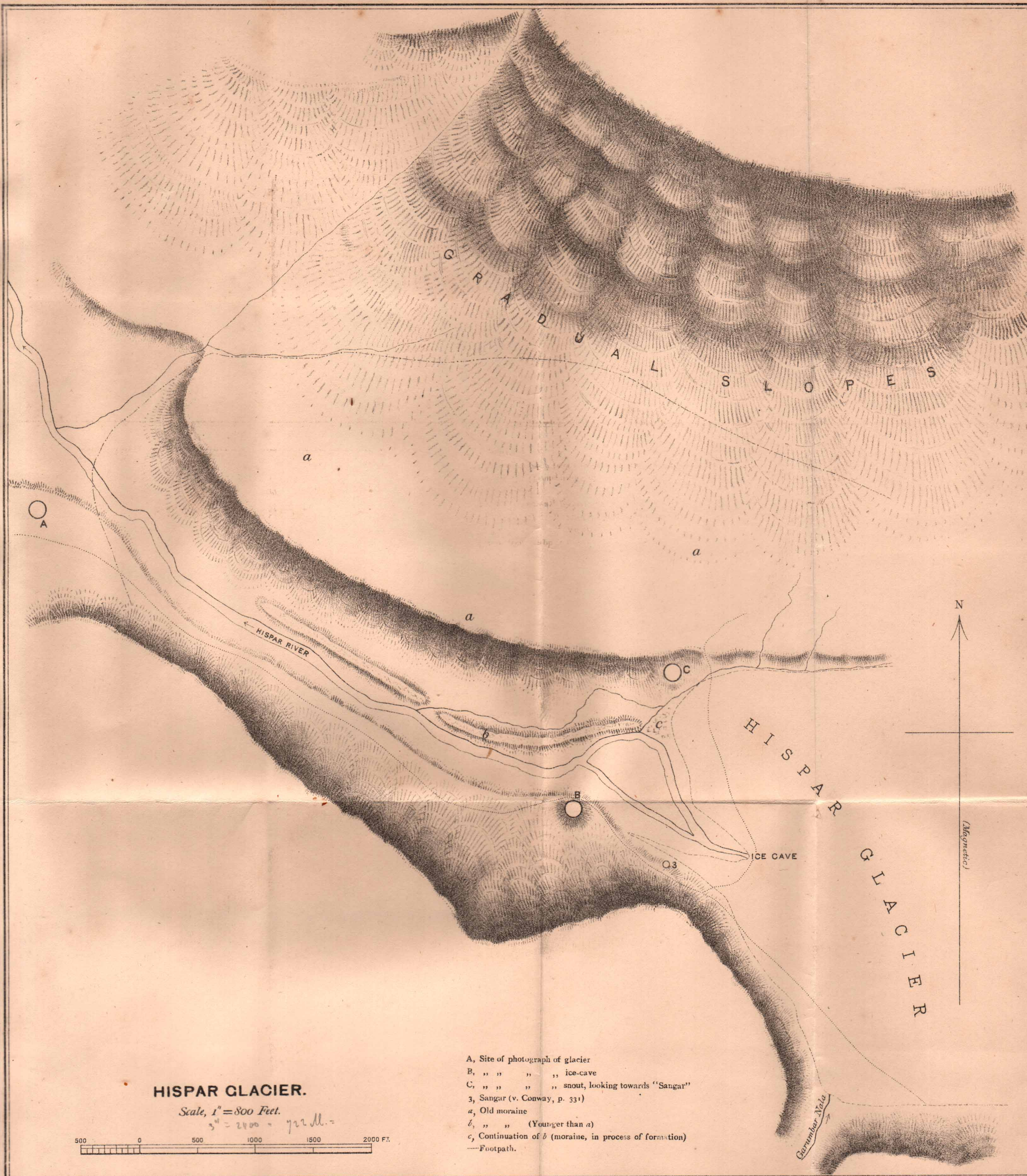



BARCHE GLACIER.
Scale. 1" = 400 Feet.
Dar
N
Magnetic
Hills of old moraine, covered with forest of pine and spruce
BARCHE GLACIER
ICE-CAVE
E
B
C
A
D
2
MARKS ON STATIONS:
On A. A ⊗ G. S. I. 30·9·06
On B. B ⊗ G. S. I. 30/9 06
On C. C ⊗ G. S. I. 1·10·06
On D. G. S. I. ⊗ 30·9·06
On E. G. S. I. 30/9/06
A, Boulder with cairn, site of photograph to North
B, " " " " " " " South
C, " " " " " " " East
D, Mark on rock-face 47'8'' from A.
E, Blazed tree on moraine cliff above B.
2, Young moraine eroded and partly rearranged by stream.



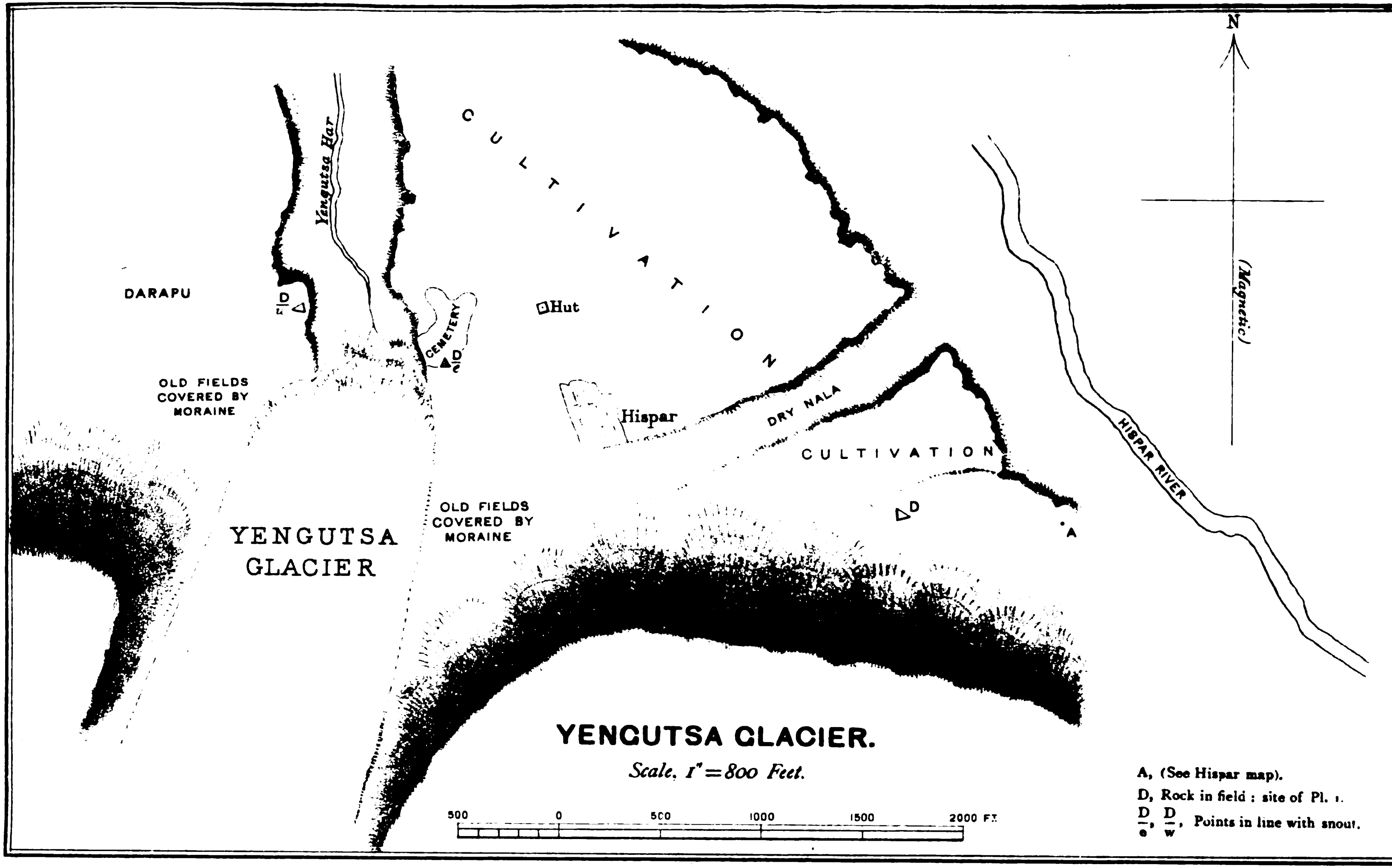
B, D, Marks in line with snout
A, P, E, Sites of photographs of snout
C, Site „ „ „ glacier and moraines
Cairns were built over A, B, & C.





HISPAR GLACIER.

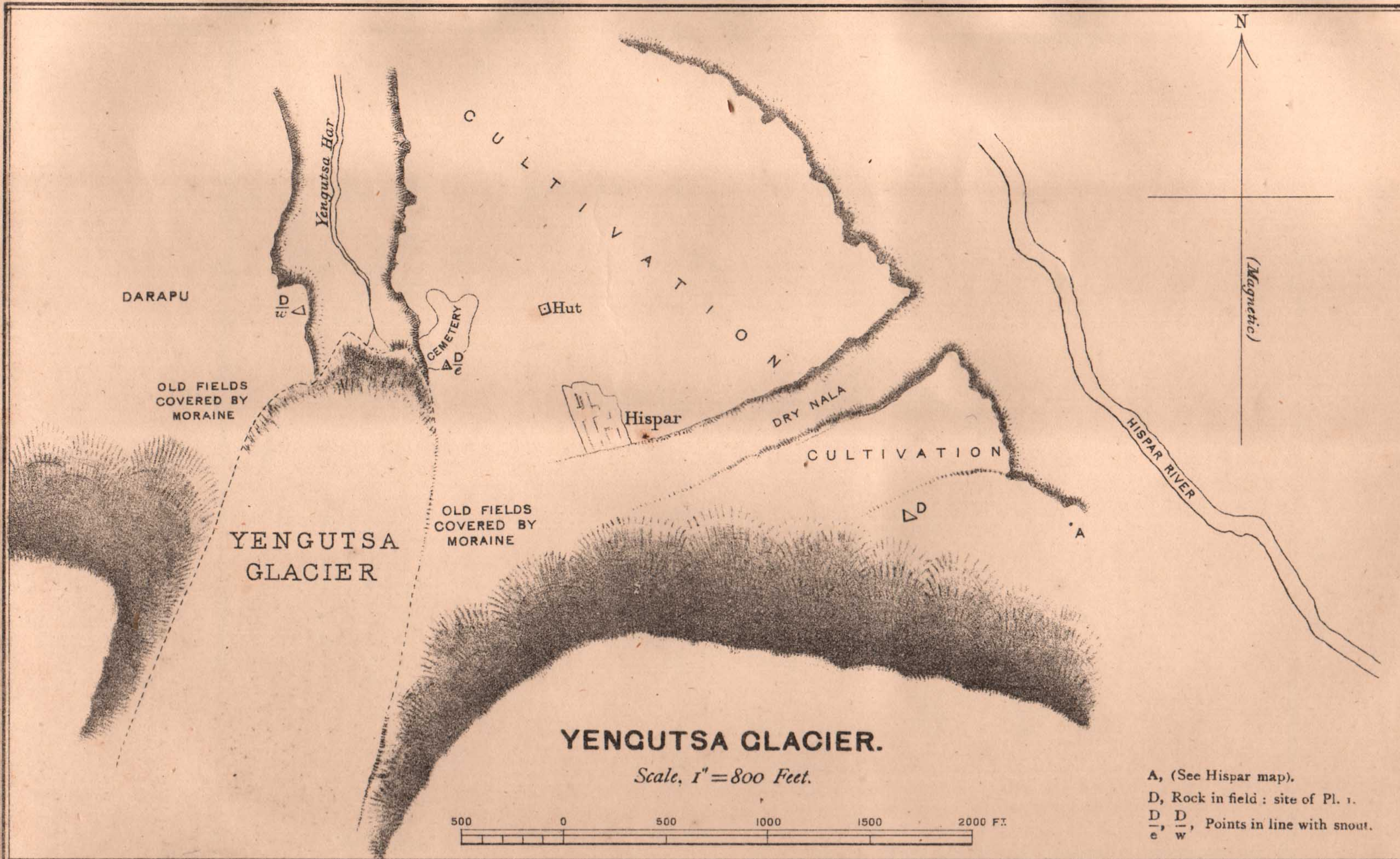
Scale, 1" = 800 Feet.



YENGUTSA GLACIER.

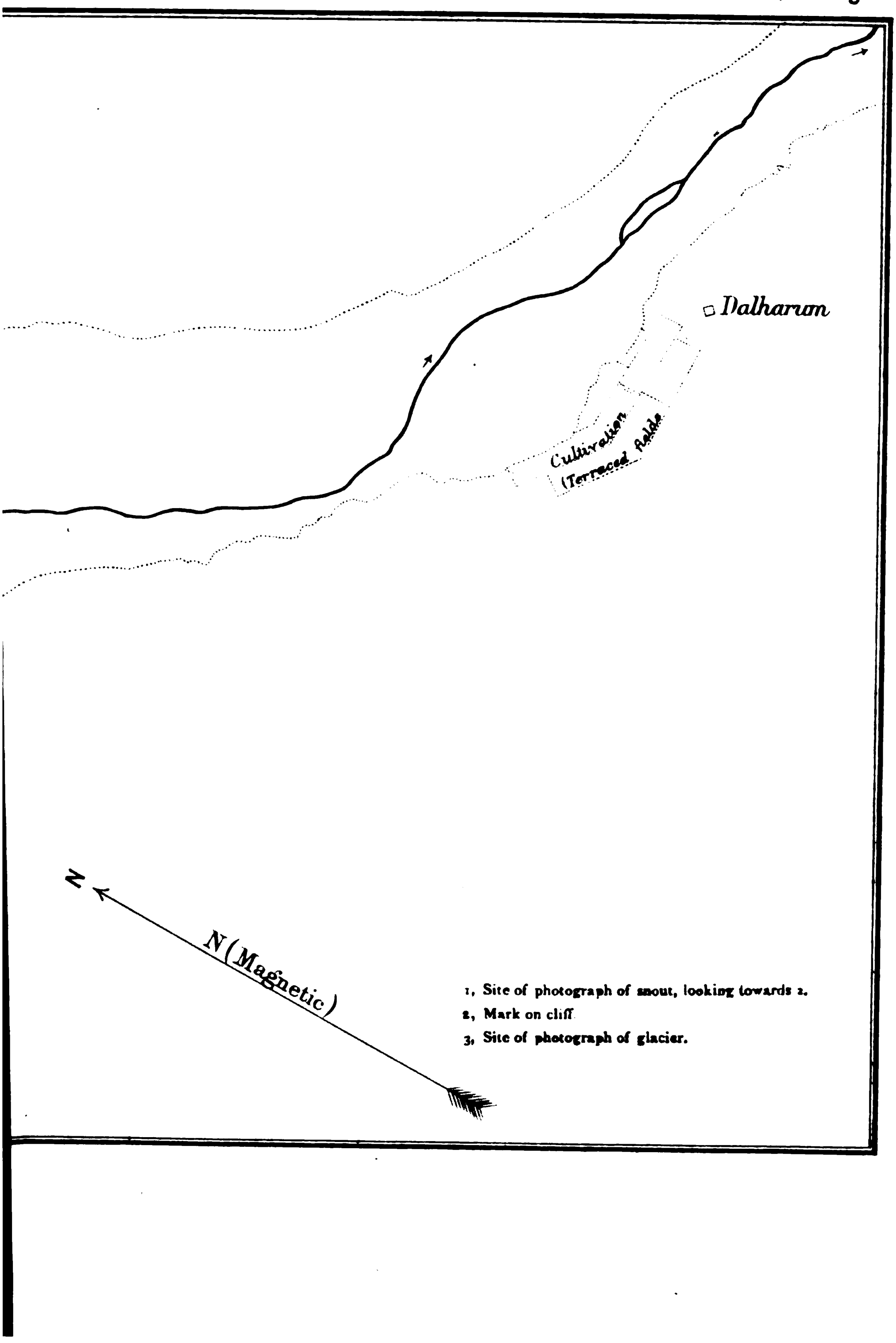
Scale, 1" = 800 Feet.

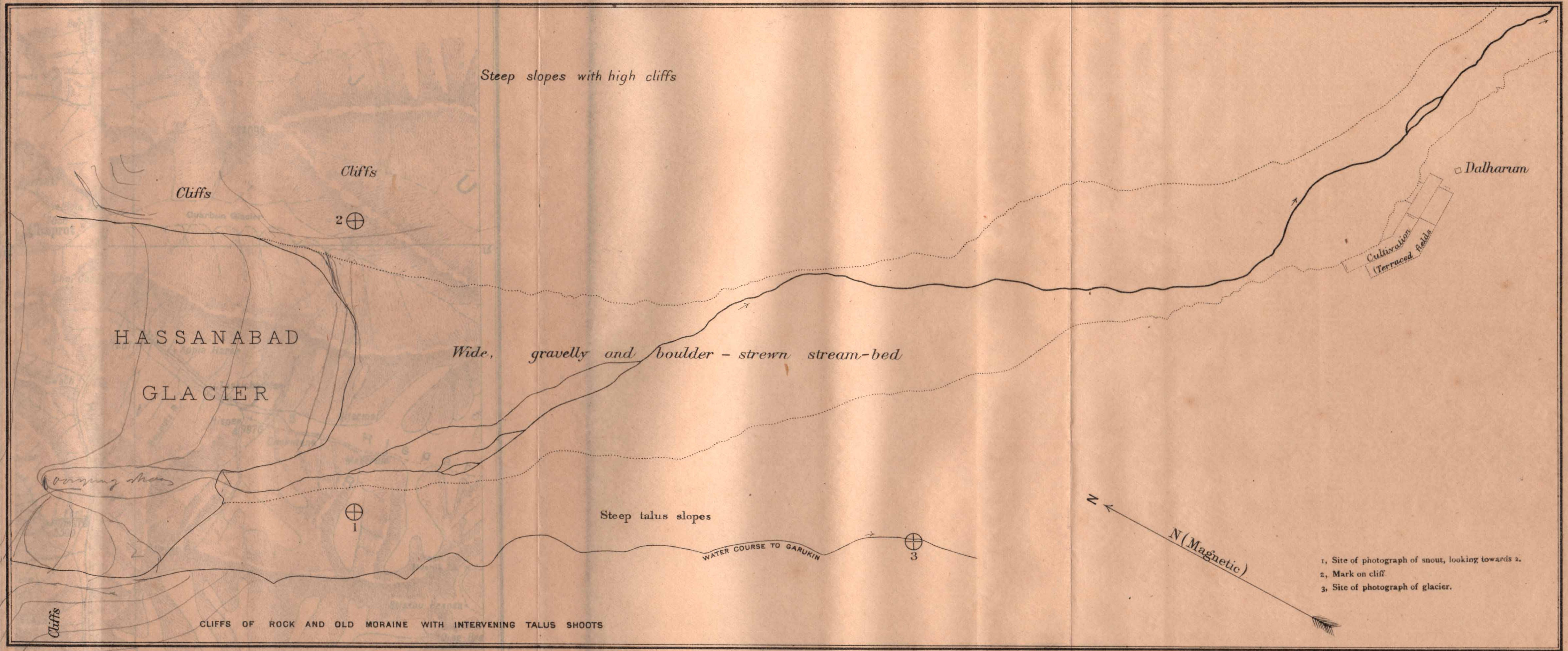
A, (See Hispar map).
D, Rock in field : site of Pl. 1.
D/e, D/w, Points in line with snout.



YENGUTSA GLACIER.

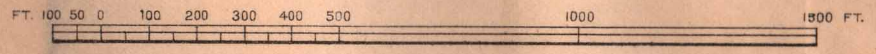
Scale, 1" = 800 Feet.

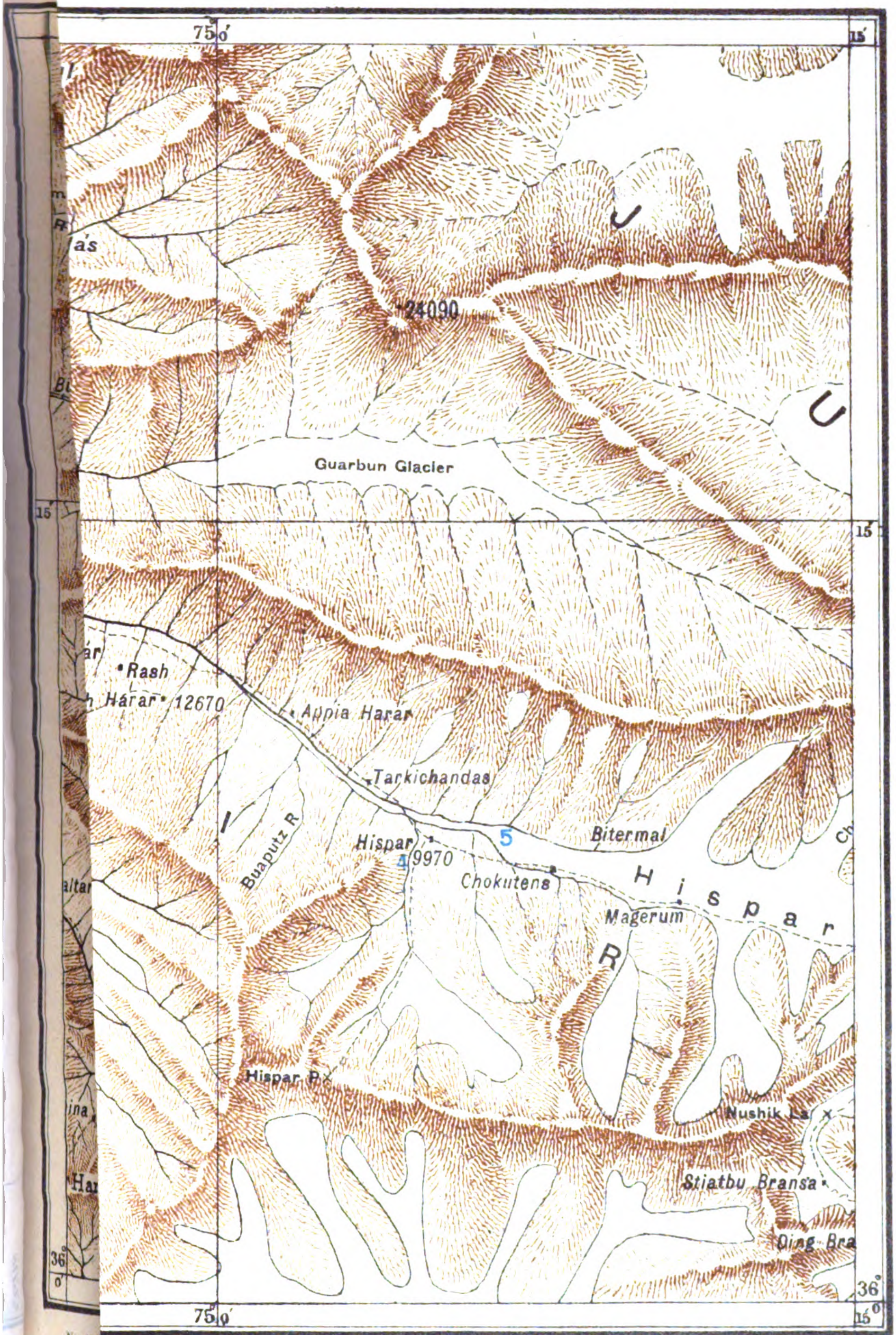

Dalharum
Cultivation
(Terraced fields
N
N(Magnetic)
1, Site of photograph of snout, looking towards 2.
2, Mark on cliff
3, Site of photograph of glacier.



HASSANABAD GLACIER.

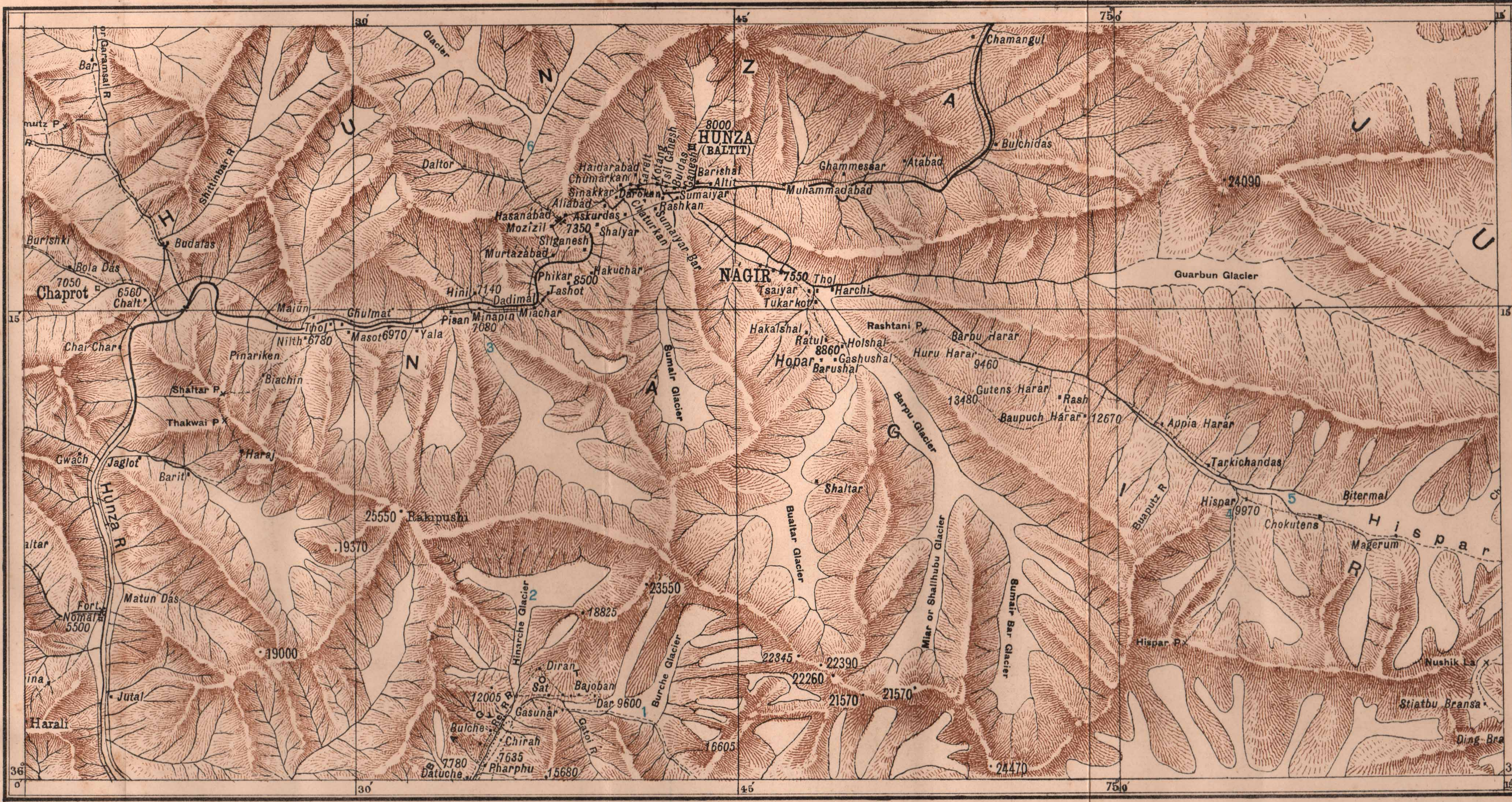
Scale. 1" = 400 Feet.





Helio., S. I. O., Calcutta

D BAGROT.



No. 90 E., Dir., Geol. Survey of India.—Aug 07.—910

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MAP SHOWING POSITION OF GLACIERS IN HUNZA, NAGIR AND BAGROT.

Scale 1 Inch = 4 Miles.

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OF

HE GEOLOGICAL SURVEY OF INDIA.

VOL. XXXV, PART 4.

1907.

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Part 4.] **1907.** **[September.**

A PRELIMINARY SURVEY OF CERTAIN GLACIERS IN THE NORTH-WEST HIMALAYA. BY OFFICERS OF THE *Geological Survey of India* (*continued*).

B.—NOTES ON CERTAIN GLACIERS IN LAHAUL. BY H. WALKER, A.R.C.S., F.G.S., A. INST. M.M., AND E. H. PASCOE, M.A., B.SC. (With Plates 40 to 46, 60 and 61.)

INTRODUCTION.

Glaciers visited. THE glaciers of Lahaul were visited in September, 1906, when observations were made on the Sonápáni (Lat. 32° 25′; Long. 77° 25′) and on the Bara Shigri (Lat. 32° 16′; Long. 77° 39′). The glaciers under notice lie on opposite banks of the Chandra river above its junction with the Bhága river.

Route. Lahaul is most conveniently reached from Sultánpur, the capital of Kúlú—by one of two passes, *viz.*, the Rhotang, 13,500 feet, or the Hamta, 14,000 feet in height. The former is served by coolies from Rálá which is three stages north of Sultánpur, the latter from Jagatsukh, two stages above Sultánpur. Since the coolies from these villages will go only on the one route it is necessary when both glaciers are to be visited to go from Jagatsukh. The same coolies remain with the traveller frôm Jagatsukh to Shigri and will, if desired, descend the left bank of the Chandra to Koksar. At this place other coolies are to be obtained for the visit to Sonápáni. Shigri is 3½ days' march from Jagatsukh, the route being *viâ* Chika, the Hamta, Chahtru and Putiruni. No habitations are to be met with after the traveller leaves Hamta village which is about 4 miles north of Jagatsukh. This necessitates taking food for the servants, and it is customary to obtain the supplies at Jagatsukh. The traveller will expedite his journey if he takes supplies from Sultánpur. The Chandra valley, especially between Chahtru and Shigri, is wild and desolate in the extreme, and wood is not to be obtained. For this reason care should be taken that an ample stock of charcoal is carried.

Supplies.

The slopes of the Chandra valley are very unstable, particularly so above Chahtru, and a look-out should be kept for falling stones. On the high bank overlooking the Chandra at Chahtru there is a small camping ground protected from stone-falls by several rocks. At Putiruni there is an excellent camping ground, and at Shigri, where the track rises to cross the shoulder of the hill, there is a small sheltered flat suitable for a camp.

Camping grounds.

Shigri is on the left bank of the Chandra, and Sonápáni on the right. The river is unfordable, so that it is necessary to descend to New Koksar and cross the bridge. The new rest-house at Koksar is a hard day's march from Chahtru. From New Koksar a road, which is a disused portion of the Kúlú-Lahaul trade route, runs for about 4 miles and ends at the ruined bridge and rest-house of Old Koksar. There is then a stiff climb of 3½ miles along the Sonápáni stream before the ice-cave is reached.

Route from Shigri to Sonapani.

Along the margin of the desiccated lake-bed there are several excellent camping places, and good clear water runs in abundance from the surrounding hills.

Camping ground.

Wood is scarce, but may be obtained from the banks of the Chandra above the old rest-house. Food supplies are to be bought in New Koksar, and in cases of difficulty with the lambardár it is advisable to communicate with the Thákur Sahib of Kyelung. Colonel Tyacke in his book, "The Sportsman's Manual," writes that the Sonápáni Nalá furnishes good sport.

Supplies.

August is the best month in which to visit the glaciers for the purpose of making measurements. The passes are rarely open until May, and sometimes not until June. Snow may be expected about September 15th. Lahaul is considered a cloudless and rainless country.

Month most suitable for visit.

I.—THE SONAPANI GLACIER, CHANDRA VALLEY.

Probable origin of the name.

The word "Sonápáni" appears to mean "Golden-water." It is quite possible that the name has been given to this glacial stream, because in the lower portion of its course it runs over rocks which have a golden lustre. These rocks are micaceous schists, in which, on weathering, the mica (evidently a variety rich in iron) takes on a yellow-bronze lustre, probably due to schillerization. When wet these rocks gleam like golden pavements.

Height of glacier.

A good view of the glacier, desiccated glacier lake and old terminal moraine is obtained from the Rhotang Pass. The height of the pass is 13,500 feet, and the glacier is only slightly lower, so that its height may be taken at about 13,000 feet.

Position of glacier.

From the old rest-house of Koksar the glacier lies roughly N.N.E., and the ice-cave is distant about 3½ miles. The desiccated lake is 1½ miles long, so that from the terminal moraine which held up the lake (see Plate 60) there are two miles of glacier stream. This stream flows down a narrow valley and has cut through several moraines, which will be described later.

The glacier.

The end of the glacier is set in a circle of peaks which is broken to the N.N.E., and the ice stretches for 5 or 6 miles in that direction. Thus very little of the glacier is seen from the lake-bed (see Plates 40 and 41).

The snout of the glacier.

An ice-cliff forms the snout and it has a concave shape with the concavity pointing northwards. The stream issues from an ice-cave situated towards the western limb of the curved ice-cliff. To the south of the snout, and near to it, is a small terminal moraine. Just before our arrival at Sonápáni there had been three days of heavy snowfall, so that until near the time of our departure the glacier was hidden. When the snow on the lower portions disappeared the ice near the snout was seen to be entirely covered by stones. At this time there was a constant fall of boulders and small rocks from the ice-cliff on to the moraine at the foot.

The desiccated lake-bed.

A plain consisting of mud, fine sand, pebbles and angular gravel— very long in comparison with its width, and twisting as it follows the contours of the bounding slopes—is all that remains of what undoubtedly was a glacier lake. Along the length of the bed one main glacier stream runs at a good rate. In addition to this, many smaller branches meander and are augmented by the clear-water streams from the surrounding hills. As one would expect, the material forming the surface of the bed at the northern end is larger and more angular in character than that at the southern end. The lake-bed is bounded almost everywhere by large talus slopes, which, especially near the glacier, are very unstable.

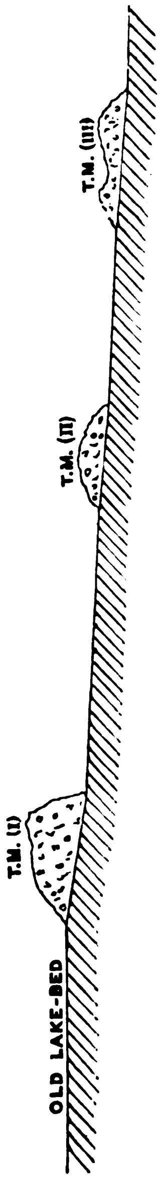


FIG. 1.—DIAGRAMMATIC REPRESENTATION OF GRADIENTS IN THE SONÁPÁNI STREAM.

[T. M. indicates a terminal moraine.]

The lake moraine.

The waters of the old lake were held up by a large terminal moraine. The surface of the present gravel bed is on a level with the breach which is at the western end of the moraine.

Older terminal moraines.

Three more old terminal moraines are cut through by the Sonápáni stream after its escape from the lake-bed.

The accompanying woodcut (fig. 1) diagrammatically represents the gradients seen in the course of the stream. Through the moraines the gradients are steep, whilst between them they are much flatter, and all the gradients in the lower course of the stream are less than those in the higher parts. The lowest moraine is probably the oldest, since it is found clinging to the northern slope of the Chandra valley and within a short distance of the present Chandra river. The central portions of the moraine have been removed by the glacier stream and two long ridges, running away at right angles from the hill slopes and parallel to the stream, are all that now remain (see Plate 43).

Details of Photo. Stations.

Six stations from which to take photographs were selected (see sketch-map, Plate 60). Stations Nos. I, II and III, situated at the southern end of the lake-bed, were not marked, but bearings of prominent peaks were taken by a prismatic compass. Large rocks were selected for stations Nos. IV, V and VI. Marks were cut in the rocks and were then thickly painted red. Prismatic compass bearings to peaks were also taken. All the photographs taken have not been reproduced in this paper; but the negatives of those not reproduced, together with full details, are stored for reference in the office of the Geological Survey.

The photographs were taken with a Ross ordinary rapid rectilinear lens, the camera being horizontal in all cases.

Photo. Stations.

STATION.	Marks.	Direction of Camera.	BEARINGS OF PEAKS. (See Plates 40, 41, 42 and 43.)				
			Peak A.	Peak B.	Peak C.	Peak D.	Peak E.
I	Unmarked.	N. 36° E.	N. 16° E.	N. 22° E.	E. 39° N.	...	...
II	Unmarked.	N. 42° E.	N. 33° E.	N. 40° E.	E. 23° N.	...	...
III	Unmarked.	N. 35° E.	N. 30° E.	N. E.	...	...	...
IV	⊕ Cut in rock and painted red.	N. 41° E.	N. 25° E.	N. 35°·5 E.	...	...	...
V	◁ Cut in rock and painted red.	E. 20° N.	...	N. 36° E.	E. 16° N.	...	...
VI	+ Cut in rock and painted red.	S. 30° W.	N. 28°·5 E.	N. 37° E.	E. 17° N.	S. 21°·5 W.	W. 42° S.

List of Plates.

II.—BARA SHIGRI, CHANDRA VALLEY.

This glacier, whose name signifies "boulder-covered ice," flows northwards and debouches into the Chandra river where the latter from a southerly course is deflected westwards, close to the Spiti border. It is mentioned in a book by J. Calvert, F.G.S., M.I.C.E., called "Kullu, the silver country and Vazeer-Rupi of the Vazeers," p. 60 (map inaccurate): the Gazetteer of the Kángra District, Vol. II, Part 3, contains a brief notice of the glacier and the surrounding country. An interesting description of the former with large photographs of the ice-cave are given in P. H. Egerton's "Journal of a Tour through Spiti (p. 11)."

The ice-cave is large and well-marked. Ice extends beyond this for a short distance on the left bank, which is formed by the precipitous talus-covered slope of a mountain-spur, and for a long distance on the right bank which is composed of ice and a vast area of moraine matter and talus (see Photographic Station No. IV, Plate 46). The ice on the right bank is exposed in several places as an ice-cliff, but the amount of moraine is so enormous on this side that it would be difficult to locate the boundary of the ice: from the shape of the moraine, ice probably extends at least as far as Photographic Station No. III (see map, Plate 61). Above the cave the ice is more or less completely covered by moraine and débris as far as can be seen from the cave or from the mass of moraine material below this. The upper part of the glacier is hidden from view by the above-mentioned mountain-spur round which the glacier curves.

There are no means of crossing the glacier stream which is everywhere and at all times of the day a roaring torrent. To reach the right bank of the stream the glacier must be crossed above the ice-cave.

Owing no doubt to the lateness of the upheaval in this region, and the consequent immaturity of the drainage system, the valleys are narrow and their enclosing ridges lofty and precipitous. Consequently the former are covered irregularly but very extensively with ordinary débris split off by heat, frost and rain, from the peaks above. This happens in the neighbourhood of glacier snouts as well as elsewhere, and it is frequently impossible to distinguish between true ice-borne moraine matter and ordinary débris fallen directly into the valley from the mountain sides. At the debouchement of the Shigri glacier, however, the Chandra valley is comparatively wide, and the greater number of the boulders covering it, with the exception of those near the base of the mountain slopes, no doubt represent true 'moraine.' Many of them shew distinct grooving and polishing, a rock face of true granite being made thereby to simulate gneiss. Well-rounded water-worn boulders are locally abundant, indicating former courses of the glacier stream.

At some considerable distance from the ice-cave, on the right bank of the stream, the ice which forms the core of the stream bank ends in a concave cliff, below which is a water-course with well rounded boulders, proceeding in the direction of the Chandra: this has evidently been a secondary 'ice-cave' or point of issue for water, though none could be seen flowing at the time.

Mr. Skemp, the Officiating Assistant Commissioner of Kúlú, informed us that, a mile or two northwards from the bend in the Chandra river, there is evidence of a lake having existed in the course of the river, in the form of a large sandy plain. This is said to have been formed by the damming up of the Chandra by the Shigri moraine, and is mentioned in Egerton's book[1] as existing seventy years ago. Colonel Tyacke[2] also records it. There is no doubt that the glacier did at one time extend much further than it does now: the vast size and extent of the terminal moraine is sufficient to prove this. The ¼ inch Frontier map published in 1874 shews the Shigri stream

[1] Journal of a Tour through Spiti by P. H. Egerton, D. C. of Kangra.

[2] Page 52, Sportman's Manual in Kullu. Colonel Tyacke.

running straight into the Chandra river immediately opposite where the glacier should be[1]: now however the junction is about two miles further down the river. This appears to be due to the retreat of the ice until it was possible for the stream to find its way round the back of the terminal moraine and so join the Chandra farther down. From Egerton's photographs taken in July 1863, the mountains behind the glacier snout appear to be closer than they do in the plates published in this paper, but distances in photographs are deceptive when the latter are taken from different places, and with different lenses. Although the termination of the glacier is so concealed by the vast quantity of boulders, there is no evidence of the latter having been pushed forward by the ice.

Details of Photographs.

The only places suitable for photographic stations were large boulders in the vast field of moraine matter lying around the glacier termination. The only rock *in situ* near the glacier snout was the mountain spur the base of whose steep talus-covered slope is seen in Plate 44, and this was unsuitable for a photographic station on account of constantly falling débris, difficult accessibility, and inconvenient position.

Photographic Station I (*Plate 44*).—An enormous granite boulder on the edge of the left bank of the glacier stream, close to ice-cave—at the time of our visit by far the largest boulder in the neighbourhood. The upper surface was marked with chisels and vermilion paint thus :—

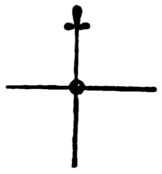


FIG. 2.

The bearings of three peaks (lettered in the plates), taken with a prismatic compass, from this mark on the boulder were :—

Peak A	83° E. of N.
Peak B	65° E. of S.
Peak C	41° E. of S.

[1] The glacier is not recorded on this map.

Direction in which levelled camera pointed . .	70° E. of S.
Lens	Ross' wide angle —6 inches.[1]
View	Ice-cave, glacier stream, and peaks: the upper part of the glacier lies between Peak C and the talus-covered slope in the foreground to the right of the picture. The cliffs of ice shew "dirt-bands."

Photographic Station III[2] (*Plate 45*).—A large gneiss boulder towards the margin of the moraine and some distance from the ice-cave. As the boulder would probably move, it was not marked: its *bearings* are—

Peak B	63° E. of S.
Peak C	39° E. of S.
A low spur on the opposite side of the Chandra river	43° E. of N.
Direction in which camera pointed . . .	49° E. of S.
Lens	Ross' wide angle.
View	Ice-cave, slope forming left bank, and moraine with ice shewing here and there. Ice probably extends as far as or close to this station.

Photographic Station IV (*Plate 46*).—

Direction in which camera pointed	43° E. of S.
Lens	Ordinary rapid rectilinear.
View	Ice-cave, mountain slope forming left bank, and peaks.

PERAD GLACIER.

An attempt was made to survey this, but had to be abandoned on account of continued snow. The glacier is very accessible, being within half a mile of the camping ground of Putiruni, and, although small, would be eminently suitable for the purpose under consideration. There is a well-marked ice-cave which could be photographed from accessible rock *in situ*. The glacier stream runs between two large lateral moraines, and is bridged by planks. Snow is to be expected here and at Shigri after the 15th September, and any examination of these glaciers should precede this date.

[1] A second similar photograph (not reproduced) was taken with an ordinary rapid rectilinear lens.

[2] Photos from *Station* II not reproduced.

C.—NOTES ON CERTAIN GLACIERS IN KUMAON. BY G. DEP. COTTER, B.A., F.G.S., AND J. COGGIN BROWN, B.SC., F.G.S. (With Plates 47 to 59, 62 to 65.)

INTRODUCTION.

OUR visit to the glaciers of Kumaon took place in the summer of 1906, when four of the largest and most easily accessible glaciers were examined, *viz.*, the Pindari (Lat. 30° 15½′; Long. 80° 2′), the Milam (Lat. 30° 27′; Long. 80° 10′), the Shankalpa (Lat. 30° 19½′; Long. 80° 21½′), and the Poting (Lat. 30° 12½′; Long. 80° 12′).[1] Of these the Pindari is the best known, being a favourite tourist resort, and approachable by an excellent road with staging bungalows to Phurkia, four miles from the glacier. The route to the Pindari glacier leads from Ranikhet or Almora, through Bagesar and Kápkot, (near the latter of which villages the road to Milam diverges eastward) and is seven days' journey from Almora by easy marches.

To visit the remaining three glaciers, it is necessary to take small tents. The best route to Milam leads from Kápkot through the villages of Sáma, Tejam, Girgaon, Munsyari, and the camping grounds of Lilam, Bugdiar, Rilkot, and Burphu. The village of Milam is one mile distant from the Milam glacier, and is about eleven days' march from Almora. The road is suitable for ponies as far as Munsyari; beyond this village however the remaining thirty miles along the valley of the Gori Gunga to Milam must be traversed on foot, as the steepness of the ascent has made it necessary to build the road in the form of a staircase in many places.

The Poting glacier is about six miles distant from Bugdiar, and is reached by an easy hill-path leading through some of the most beautiful scenery of Kumaon. To reach the Shankalpa glacier, it is wiser to take the hill road from Rilkot over a ridge about 15,500 feet high north of Haseling peak, and from whence a fine view of Nanda Devi can be obtained, rather than to travel from Lilam up the valley of the Rálam river, as the latter route is difficult for coolies with burdens, and is impossible for baggage animals. By the former route Rálam

[1] See Atlas of India, Quarter-Sheet, 66 N. E.

village, which is 2½ miles from the Shankalpa glacier, may be reached in two days' march from Rilkot.

The country north of Munsyari is inhabited by the Bhotias, a pastoral people of Mongolian affinities, who still retain their nomadic habits. In June they move north to Milam and the neighbouring villages from Munsyari and Tejam, to which places they again return southwards in the latter half of September owing to the advance of the winter snow. It would therefore be a matter of great difficulty to reach the glaciers at any other time than from the months of June to September; and indeed a visit made at another time of year would be of little service to those who wish to study the glaciers of these parts as the country is more or less covered with snow. Owing to the exceptional lateness of the fall of the winter snow in 1906, we were enabled to visit the Poting glacier in October, but at that time the country had been already deserted by the Bhotias, and the snow was beginning to fall at the time of our visit.

The altitudes of the snouts of these four glaciers average nearly 12,000 feet. At Martoli camping ground near the Pindari glacier, the elevation is 11,720 feet; while at the snout of the Milam glacier it is 11,340 feet. The elevations at the snouts of the other two glaciers had to be guessed by aneroid, and were judged to be roughly 12,000 feet. The Bhotia shepherds all agree in the opinion that the glaciers are in retreat. In no case did we fail to find numerous terminal moraines in front of the ice-caves, indicating a retreat at some past period: and from local information there is reason to believe that this retreat is still going on.

In conclusion, it is worth remarking that the scenery along the road to Milam from Girgaon onwards would well repay visitors for the inconvenience of tent-marching in the monsoon. The savage precipices and luxuriant vegetation of the Gori Gunga valley between Munsyari and Bugdiar form a picture not easily forgotten; and it seems a pity that the more popular and easy, but somewhat tamer route to the Pindari glacier has drawn away the attention of visitors from this fascinating valley.

I.—THE PINDARI GLACIER.

(BY G. DEP. COTTER.)

The following paper and sketch-map is based upon observations made during my visit to the glacier in July, 1906.

General description.

The glacier is fed by two ice-flows, the larger originating from névés on the slopes of 22,530 feet peak called locally Nanda-Kot; and the other descending in a cascade from between 20,740 feet peak (Banghattia) and an unnamed peak, 21,624 feet in height, wrongly identified with Nanda Devi by the Bhotias of the vicinity. These two flows are separated by a medial moraine which terminates about a mile from the ice-cave. Of the lateral moraines flanking the glacier, that to the left or S.E. is in comparatively open ground, while that to the N.W. (the right lateral moraine) is pressed close against the cliff-wall, and is therefore imperfectly developed. Surface moraine is seen both on the lower glacier and on the flow which descends from Nanda-Kot, but the smaller cascade is of clear ice (see Plate 51).

Crevasses appear to be of less frequent occurrence here than in the case of the other three glaciers of Kumaon included in this paper; possibly this may be due to a slower rate of movement of the glacier-ice. General Strachey, who examined the glacier in May, 1847, in an interesting paper upon the Pindari and Kuphini glaciers (*Journal, Asiatic Society, Bengal,* Vol. XVI, 2, page 203), gives the following theodolite-observations, showing the rate of movement of the glacier-ice :—

	MEAN MOTION OF ICE IN 24 HOURS (IN INCHES).	
	At lateral moraine.	On middle of glacier.
Lower part of glacier	4·8	9·4
Upper part of glacier	5·3	10·0

These results, compared with the calculations given by Professor Tyndall of the rate of motion of the Mer-de-Glâce (Glaciers of the Alps, page 275), lead us to suppose that the motion of the Pindari glacier is, comparatively, very slow.

Terminal moraines.

Recent terminal moraines are very small and imperfectly developed, and are situated close to the glacier-snout. Ancient grass-grown moraines occur in the Pindari valley near Martoli, about 1½ miles from the glacier (see Plate 47).

The old grass-grown moraines marked on the sketch-map (Plate 62) appear to be lateral from their position.

Secular movement of glacier.

The villagers of the neighbourhood say that the glacier is in retreat, but cannot give any exact data. Colonel J. W. A. Mitchell, writing in 1894, says "the glacier appears to have retreated about 100 yards since I visited it in 1884."[1]

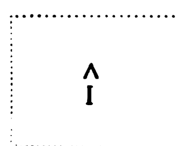
Ice-cave and measurements from four fixed points.

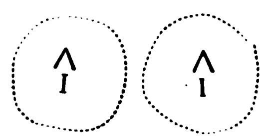
The ice-cliff above the ice-cave of this glacier is very small, as compared with those of the Milam, Poting, and Shankalpa glaciers (see Plate 48). At Shankalpa the ice-cave together with the ice-cliff above is about 300 feet in height, while at Pindari the ice-cave and cliff is roughly about 40 feet.

The four fixed points, indicated on the map as A, B, C, D, forming Plate 62 have been marked in the field by arrows cut in the rock thus :—

A is marked........................ · ^I ·

B is marked... .... × ^I ×

C is marked...... .... 

D is marked......................... 

These marks were afterwards paintedred; the dotted lines indicate that the rock has been painted, but not chiselled.

It would be convenient for visitors to the glacier to calculate its secular movement by reference to the sketch-map forming Plate 62, which is on a sufficiently large scale to determine a change of 20 or 30

[1] This remark is quoted from a book kept in the Phurkia dâk bungalow for the purpose of recording observations upon the movement of the glacier.

feet. Photographs were taken from stations C (Plate 49) and D (Plate 50) showing the position of the glacier; and it would be useful for visitors in estimating the secular change, to take similar photographs from these points. I have also made measurements to a cairn built over the ice-cave, from the four fixed points. This cairn was 77 feet distant in a direction 340° E. of N. from the centre of the ice-cave.

Wherever measurement was made on sloping ground the horizontal distance was calculated by taking the angle of slope; and the same method has been adopted in taking the measurements of the remaining glaciers of Kumaon, described in this paper.

Horizontal distance from A to cairn over ice-cave .	2,027 feet.
" " " B " " " .	2,571 "
" " " C " " " .	1,155 "
" " " D " " " .	1,023 "

The stations may be distinguished by reference to the map (Plate 62), and by the following characters:—A is a grey schistose boulder; B is a small cliff of grey schistose rock, the top of which is grass-grown; C is a white boulder lying on the ridge of the right lateral moraine; D is a cliff similar to B.

List of Plates of the Pindari Glacier.

PLATE 47.—Old grass-grown moraines near Martoli camping ground.

PLATE 48.—Pindari glacier; ice-cave, right and left views.

PLATE 49.—View of Pindari glacier from C, showing snout.

PLATE 50.—View of Pindari glacier from D, showing right and left lateral moraine with glacier between.

PLATE 51.—View of Pindari glacier from D, showing the upper glacier, with medial moraine and the two ice-flows.

PLATE 52.—Plane-table sketch-map of the snout of the Pindari glacier, as it was in July, 1906.

II.—THE MILAM GLACIER.

(BY G. DEP. COTTER AND J. COGGIN BROWN.)

This glacier was visited in August, 1906, when the accompanying photographs (Plates 52 to 55) and sketch-map (Plate 63) were made.

General remarks.

The earliest mention of this glacier, which we are able to find, is in a journal by Captain Hodgson, describing a visit to the sources of the Ganges in the year 1817 (*Asiatic Researches*, No. XIV, Qu., pages 117-128). He says:—

"The . . . Ganges issues from under a very low arch at the foot of a grand snow-bed . . . . over the debouche, the mass of snow is perfectly perpendicular, and from the bed of the stream to the summit we estimate the thickness at little less than three hundred feet of solid frozen snow, probably the accumulation of ages; it is in layers of some feet thick, each seemingly the remains of a fall of a separate year. . . . . Many rents in the snow appear to have been recently made, their sides shrinking and falling in. . . . . Ponds of water form in the bottoms of these."

This glacier, being about 12 miles in length, is the second in size of the glaciers of Kumaon, and is formed by the junction of nine large tributary glaciers. It fills practically the whole valley, so that the lateral moraines are in many places indistinguishable from the scree of the hill-sides. Terminal moraines are numerous, and tend to run in low ridges parallel to the glacier front. The ice-cliff above the cave sweeps in a huge horse-shoe curve, and the moraine-talus, which covers the ice of the glacier-snout, grades imperceptibly into terminal and lateral moraines. We were unable to fix the precise limit of the extension of the ice.

Amongst the morainal débris, fossiliferous rocks are rare; schist is common, and occasionally contains malachite. The most common rock is red Haimanta sandstone; the conglomerate is rare. Scratched boulders are of common occurrence at this glacier, the scratches crossing one another at all angles. The boulders also often show polishing. We have marked on the map the places where such boulders are most numerous. We saw no traces of glaciation of the rock walls of the valley-sides, since they are hidden by scree. Glaciers-tables are found on the clearer ice some distance up the glacier. On the lower part of the glacier, numerous transverse crevasses can be seen.

Secular movement of the glacier.

There is a tradition amongst the Bhotias, that the glacier about 1,000 years ago extended to Milam village, one mile distant. That it extended at least to Bilju village south of Milam is shown by the old moraines which lie to the E. of the Gori Gunga river (see Plate 52). According to Rai Kishen Singh Bahadur of Milam, well known to science as "A. K.," the explorer of Tibet, the ice-cave fifty-seven years ago was about 800 yards in advance of its present position.

The successive ridges of the lateral moraines, which can be observed in the photographs (Plates 53 and 55) and the map (Plate 63) seem to indicate that there have possibly been several periods of maximum rate of retreat, divided by intervals of comparative quiet.

Photographs and observations from fixed points to ice-cave.

Three points, A, B, and C, were chosen, and their positions marked on the map (Plate 63). A to the S.E. of the ice-cave, high up on the top of the left lateral moraine, is marked by an arrow chiselled in a large boulder, and smeared with red paint ; B is situated in the low ground near the river, in front of the glacier, and is marked by a cairn, on the topmost stone of which an arrow is cut ; C is also marked by an arrow cut in the rock of the valley wall. From each of these three fixed points photographs (Plates 53 to 55) of the ice-cave have been taken. The following bearings from A and C to a cairn built over the centre of the cliff of the ice-cave, taken with the prismatic compass, may be found useful in the determination by subsequent visitors of the change of position of the ice-cave :—

From A to cairn	295½° E. of N.
From C to cairn	83½° E. of N.

We have requested Rai Kishen Singh Bahadur of Milam to see that the cairn erected at station B is preserved from dilapidation from year to year.

List of Plates of the Milam Glacier.

PLATE 52.—The valley leading to the Utardhura Pass blocked up by moraine from the Milam glacier. Taken from Milam.

PLATE 53.—Milam glacier and ice-cave from A.

PLATE 54.—Milam glacier and ice-cave from B.

PLATE 55.—Milam glacier and ice-cave from C.

PLATE 63.—Plane-table sketch-map of the snout of the Milam glacier, as it was in August, 1906.

III.—THE SHANKALPA GLACIER.

(BY G. DEP. COTTER AND J. COGGIN BROWN.)

We visited this glacier at the end of September, 1906. The Rálam valley, in which this glacier lies, becomes a narrow cañon near its junction with the Gori Gunga valley, and owing to the difficulties of the road through this gorge, travellers usually use the road from Rilkot or Burphu over the Haseling ridge. The Bhotias, who are the only inhabitants of this part of the Himalayas, move south at the end of September to Munsyari and Tejam ; and as a rule, from October to March, all the villages in the Gori and Rálam valleys north of Lilam are deserted for the winter, the country being covered with snow.

General description.

The Shankalpa glacier is formed by the union of two tributary glaciers, the Kálá Buland, and the Thercher. The surface of the glacier is much cut up by crevasses, both longitudinal and transverse ; and to walk upon it is often difficult. The snout of the glacier, as can be seen from the map, has now reached a spot where the valley suddenly narrows. The ice-cliff above the cave is pressed close against a large rock, possibly a landslip from the S.E. valley-wall. It will be seen from the map, forming Plate 64, that the lateral moraines extend only 800 yards in front of the glacier. We found no evidence (such as old grassy moraines) to show that the glacier had ever advanced further down the valley than the limit of the present lateral moraines.

The Bhotias, who inhabit Rálam village close to this glacier, are a branch of the Dhárma valley stock, and are a simple pastoral folk, while their neighbours of Milam have in part adopted Hindu customs. From them we learned that the glacier twenty-five years ago occupied a position about 700 feet in advance of the present terminus. According to the Bhotia shepherds, the terminal moraine, which lies on the N.W. side of the river and between the two streamlets (see map, Plate 64), was then the boundary of the ice. It therefore seems probable that the glacier is in retreat.

Glaciation.

The cliff on which the N.W. side of the ice-cave touches and also the cliff on which station A is marked exhibit striæ and polished surfaces in a manner unmistakably glacial. We found rock-surfaces similarly polished on the N.W. valley-wall about one mile up the glacier. In addition to this, scratched boulders occur here as at the Milam glacier, but we saw them only on the S.E. side of the river.

Surface moraine.

Many fossiliferous rock-fragments are found upon the surface moraine of the glacier ; we have also seen specimens containing traces of azurite ; especially interesting is the occurrence of orpiment about one mile up the glacier ; this has been already mentioned in these *Records* (Vol. XXXV, Part I, page 28).

Ice-cave :—measurements and photographs from fixed points.

Of the three fixed points selected at this glacier, A and C are marked by arrows cut in the rock of the valley-walls, and smeared with red paint ; B is similarly marked on a large boulder close to the river bank. For the purpose of measurement a cairn was built over the ice-cave (see Plate 64) and measurements were obtained from the three fixed points. The following are the horizontal distances from the fixed points to the cairn :—

From A	468 feet.
From B	1,106 „
From C	1,370 „

Photographs of the glacier from A and B are reproduced in Plates 56 and 57.

List of Plates of the Shankalpa Glacier.

PLATE 56.—Shankalpa glacier and ice-cave from A, showing glaciated rock.
PLATE 57.—Shankalpa glacier and ice-cave from B.
PLATE 64.—Plane-table sketch-map of the snout of the Shankalpa glacier, as it was in September, 1906.

IV.—POTING GLACIER.

(BY G. DEP. COTTER AND J. COGGIN BROWN.)

The Poting glacier, being one of the more southerly of the glaciers of Kumaon, and situated as it is in the gneissic zone of the Himalayas, is surrounded by perhaps the most beautiful scenery in this district. The valley in which the glacier lies, from the glacier-snout to where it joins the valley of the Gori Gunga at Bugdiar, is clad with pines, and the more level parts are densely wooded with juniper, birch, rhododendron, and the Himalayan rowan or mountain-ash. The hardness of the gneissic rocks gives rise to narrow gorges, and streams, which near Milam and Rálam have cut out valleys in the hill-sides, and here descend in waterfalls. Our visit to this glacier was in October, 1906.

General description.

The glacier is formed from névés on the slopes of Nanda-Kot (22,530 feet peak). As waterfalls characterise this area, so also the ice flows in a cascade from the shoulder of Nanda-Kot to form the lower glacier. While the three glaciers already described all lie at a low level between their lateral moraines, the Poting is, at a short distance above the ice-cave, level with the ridges of its laterals. These laterals are separated from the valley-walls by open ground. Terminal moraines in front of the glacier appear to be not recent. Many of the boulders which strew the floor of the valley are metamorphosed schists, into which has been intruded a network of tourmaline-granite veins; the schists often contain abundant blue crystals of kyanite.

Diurnal movement of glacier.

We were unable to make accurate measurements of the diurnal flow of the ice, since we had not brought a theodolite; four flagstaffs were however placed in a line upon the glacier. After eight days two of the flagstaffs in the centre of the glacier appeared to have moved slightly in advance of the rest (not more than six, and probably nearer to three inches in advance). The remaining flagstaffs appeared not to have moved. It must be remembered that at this time of year the daily movement of the ice would be approaching its minimum value.

Measurements to the ice-cave from fixed points.

A cairn was made over the ice-cave (see Plate 65) and measurements taken from three fixed points, A, B, C, all marked by arrows cut in the rock and painted red. The measurements are as follows:—

From A to cairn, horizontal distance	. .	1,405 feet.
From B ,, ,, ,,	. .	949 ,,
From C ,, ,, ,,	. .	500 ,,

Photographs, reproduced as Plates 58 and 59, show in one case a general view of the glacier, and in the other a view from station C.

List of Plates of the Poting Glacier.

PLATE 58.—Poting glacier and ice-cave with snowy ranges in the background. Taken from camping-ground.

PLATE 59.—Snout of the Poting glacier from C.

PLATE 65.—Plane-table sketch-map of the snout of the Poting glacier, as it was in October, 1906.

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View from Station No. III.

Photo. by H Walker. | Bemrose, Collo., Derby.

SONAPÁNI GLACIER, LAHAUL.

View from Station No. V.

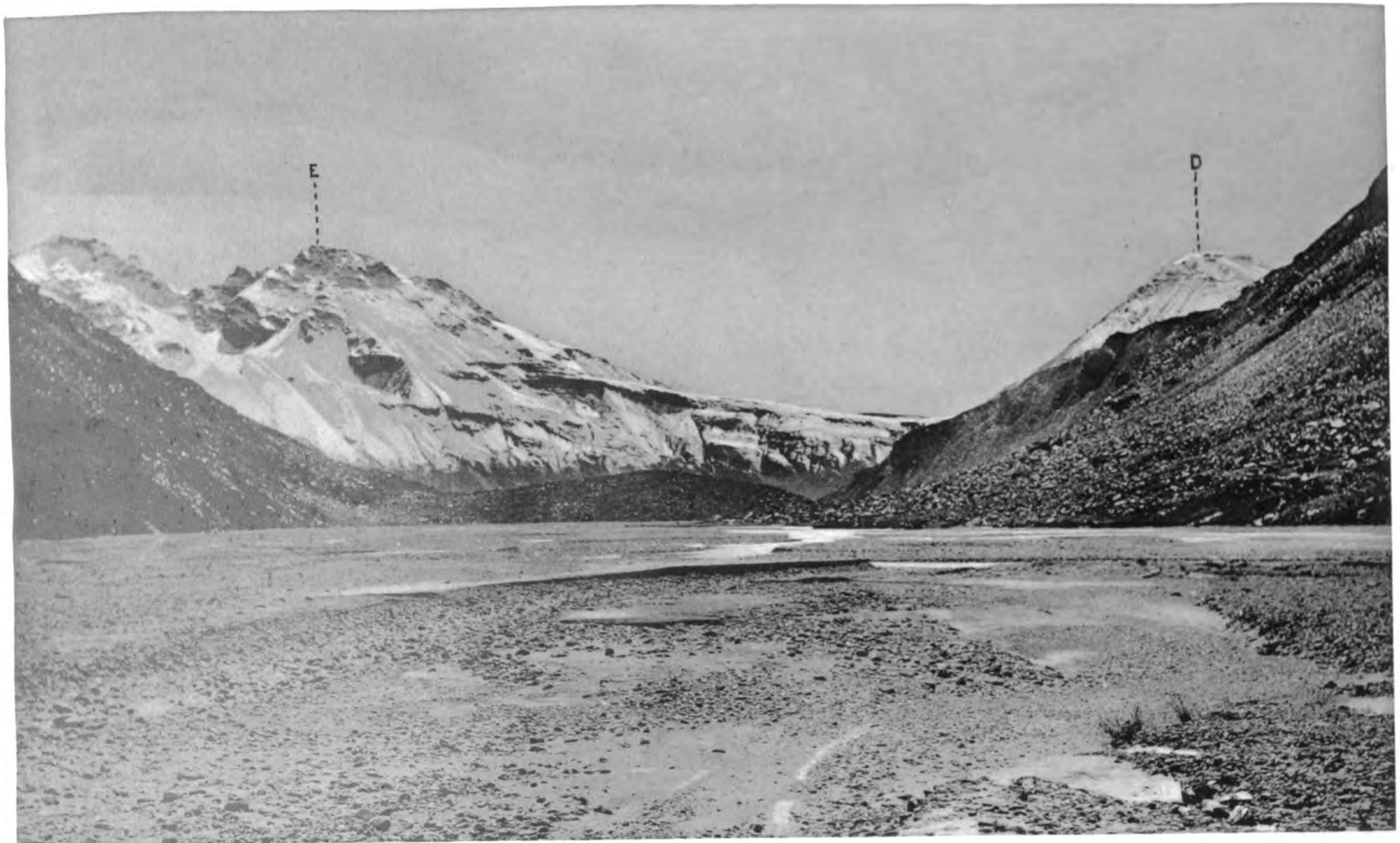

Photo. by H. Walker.

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SONAPÁNI GLACIER, LAHAUL.

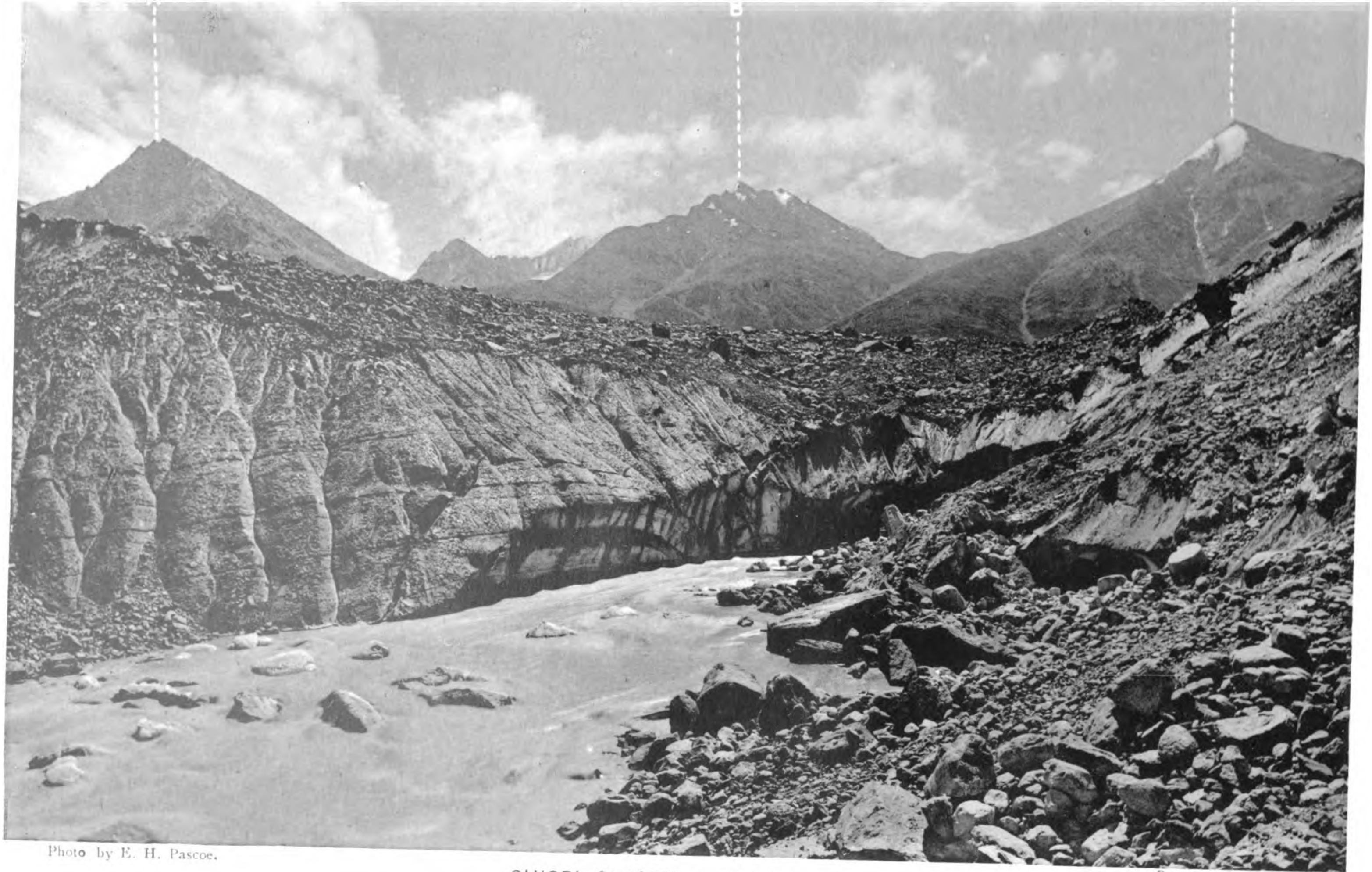
Old terminal Moraine with lake deposits in foreground.

View from Station No. VI.

Photo. by H. Walker. *Bemrose, Collo., Derby.*

SONAPÁNI GLACIER, LAHAUL.

Oldest terminal moraine cut through by glacier stream.



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SHIGRI GLACIER, LAHAUL.

Bemrose, Collo., Derby.

View from Station No. I.

Photo. by E. H. Pascoe. Bemrose, Collo., Derby.

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Photo. by E. H. Pascoe.

SHIGRI GLACIER, LAHAUL.

View from Station No. IV.

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Photo. by G. de P. Cotter. *Bemrose, Collo., Derby.*

OLD GRASS-GROWN MORAINES NEAR MARTOLI CAMPING GROUND.

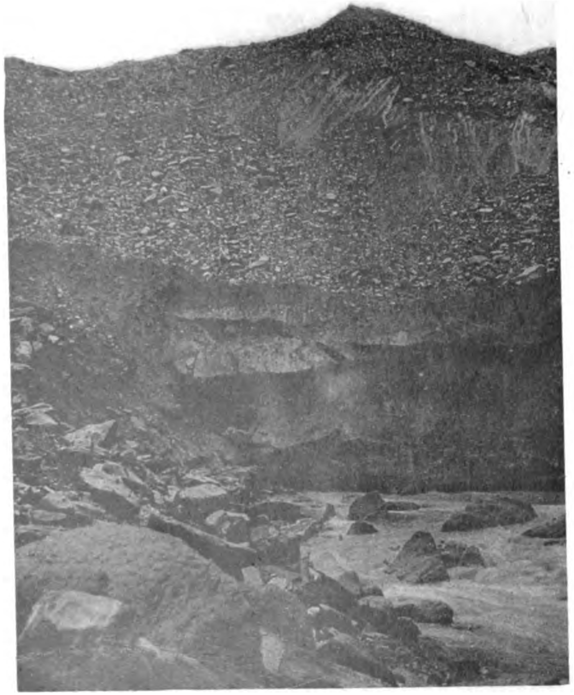
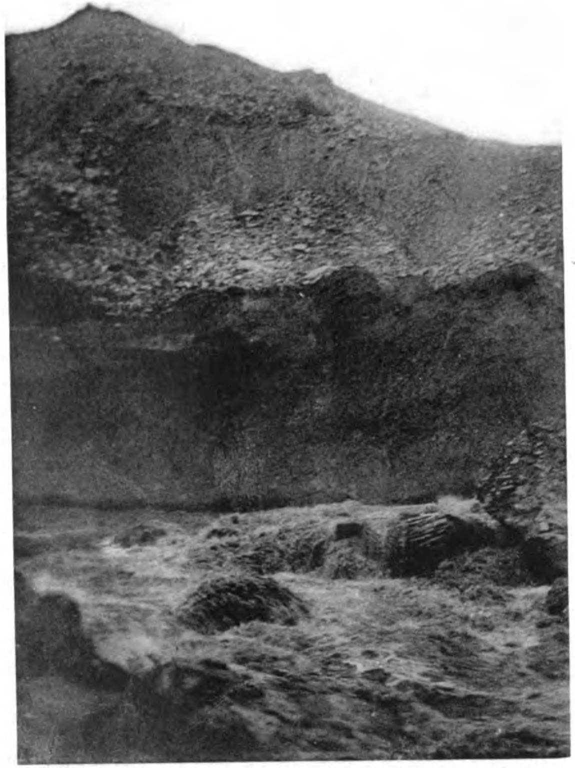


Photo. by G. de P. Cotter.

ICE-CAVE, LEFT VIEW.



Bemrose, Collo., Derby.

ICE-CAVE, RIGHT VIEW.

Photo. by G. de P. Cotter.

Bemrose. Collo., Derby.

VIEW OF PINDARI GLACIER FROM C. SHOWING SNOUT.

Photo. by G. de P. Cotter. Bemrose, Collo., Derby.

VIEW FROM D. SHOWING RIGHT AND LEFT LATERAL MORAINES WITH GLACIER BETWEEN.

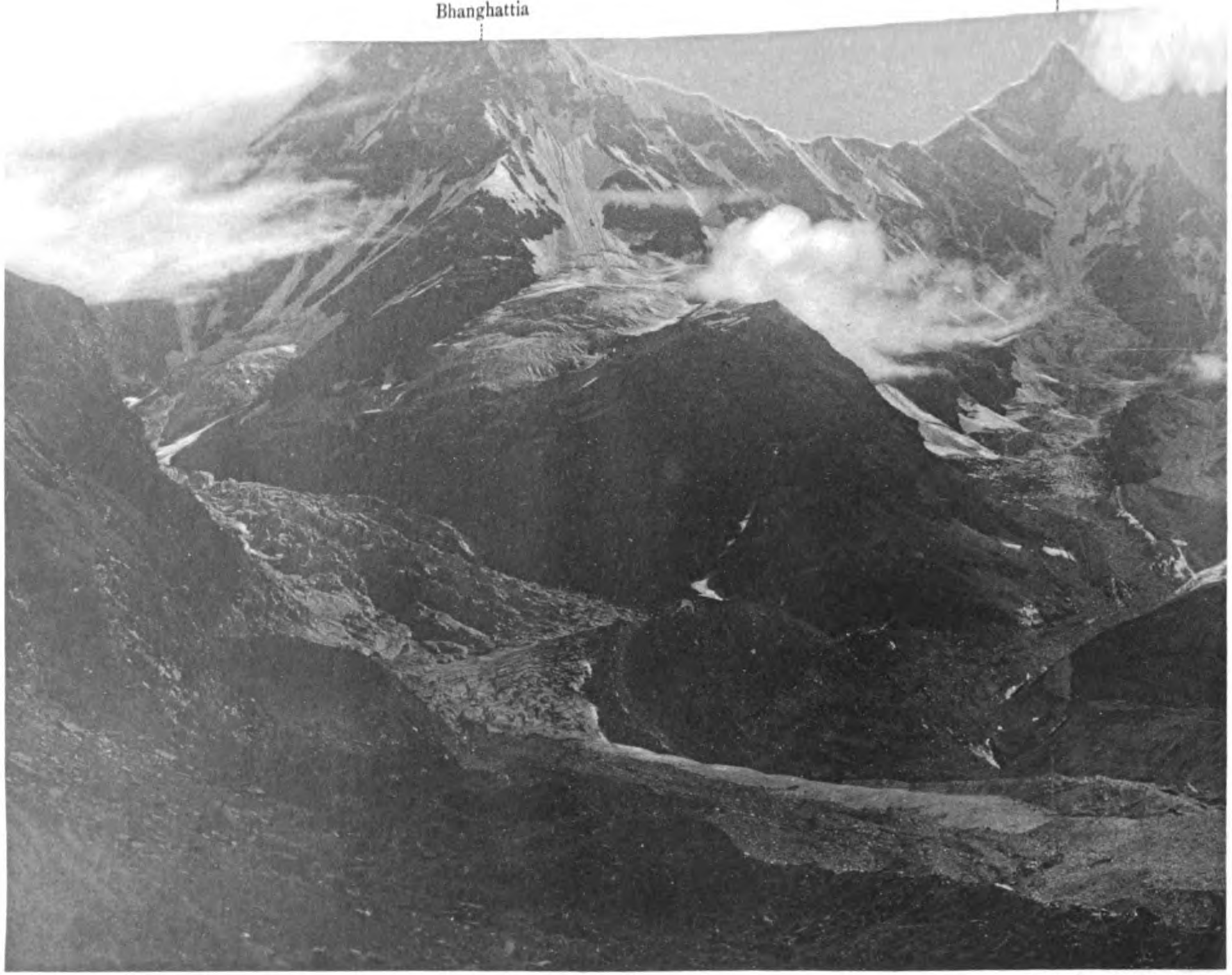


Photo. by G. de P. Cotter. *Bemrose, Collo., Derby.*

VIEW FROM D. SHOWING THE UPPER GLACIER WITH MEDIAL MORAINE AND THE TWO ICE FLOWS.

Photo. by G. de P. Cotter. *Bemrose, Collo., Derby.*

THE VALLEY LEADING TO THE UTARDHURA PASS BLOCKED UP BY MORAINE FROM THE MILAM GLACIER. TAKEN FROM MILAM.

Photo. by G. de P. Cotter.

MILAM GLACIER FROM A.

Bemrose, Collo., Derby.

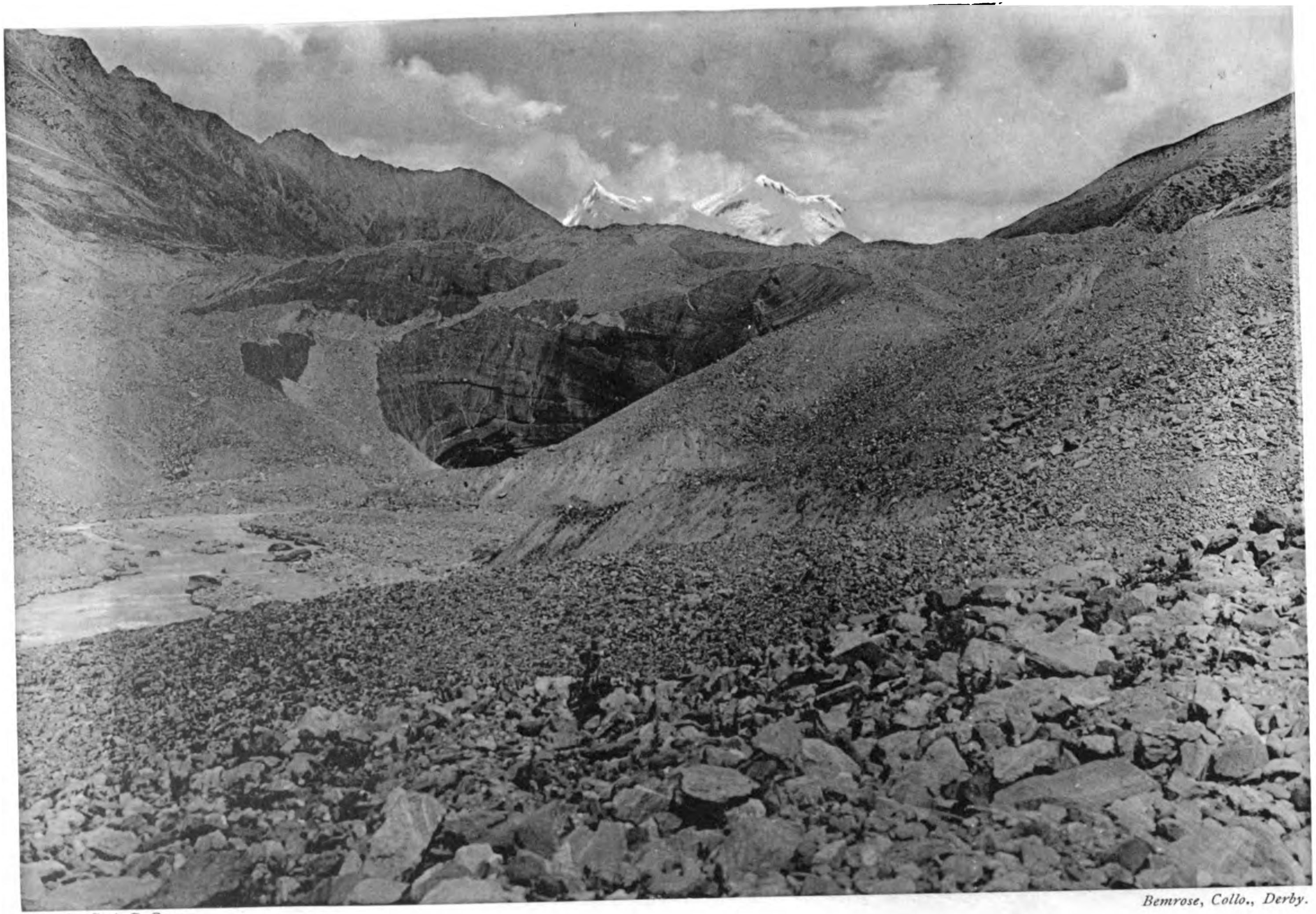


Photo. by G. de P. Cotter. *Bemrose, Collo., Derby.*

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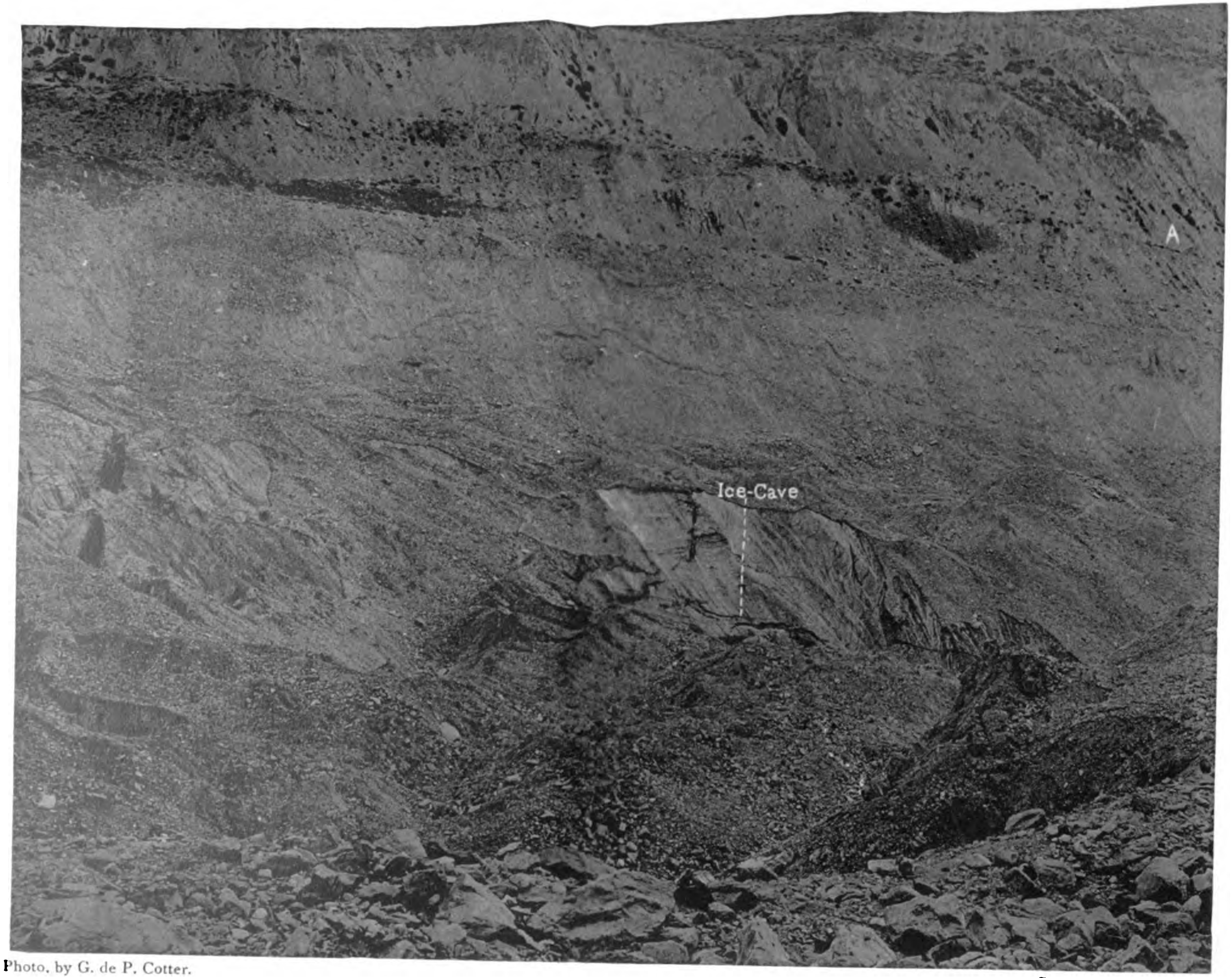

Photo. by G. de P. Cotter.

MILAM GLACIER AND ICE-CAVE FROM C.

Bemrose, Collo., Derby.

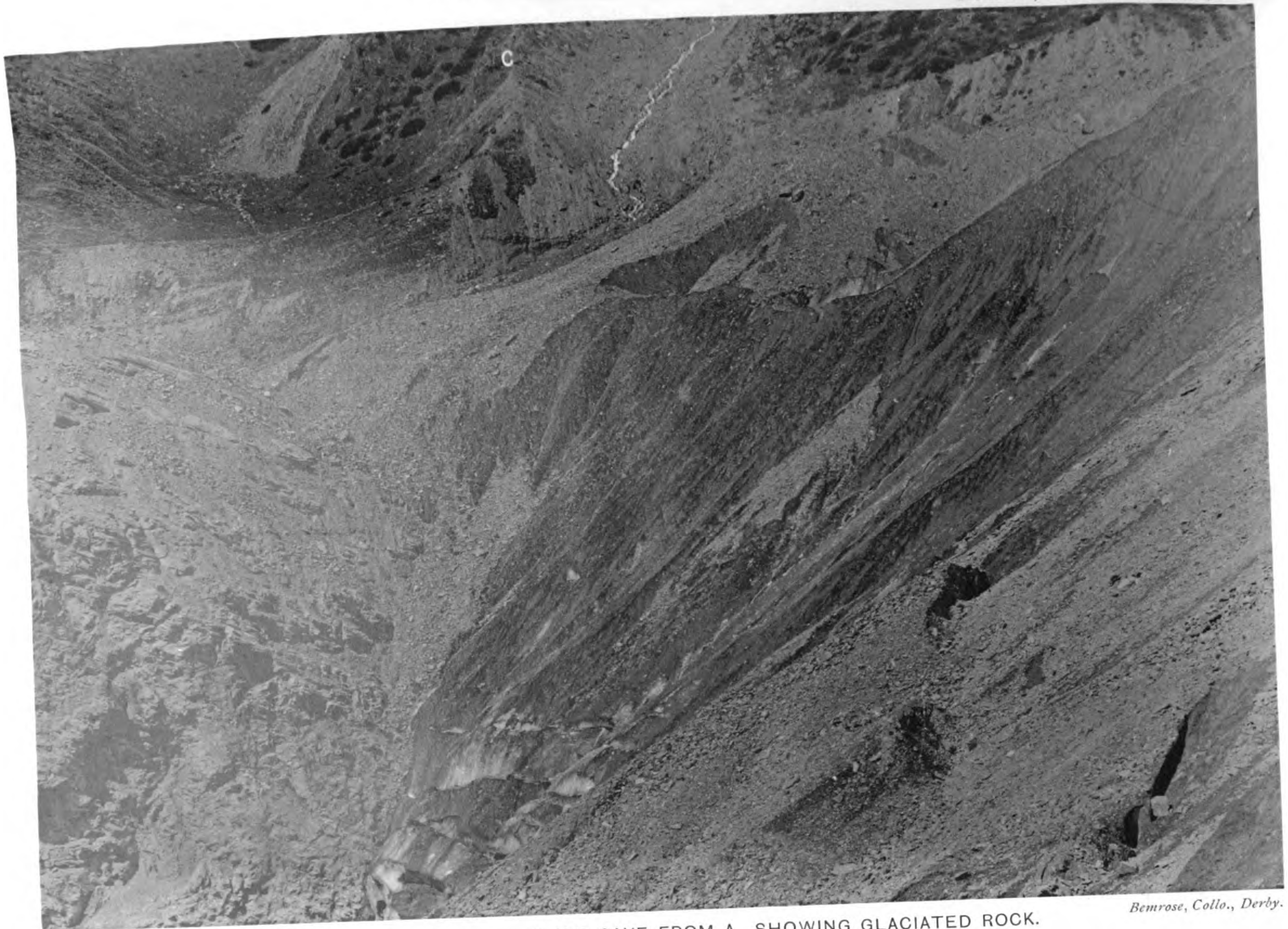

Photo. by G. de P. Cotter. SHANKALPA GLACIER AND ICE-CAVE FROM A., SHOWING GLACIATED ROCK. Bemrose, Collo., Derby.

Bemrose, Collo., Derby.

SHANKALPA GLACIER AND ICE-CAVE FROM B.

Photo. by J. C. Brown.

Photo. by J. C. Brown.

SHANKALPA GLACIER AND ICE-CAVE FROM B.

Bemrose, Collo., Derby.

Photo. by J. C. Brown.

SHANKALPA GLACIER AND ICE-CAVE FROM B.

Bemrose, Collo., Derby.

Photo. by J. C. Brown. *Bemrose, Collo., Derby.*

POTING GLACIER AND ICE-CAVE, WITH SNOWY RANGES IN BACKGROUND. TAKEN FROM CAMPING GROUND.

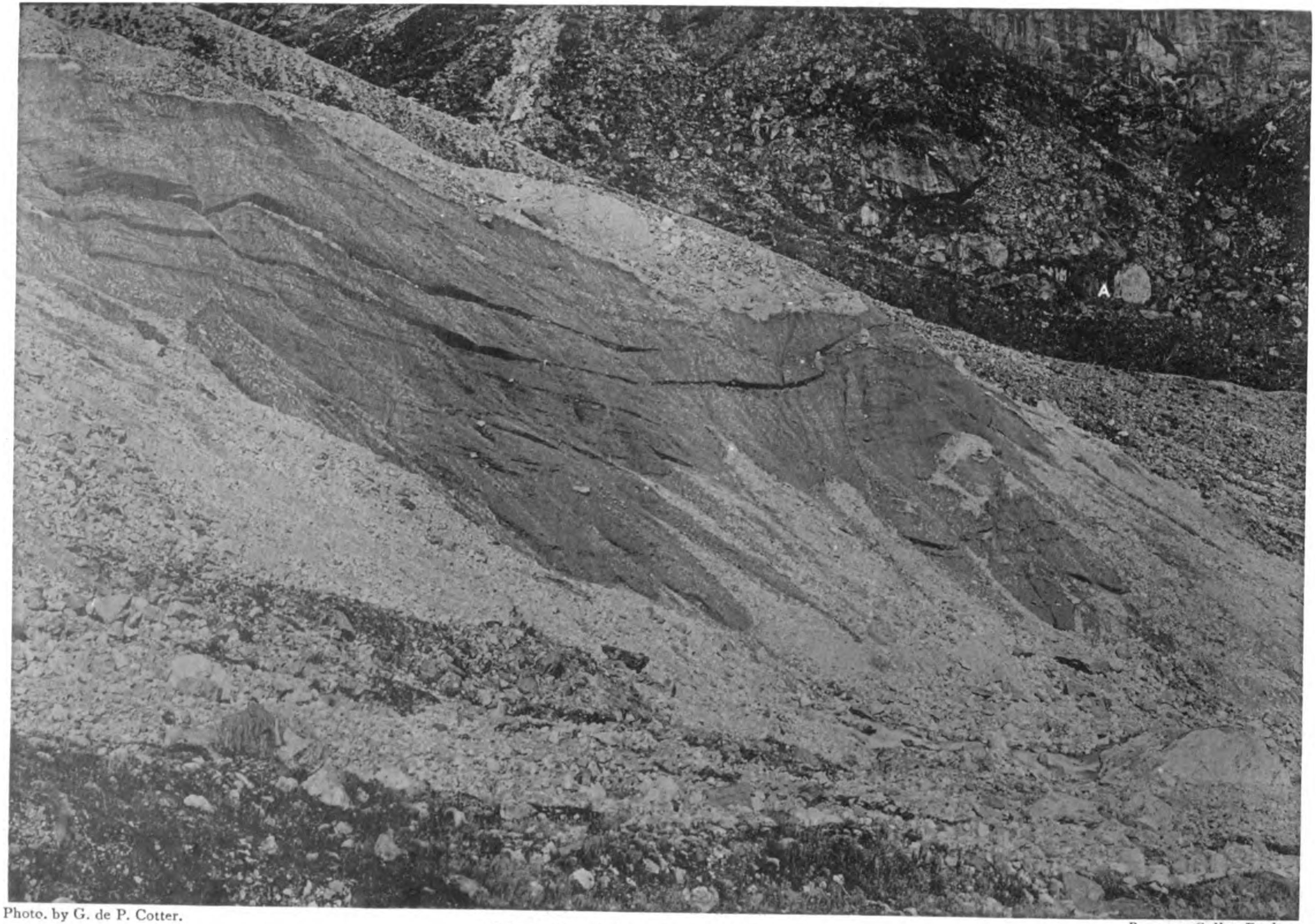

Photo. by G. de P. Cotter.

Bemrose, Collo., Derby.

POTING GLACIER FROM C.

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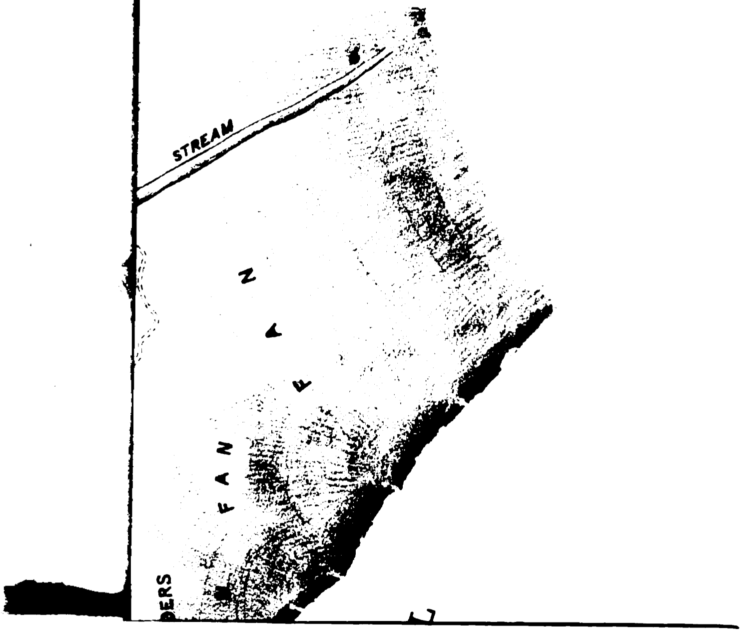
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