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FROM SRINAGAR TO THE SOURCES OF THE CHOGO LUNGMA GLACIER.*

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It was my fortune to spend the summers of 1902 and 1903 in exploring, with Mrs. Fanny Bullock Workman, the hitherto unvisited upper portions of the Chogo Lungma, Hoh Lumba, Sos Bon, and Alchori glaciers. We were accompanied, in 1902, by the guide Mattia Zurbriggen and porter Giuseppi Muller, of Macugnaga, and in 1903 by the guides Joseph Petigax and Cyprien Savoie, with Laurent Petigax as porter, all of Courmayeur, who were engaged and sent to us in Kashmir by Signor Francesco Gonella, president of the Turin section of the Italian Alpine Club, and Signor Ettore Canzio, of Turin, well-known Italian alpinists, to whom we are greatly indebted for their prompt and friendly assistance. We had with us, also, in 1903, Mr. B. H. M. Hewett, of London, as topographer.

I invite you to revisit with me to-night that portion of our route, which lay between Srinagar and the sources of the Chogo Lungma, noting as briefly as possible some of its most salient features.

The Chogo Lungma, one of the largest of Himalayan glaciers, lies in the northern part of Baltistan, its termination or snout being just above the village of Arandu, in lat. 35° 52′ N. and long. 75° 23′ 40″ E., twenty-three marches north of Srinagar, the capital of Kashmir. It is best reached from Srinagar *viâ* Skardo, the chief town of Baltistan, and thence up the Shigar and Basha valleys.

* Read at the Royal Geographical Society, November 21, 1904. Map, p. 352. The map is based on theodolite survey by Mr. Hewett, corrected and supplemented from observations and photographs by Dr. William Hunter Workman and Mrs. Fanny Bullock Workman.

Several routes lead from Srinagar to Skardo, the shortest in twelve marches being up the Gilgit road to the Burzil Chowki and thence over the Deosai Plains. This route, owing to the elevation of the Deosai Plains, between 12,000 and 13,000 feet, and that of the Burji La, nearly 16,000 feet, is only free from snow and available for travel during July, August, and the first half of September.

The longer, more disagreeable, but more convenient and generally used route, because open the greater part of the year, takes one in eighteen marches up the Sind valley, praised for its scenery by summer visitors who have never been farther afield and beheld the supreme majesty of the wilder regions beyond, over the Zozi La, a low pass of about 11,000 feet to Kharbu, and thence down the valleys of the Dras and Indus.

The Dras and Indus valleys are dreary and desert, being walled in on both sides by high mountain barriers of scarred and gullied clay, crumbling granite, and shale, without vegetation, except here and there the aromatic shrub called boortsa and wild rose trees, which will flourish where nothing else will grow, and which often bear such a profusion of blossoms as to hide their stems entirely from view. They flash up in the stony wilderness like marvellous colour gems, each tree or group brilliant with every shade of mauve from the palest pearl to deepest crimson.

The path here is narrow and rough, running up and down steep ragged inclines, across gorges swept by mountain torrents, through stretches of soft sand, and over narrow ledges projecting from perpendicular rock walls which overhang rushing rivers beneath. Every 5 or 6 miles, usually at the entrance of side valleys, the landscape is varied by oases perched on the mountain flanks, or nestling at the bottom of the valley by the river-bank, beautiful in their bright spring green, or later, with their golden harvest, in striking contrast with the brown barren surroundings. The eye, wearied with the dull monotony of the chaos of rock and *débris* through which one has been passing, rests with delight on the terraced fields of waving grain, bordered by a profusion of mulberry, apricot, pear, walnut, poplar, and willow trees.

In the centre of the oases stand villages of a size proportioned to each, by the industry of whose inhabitants these gardens in the desert are created. Every available bit of alluvium among the rocks is cultivated, and good-sized terraces, bearing excellent crops, are seen, the alluvium of which has been brought in baskets from wherever it could be found in the neighbouring wilderness.

These oases are of artificial creation. The land on a sloping surface is built up in terraces, one above the other, retained by stone walls. A mountain torrent near by, which furnishes a never-failing supply of water, is tapped at a point above, and a canal constructed from it to carry the water along the upper side of the land to be reclaimed.

FIG. 1.—TYPICAL VIEW IN THE INDUS VALLEY NEAR TOLTI. PATH SEEN AT EXTREME RIGHT.

FIG. 2.—OASIS ON TALUS. WATER CANAL BORDERED BY TREES ABOVE. TO RIGHT, GORGE THROUGH WHICH WATER IS BROUGHT. IN FOREGROUND RIVER WITH HIGH BANK.

Openings are made in the canal walls at desired points, and the water is distributed as required over the whole series of terraces from top to bottom.

Oases like these, which form the homes of the greater part of the population of the mountain valleys, depend for their existence entirely on irrigation. Cut off the artificial water-supply, and they would become as arid as the desert wastes around them. The semi-barbarous Himalayan valley-dwellers, who in their habits are but little above their domestic animals, are experts in the art of irrigation, and have nothing to learn in regard to it from Western civilization. Their implements are simple, their methods of construction rude, but they apply the means at their disposal to the desired end in a manner absolutely scientific, and the results show their skill to the confines of the oases.

It is marvellous to see what crops are obtained from land that is often sandy and stony. Such luxuriant grain-fields I have seldom seen elsewhere. One is at first surprised at such results when one considers that these lands have been constantly under cultivation probably for untold thousands of years, that the cultivators have not at their command manure and other fertilizers such as are used in Western lands, and that they harvest their grain by pulling it up by the roots, thus leaving nothing in the ground to nourish future crops.

A little observation reveals the secret of their success. The sediment brought down from the mountains in the water of the streams is a potent fertilizer, which is kept constantly applied to the crops from the time they are planted till they are ripe for the harvest, so that the ground is continually enriched rather than exhausted.

One of the most interesting features of the Dras and Indus valleys is the evidence of water-erosion everywhere to be seen. Not only near the present level of the rivers, but at all elevations, even to the mountain-tops several thousand feet above, the granite rocks are smoothed, rounded, eroded in every conceivable manner and dented with pot-holes, showing that at some distant period they were subjected to the action of moving water carrying stones. Boulders of various sizes are strewn about at all levels, honeycombed in the most remarkable way, some being mere shells eroded both outside and inside.

From the shapes and positions of the pot-holes and erosions, it is evident that the direction of the currents that produced them was about the same as the flow of the two rivers at the present time. The erosions are seen mostly on the left banks of these rivers or west sides of the valleys, which slope away from the rivers much less precipitously than the right or east sides. The explanation of this, as well as the question whether the erosions were made at the levels where they now stand by water flowing thousands of feet above the present rivers, or at or near the river-levels and afterwards pushed up with the mountain masses, I leave to those better equipped with geological knowledge than myself.

Skardo is situated in an amphitheatre among the mountains at the point of entrance of the Shigar into the Indus river, and is surrounded by imposing peaks. It is the most important town in Baltistan, being the seat of residence of the Tehsildar, and possessing a post-office, telegraph-office, sub-treasury, and bazaar. The Government maintains a meteorological station with mercurial barometer and other instruments, the readings of which at 8 o'clock a.m. are daily forwarded to the meteorological office at Calcutta. During both our expeditions to the Chogo Lungma and adjacent glaciers in 1902 and 1903, this served as our lower station for the calculation of altitudes, and the Government official kept a daily record of readings at 8 a.m., 12, and 3 p.m. for us.

A short distance above Skardo the Indus is crossed in a flat boat, and a large basin several miles in diameter, surrounded by mountains and deeply covered with sand, has to be traversed. The wind-storms, which rage here almost daily in the afternoon, have driven the sand into a series of remarkable sand-dunes. These take the shape of long elevated ridges and hillocks, surmounted by sharp arêtes and curling crests, some of which strongly resemble snow-cornices. I could not perceive that these last actually overhung the perpendicular, though I suspect they do when formed in damp weather, the overhanging portions afterwards crumbling and falling when dried by the burning sun, as loose sand was seen on the leeward slopes just below the sharp edges.

The sand acts like snow under the influence of the wind, and the result here was an exact counterpart of a high snow region exposed to strong winds. The tops of the highest of these hills and ridges must have been 300 feet or more above the general level of the basin. They were composed of fine white sand, whilst the lower slopes consisted of coarse sand driven into wavelets 3 or 4 inches deep, and from 3 to 12 feet in length.

From here the route leads up the wide Shigar valley, with its constant succession of villages situated on fertile alluvial fans, which radiate from the openings of the gorges cleaving the mountain barriers on either side. The Shigar valley is renowned for the quality of its apricots and mulberries, which are delicious, as well as for the abundance of its grain. The village of Shigar is the principal grain depôt of this region, and there we purchased the large supply of ata, or meal —some 4 tons—which in 1903 was required to feed the eighty-five coolies who accompanied us. The ata, which had to be forwarded in skin sacks eight to ten marches to us, shrunk about 20 per cent. in bulk at the hands of the coolies who carried it. As we paid for it in advance when ordering it, the burden of this shrinkage fell upon us, and not, as should have been the case, on the official who agreed to deliver it under seal. One finds human nature much the same in all parts of the world. Some of the devices resorted to by these primitive Asiatics to overreach would do credit to the ingenuity of their more civilized neighbours of the western world.

In order to reach the Basha valley, at the head of which Arandu lies, a series of rushing, mud-laden streams, which anastomose with one another along the valley bed, has to be crossed. The passage of these is made by means of a primitive, apparently frail, but really staunch craft called a zak. This consists of goat skins, usually twenty-four in number, inflated and attached by woollen cords to six or eight slender poles placed parallel to one another. It is buoyant, and breasts the billows of the most turbulent streams in safety. It is managed by a crew of four men, armed with willow or poplar poles about 8 feet long, with which they push it with considerable skill across the rapid currents. It is so light that its crew can easily carry it to any desired point, and the skins can be deflated, detached from the poles, and packed for transport in a short time.

As it has no floor except the skeleton of poles, the passenger must be careful where he treads, or he will find himself stepping through into the water. He stoops so as to keep the centre of gravity low, balancing his feet on two poles whilst he grasps two others with his hands. The water of the seething torrents washes over the craft when well laden, often wetting the feet of the passenger to the ankles; but this is an incident he does not mind so that he gets safely over the river. The embarkation is made at a point hundreds of feet above the landing-place on the other side to allow for the rapidity of the current, which carries the zak swiftly downward. As only five or six persons can be carried at one time, several hours are required to get a caravan over a river.

The village of Arandu lies at an altitude of 9500 feet, on an alluvial terrace directly in front of the converging snouts of the Tippur glacier on the south and the Chogo Lungma on the west. This terrace differs from the other fertile oases in the valleys below in that it has no fruit trees, producing only grain and a few vegetables. It belongs to the Tippur slope rather than to that of the Chogo Lungma. It may be an alluvial fan washed out at some distant period from the Tippur nullah; but it seems more likely to be the termination of the talus sloping down from the mountain, which forms the opening wall of that valley on the west. This talus is continuous with the Arandu terrace, and for several hundred feet above it is covered with grass and other vegetation.

Arandu is a small village, and can muster only about thirty coolies. Its headman or lambardar accompanied us on both our expeditions to the Chogo Lungma, in charge of the coolies and their food. His moral code was not modelled after the strictest Christian ideals; and on one occasion, when sent down to Arandu in an emergency to bring up supplies, although he knew we urgently needed all he could get, he did not hesitate to dispose, at a good price, of a sheep and several dozen eggs and fowls charged to our account, to a sportsman whom he met, telling us they were lost in the snow.

Still, though we never felt we could depend on his loyalty, through a judicious mixture of coaxing and threatening and promises of a good bakhshish he was induced to remain fairly faithful to us, and proved really useful in keeping the coolies up to their work. In comparison with the nine other Basha valley lambardars, we came to regard him almost as a friend and a pattern of Balti morality. The last attitude in which we remember him was that of prostration before us at the door of our tent, salaaming and touching his forehead repeatedly with his right hand in acknowledgment of the reward received for his devotion to our cause.

The Tippur glacier, which has never been explored, comes down through a gorge between precipitous rock mountains high above Arandu, and extends its snout, broken into séracs to the end to within 1846 feet of the village. It has evidently been advancing for several if not many years, for it has built entirely around the part outside the gorge a high and massive terminal moraine, above which the ice towers from 50 to 100 feet, and against which it crowds, overhanging it in many places. At the extreme end and at one other point the ice has broken over its moraine barrier, and a line of séracs projects halfway down the side of the latter.

The top of the moraine at the nearest point to the village is 415 feet above it. The glacier is adding to the moraine at a rapid rate, discharging upon it constant showers of boulders, rocks, and sand with a thunder which resounds through the air day and night. In short, this glacier may be considered at present to be in an aggressive mood. Formerly it reached considerably farther down the valley than now, the old terminal moraine being covered with a thick growth of grass, shrubs, willows, and tamarisks.

On the contrary, the snout of the far larger Chogo Lungma comes down its valley without fuss or noise to within 1184 feet of Arandu, where, on a level with the latter shelving away to a thin edge, it dies out like a spent wave almost imperceptibly on the river-bed.

The Chogo Lungma glacier runs a winding course nearly north of west from Arandu for a distance of 30 miles to its source in a col nearly 20,000 feet above sea-level. In these 30 miles it rises from a height of 9500 feet at Arandu to 19,000 feet at the base of the col. Its width varies from about a mile at its lower end to about 2 miles at its upper middle portion. For convenience of description, it may be divided into three sections, according to the distinguishing characteristics of each.

The first or lowest section extends from the end of the snout 9 miles

FIG. 3.—THE LAMBARDAR OF ARANDU AND HIS WIFE.

FIG. 4.—THE SNOUT OF THE CHOGO LUNGMA GLACIER, WITH RIVER-BED AND CUL[illegible] FIELDS OF ARANDU IN FOREGROUND.

upward to a point above the first bend. The surface of this section is broken up into a confused mass of pointed hillocks, highest along the meridian line, sharp ridges, and deep ravines. It is so thickly covered with mud, sand, granite, conglomerate, and shaly detritus of every size, from small fragments to huge boulders and slabs, that ice is scarcely seen, and where it does appear it is black and smutty. Placed suddenly upon it, one could imagine one's self in a desert of torn and splintered rock rather than on a glacier.

What becomes of the immense mass of *débris* that covers this section to its very end it is difficult to conjecture. One might suppose that its accumulation would long ago have blocked the wide valley below with a wall hundreds of feet high, and buried the village of Arandu deep out of sight; but, little evidence of such accumulation is seen, and the fair fields of Arandu still lift their luxuriant burden of grain to the breezes, unharmed by the threatening monster above. There is no terminal moraine worth mention, only a few insignificant stone-heaps just beyond the end of the snout, left by the receding ice—a great contrast to the huge moraine enveloping the snout of the neighbouring Tipper glacier.

The snout itself projects from the glacier bed between the mountains like a gigantic stranded whale, its naked, sloping, glistening, black flank, at first some 200 feet high, tapering down to a small point. Some distance up on its side, near where it leaves the right lateral moraine, a good-sized river flows out from under it, which follows its edge nearly to its end, and then turns across the stone-strewn interval towards Arandu, beyond which it joins the stream coming down on the opposite side from the Kero Lungma to form the Basha river.

This section of the glacier has dwindled greatly from its former volume. Colonel Godwin Austen says that in 1862 the ice was encroaching on the Arandu terrace. Now it nowhere touches it, and has receded to a point 1184 feet west of the village. The signs of recession below the end of the snout are so faint, that one could not judge from them that more than a slight diminution in its actual length has occurred in recent years, but immediately one ascends the glacier the evidence is more pronounced. A quarter of a mile above the end the side of the snout has receded more than 200 feet from the high right lateral moraine.

On account of the broken and crevassed surface of the lower section of the glacier and the steepness of the mountain walls on the right bank, the only way to ascend it is to cross over it from Arandu to the left bank, and for the next 14 miles to follow the detritus-strewn space between the former lateral moraines and the present ones. Here the recession is very marked. The ice now lies at distances of 50 to 600 feet from the original bank, consisting of the mountain flanks, which are banded by large primary moraines.

Between these and the moraines adjoining the ice is a system of more or less parallel secondary moraines, separated from one another by considerable intervals. At one place I counted six parallel moraines of this kind. From these we may infer (1) that the shrinkage has been going on for a long time, as is shown by the fact that the primary and some of the secondary moraines are covered with vegetation and trees; (2) that there have been periods of arrest in this process when the glacier was stationary or slightly advancing, during which the secondary moraines were formed; (3) that the glacier is still retreating, as the ice slants sharply back, and in some places has melted entirely away from the moraines last formed.

Just below the upper end of this section a well-marked moraine rises on the shoulder of a mountain spur more than 100 feet above the level of the ice opposite. To build this moraine, the surface of the glacier must have been from 150 to 200 feet higher than at present. This represents an important diminution of the glacier in thickness as well as in width. At no point in this section was it advancing or crowding its left lateral moraines, but everywhere receding from them.

At one place in the lower part of the second section, for a distance of more than 1500 feet, the ice, which in 1902 had receded from the lateral moraine, in 1903 was pressing hard against and overlapping it, owing probably to the increased thrust of the large branches opposite sent down from the Haramosh range.

At some points the lateral moraines are high and massive, at others small. The height of one was measured at 115 feet on the shorter side next the mountain, and others must have been 150 feet or more. In several places moraines were being formed along the sides of huge ice-walls, the process being the same as the formation of tali at the base of mountain precipices. In this case the *débris* near the edge of the glacier is set free by the melting of the ice, and, falling down the sloping side, accumulates in a moraine at the base.

Here and there along the left bank of the first and second sections of the glacier, examples occur of the sand, grass, flower, or bush covered maidans often seen on the sides of Himalayan glaciers. These are level or gently inclined meadows lying between the mountain slopes and the lateral moraines.

They are found at places where the slopes recede from the glacial bed, at the entrance of side valleys, and at the confluence of glaciers, where the lateral pressure is not great enough to force the glaciers against the mountain walls. The moraine barriers usually run in a straight line, except at the junction of glaciers, where pressure may cause them to be formed on a curve.

The maidans are, as a rule, free from stones, and, if at the entrance of side valleys, may have small clear streams running through them, hence they afford convenient and safe places for camping purposes.

In those I have examined no moraine deposits have been found on

FIG. 5.—SECTION OF LATERAL ICE-WALL OF BLACK ICE, ABOUT 200 FEET HIGH AND 400 LONG. MORAINE FORMING AT ITS BASE.

FIG. 6.—HARAMOSH GLACIER AT ITS ENTRANCE INTO THE CHOGO LUNGMA. MOUNT HARAMOSH, 24,270 FEET, 11 MILES AWAY AT EXTREME LEFT. IN BACKGROUND BEAUTIFUL SNOW-NEEDLES OF INDUS-NAGAR WATERSHED, PEAK NO. 4, 22,810 FEET HIGH. IN FRONT OF IT ROCK SPUR ENDING IN ROCK PEAK NAMED CHOGO LUNGMA RIFFELHORN, 15,337 FEET, ON WHICH IS SEEN LAYER OF BLACK SLATE LYING OVER THE GREY GRANITE. BASE CAMP ON SNOW-FLECKED SLOPE AT END.

the mountain slopes at the foot of which they lie, and which themselves are often covered with grass and flowers continuous with those of the maidan. Nor has such deposit been found upon or in the rich alluvial surface of many of the maidans or the sandy surface of others. The first evidence of moraine deposition is seen in the sharply defined enclosing moraines, which overlie the maidan surface as extraneous structures.

These facts, together with the important one that the maidans may be covered with a luxuriant growth of grass, flowers, or bushes, while the enclosing moraines may be destitute of any vegetation, point to the conclusion that the maidans were formed like any other terraces at a time antecedent to the formation of the moraines, and that the latter were superimposed on their edges at a later period, probably curtailing their area to a considerable extent.

These maidans must not be confounded with the spaces strewn with rock *débris* lying between primary and secondary lateral moraines.

The second section extends upwards for 13 miles, to a mountain wall above the entrance of the Haramosh glacier, where the Chogo Lungma makes a short turn to the south-west. This may be called the section of medial moraines, of which there are six well-marked ones, some of the larger presenting several distinct ridges, which, if counted as separate moraines, would swell the number to between fifteen and twenty.

At the beginning of this section, white ice first appears in the shape of a vast white tongue extending downward from above along the middle of the glacier. This is flanked by dark medial moraine-bands bearing the detritus already mentioned. Opposite the peak Kupultung Kung, owing to some cause which is not apparent, the moraines, which in places rise from 60 to 150 feet above the white ice, sink to the general level and lose their identity, joining together to form the chaotic structure seen lower down, the white ice disappearing from view.

As the glacier is ascended, two bands of white ice appear, separated by a huge moraine, the second originating in the Haramosh glacier, the largest branch of the Chogo Lungma. Throughout the second section the edges of the glacier are much broken and crevassed, owing to the entrance of branch glaciers on both sides, the crevasses being comparatively short, and running in various directions according to the pressure. To find one's way from the bank through the labyrinth of resulting séracs to the white ice in the middle requires considerable mountaineering skill, but once gained, the latter, being fairly smooth and free from large crevasses, affords a safe passage to the end of the section.

The bend of the glacier to the south-west forms a good-sized basin, into which open five large feeders of the great stream below, bearing somewhat the relation to it that the spread fingers do to the palm of the hand. Four of these we explored to their sources.

Projecting well into this basin, adjacent to the Haramosh glacier on the west, is a rock promontory, the end of a ragged spur sent off from the splendid so-called Indus Nagar watershed, peak No. 4, the most beautiful snow-needle I have anywhere seen. From this promontory rise two rock summits, one of which so strongly resembles the Riffelhorn at Zermatt, as seen from the Gorner glacier, that we christened it the Chogo Lungma Riffelhorn. Although a pygmy in comparison with the peaks around it, it is a giant as compared with the Zermatt peak, having an altitude of 15,337 feet to the latter's 9617. This summit is peculiar in that a wide band of black slaty rock is superimposed from bottom to top, on the granite of which it mainly consists. We scaled this several times during both seasons, and built a cairn on its summit, in which records were left.

On this promontory we established our base camp during the seasons of 1902 and 1903, and, as both summers were stormy, we spent considerable time here. It afforded an excellent point from which to study the region and the medial moraines. Records were also deposited in a cairn built at this camp.

The large Haramosh glacier sweeps down nearly at a right angle upon the Chogo Lungma with a thrust so great that the latter is pushed over towards its left bank, and the Haramosh turns to the right in a wide curve and crowds itself in on the right of the main stream, forming thenceforth nearly half the width of the glacier, and preserving its identity to the middle of the second section.

The detritus borne along on the left edge of the Haramosh glacier forms, at the line of junction with the Chogo Lungma, a large moraine in the middle of the glacier, which is pushed high up above the surrounding level by the lateral pressure of the two streams. Where the glaciers first come together, the moraine is not very pronounced, but it becomes more so as they descend. The granite of which it is composed has a reddish colour from the iron it contains. About a mile below the junction of the two glaciers, another medial moraine of black *débris* springs up by the side of the former without traceable origin, and after a short distance increases in size and height, rising 150 feet or more from the general level until it quite overshadows the Haramosh moraine, though it nowhere reaches more than half the width of the latter.

It is cleft by enormous transverse crevasses. Below the Bolucho branch these two moraines coalesce and present a uniform dark colour, sinking nearly to the level of the white ice. The detritus on the right side of the Haramosh glacier with that from the tributaries below, forms a wide right medial moraine belt with several moraines, whilst that from the left side of the basin and left tributaries forms a left medial moraine much narrower than the belt on the right.

The greater part of the *débris* of the left moraine appears to be cast out on the side to form the giant lateral moraines there seen, but sufficient

FIG. 7.—VIEW DOWN THE CHOGO LUNGMA FROM HEIGHT OF 18,700 FEET, SHOWING THE WINDING MORAINES. AT RIGHT SNOW-PEAK OF 17,814 FEET ASCENDED IN AUGUST, 1902.

FIG. 8.—BASE CAMP ON RIFFELHORN SLOPE, TAKEN FROM ABOVE. GLACIER ABOUT 2 MILES WIDE. SÉRACS ON NEAR SIDE. ICE-LAKE ABOUT HALF A MILE FROM GLACIER EDGE BELOW CAMP. BLACK LINE AT EXTREME RIGHT SHOWS THE BEGINNING OF THE LARGE HARAMOSH MORAINE WHERE GLACIERS FIRST COME TOGETHER.

is left with that of the right central ones to conceal the ice of the lowest section entirely from view.

The medial moraines mark the course of the ice-currents caused by the entrance of tributary glaciers and the conformation of the bed of the main stream. These currents, which are complicated, would make an interesting study for one who had time to devote to mapping them. Above the Riffel promontory, one black moraine originating under a mountain on the right bank pushes diagonally across the glacier some 3 miles to join the left latero-medial moraine.

Opposite Riffel camp a large depression occurs in the glacier, the surface of which here is much cut up by crevasses. In the centre of this there is a good-sized lake with streams running into and out of it. This presented the same appearance in 1903 as in 1902, and will probably continue to exist until the movement of the glacier opens an outlet in its bed.

The Haramosh glacier runs south by west from the Chogo Lungma 11 miles to the base of the steep flanks of Mount Haramosh (24,270 feet), where it ends in a long snow-covered ice-field or pass seamed with wide crevasses, which dips down steeply on the other side to a valley leading to the Indus. The height of this pass is 17,412 feet. As its discoverers, we named it the Amar Singh La, after General Raja Sir Amar Singh, K.C.S.I., of Kashmir. The scenery here is of the wildest and most sublime description, whole mountain slopes presenting a chaos of glittering ice-falls.

The third section of the Chogo Lungma comprises the remaining 8 miles to the col. In this distance the glacier rises 5000 feet, from 14,000 to 19,000, and is walled in by impressive mountains from 21,000 to 24,500 feet high, whose ice-clad sides rise sharply from it. Here moraines and rock *débris* cease to be prominent, their place being taken by a broken surface of séracs and icefalls, and higher up by *névé* and driven snow.

The séracs begin at Riffel promontory and continue for about a mile, spreading halfway across the glacier. They are largest and most broken near the right bank. Two other series occur above, rising so steeply as to constitute ice-falls. Wide crevasses of unmeasured depth exist over the whole of this portion, in some places in great numbers, in others more scattered. These crevasses do not run transversely from bank to bank as at one place on the Biafo glacier, but take every direction, often ending in huge ice-caverns. This indicates irregularity of the glacial bed. The general effect of the second ice-fall, about 3 miles above Riffel promontory, is, however, that of transverse terraces rising above one another.

This section is not easy to ascend. In addition to the steepness of the gradient and the effect of altitude on the system, one has to thread one's way through the pathless labyrinth of séracs, neither a very easy nor safe operation, to contend with soft snow which increases in quantity as one ascends, till near the col it reaches a depth of over 3 feet, endure the burning heat of the sun in clear weather, and cold winds and cutting sleet in foul; camp on the glacier in soft snow, with a temperature falling perhaps to zero, and, worst of all, contend with the unwillingness of coolies to proceed, without whose aid nothing can be accomplished, running the almost certain risk of being forced back by them or of being deserted and left helpless in the snow in case the weather becomes threatening.

This is the formative basin of the glacier, an elevated savage wilderness of snow, ice, and rock. Here the snow collects with every storm throughout the year till it lies many feet deep on the solid ice beneath, to which it freezes, and whose volume it helps to swell. Large hanging glaciers pour down their ice contingent in tumultuous confusion to add to the masses below, while the precipitous mountain flanks hurl down snow and ice avalanches of enormous size with a force which causes the earth to tremble, and a thunder which is heard for miles. Avalanches here are constantly falling, and constitute an element of danger which has to be reckoned with in every move that is made.

Near the head of the glacier we narrowly escaped the largest avalanche it has ever been my fortune to see. The width of the glacier at this point is about a mile, the surface strongly undulating, and the mountain slopes on both sides extremely steep. As we passed along the middle of the glacier in front of one threatening wall we tried to hurry the coolies, whose movements, as usual, were of the most leisurely character. They gave little heed to our admonition, and would not quicken their pace.

The last coolie had passed the wall by only ten minutes, when we were startled by an ominous roar behind. Looking around, we saw what seemed to be the whole mountain-side in motion. The huge curling cornice that had graced its brow and excited our fears had broken loose. Vast masses of snow and solid ice were sliding downward, rolling over one another, leaping through the air, and smashing themselves against the rocks with hissing, growlings, and crashings, as if all the demons of the infernal regions were expending their wrath on that mountain wall. Thick clouds of snow-dust were thrown hundreds of feet in the air.

As the mass struck the glacier it seemed to hesitate a moment, then, gathering head, with a high swelling front at least half a mile wide, it shot across the glacier regardless of undulations and gradients, leaving in its train a chaos that must be seen to be appreciated, till it finally expended its force well over towards the farther side of the glacier. The cloud of snow-dust raised by it rolled majestically onward till it was dissipated on the heights opposite. The forces of nature among these great mountains, when dormant, pass unobserved, but when aroused to action, be they those of air, water, rock, or snow, the effects are indescribably sublime and awe-inspiring.

Five miles from the col the last and highest tributary of the Chogo Lungma enters it from the south with a great, much-broken ice-fall, the confluence of the two forming a large slanting basin, the middle of which lies at an altitude of about 16,000 feet. This glacier is about a mile wide and 6 miles long. It is deeply covered with snow, as are the mountains around it, which discharge from both sides upon it avalanches that sweep its whole width. It is seamed with crevasses, some of which extend from one bank to the other. It ends in a snow-col above 19,000 feet in height, beyond which valleys descend towards the Indus and Gilgit.

From the entrance of this tributary to the base of the terminal col, 5 miles distant, the Chogo Lungma consists of a series of vast rounded ice-hillocks slanting sharply up to the mountains at the sides and rising steeply above one another, their surfaces broken by yawning ice-caverns, and deeply covered with snow. The ascent here is very fatiguing, resembling that of a stiff snow-mountain. The col itself crowns a massive ice-wall rising sharply from the glacier to an estimated height of 800 feet above it. The col is nearly 20,000 feet above sea-level. The continuity of the wall is broken by ice-falls and bergschrunds, and its whole surface is covered with a thick mantle of soft snow. We named this the Pratap Singh Col, in honour of His Highness the Maharaja of Kashmir and Jammu.

In August, 1902, after much trouble with our coolies, who were disheartened by the steep gradient and depth of the snow, we succeeded in reaching the base of this wall, and camped at a height of 18,995 feet with the intention of climbing it. In the afternoon we cut steps up the lower half, intending to make the ascent the next morning. At daylight clouds and mist began to roll over the col, and by seven o'clock it was entirely obscured from view. The barometer fell rapidly, and, as a storm was evidently on, we struck tents and beat a retreat to a camp at 15,096 feet, six hours below, on a mountain-side.

By ten o'clock snow was falling thick and fast. At one we pitched our tents in 4 inches of snow on the stone terraces we had previously built out from the rather steep slant for this purpose. That storm lasted sixty hours without interruption, during which time it kept us occupied in clearing away the snow from and about the tents to prevent their collapse. The next morning the fifty-five coolies who were with us deserted in a body, returning to the base camp, and left us alone with the camp-servants to weather the storm. After the storm had ceased forty of them returned, having been sent back by the lambardar.

A few days later the porters and two coolies went up to bring down the Mummery tents we had left behind with the intention of returning.

These were found buried under 5 feet of new snow. The depth of the snow, the lateness of the season, and the danger from avalanches prevented our returning to the col that season. During the stormy summer of 1903, there was so much snow on the glacier above 17,000 feet that we did not attempt to revisit it, knowing it would be impossible for loaded coolies to reach its base.

In 1902, when we made the terraces for the camp here seen, the mountain-side for 1000 feet above was free from snow. In July, 1903, the camp site was covered with avalanche *débris*. Our tent terraces and a strong stone cairn we built just above had been swept away by avalanches, resulting from the unusual accumulation of snow during the winter.

The upper section of the Chogo Lungma is bounded on the north by a massive mountain wall covered with ice, leading up to three splendid snow summits, the highest of which, over 24,500 feet, dominates the whole region. Taking advantage of a series of fine days in August, 1903, we pushed our camp to a height of 19,358 feet on the much-broken snow-flank of the first peak. On August 12, after scaling the first two peaks having altitudes of 21,500 and 22,567 feet respectively, the two guides, Petigax, Savoie, and myself succeeded in reaching a point on the south-west arête of the third, 23,394 feet in altitude, from which we had a wonderful view, three-quarters of a circle in extent, upon a billowy mass of glaciers, valleys, mountain ranges, and peaks of every shape and height. The Pratap Singh col beneath our feet, at the head of the Chogo Lungma, was seen to be the beginning of a snow pass, named by us the Pratap Singh La, that runs for some distance between high snow-peaks, and then suddenly drops down to a glacier that slopes gently away to a rock valley leading apparently toward Nagar. This route to Nagar would not be available to travellers on account of its mountaineering difficulties, and no coolies could be induced to pass the Pratap Singh La.

To do justice to the remaining branches of the Chogo Lungma would require an evening. They have their origin in high, wild, riven, and snow-covered rock basins, fall sharply, are split up by deep crevasses into ice-falls and séracs, and bring down immense quantities of mountain *débris* to the main glacier. Some of them are beautifully marked by moraines.

The southern branches, coming from higher and more snowy mountains, are larger than those on the north side, and are, apparently, not receding. Several of the northern branches have receded greatly, and some of the smaller ones have entirely disappeared. One of the large tributaries, the Bolucho, has ceased to have any connection with the Chogo Lungma, having retreated some distance up its valley, leaving its bed covered with a chaos of granite *débris*. Two large moraines on the mountain-sides at the valley opening show that the ice must formerly

FIG. 9.—SECTION OF THE ICE-LAKE, WITH ICE-WALL ON FURTHER SIDE.

FIG. 10.—ON THE EDGE OF A CREVASSE AT TOP OF ICE-FALL.

have been at least 250 feet thick at its junction with the Chogo Lungma.

It might be supposed that, at altitudes of 16,000 to 20,000 feet, in a region covered with ice and snow, where the temperature in the shade rarely exceeds 55° Fahr. at noon, and at night always falls as low as 20° Fahr., and sometimes to the neighbourhood of zero, one would not suffer from heat. The reverse is, however, the case. On clear and partially cloudy days, as soon as the sun appears above the mountains, the heat of its rays becomes quite sensible, and after nine o'clock one feels as if one were in a fiery furnace. The more snow there is—at these altitudes everything except perpendicular rock faces is usually covered with snow—and the fresher and whiter it is, the greater the heat. The reflected heat is as hard, if not harder, to bear than the direct heat of the sun, and shielding one's self from the direct rays of the latter affords no relief so long as one is exposed to the reflection from the snow. By noon, with new snow, the heat becomes intolerable, and together with the altitude causes headache and lassitude.

The effects of the reflected heat on the skin of Europeans are more severe than I have ever seen at sea-level or at low altitudes. The hands and face are soon burned to a deep copper red. The skin of the face becomes swelled, vesicated, and even blistered. The lips likewise swell, and become covered with exceedingly painful herpetic eruptions, which require a month to heal. In fact, one becomes so disfigured that one's best friends would not recognize one. The submaxillary glands enlarge and become tender in sympathy with the facial inflammation. The pain, especially from the lesions of the lips, is referred to the dental nerves, and the explorer often comes to doubt the integrity of teeth with which he has never before had occasion to quarrel. We tried to protect our faces by wearing white muslin masks, but, in spite of apertures for nose and mouth, we found they interfered with respiration to such a degree that they were cast aside as useless. Moreover, they were uncomfortable, the reflected heat burning strongly through them. In any case, to be really effective, the white muslin should have a lining of black or red, which combination has been found in the tropics to afford the best protection against the sun's heat.

As a comparison with the effect of heat on the skin in the Indian plain, I may state that in the course of our extensive cycle journey of 14,000 miles in India, Mrs. Fanny Bullock Workman and myself were exposed day after day for weeks together from morning till night to the full blaze of the Indian sun, in shade temperatures reaching above 100° Fahr., with no protection to our faces except a sola topi, and our faces were never burned so as to be in any degree painful.

The lighter the complexion the more one suffers from the reflected heat. The darker-skinned coolies and servants with us were not affected at all, whilst some with blue eyes, brown hair, and moderately dark skin showed slight reddening of nose and cheeks, but nothing more. The Europeans of the party shed the cuticle of their faces every three or four days. This suggests that the application of burnt cork to the face might prove an efficient protection. We tried this for one day, after our faces had been painfully burned, and thought the skin felt cooler for it; but the disadvantages of this preventive, in the absence of water to wash it off with, were such that we did not repeat it.

The actual temperature of the sun's rays may be judged from the following figures. The maximum temperature taken with the black-bulb solar thermometer on the only ten available clear days between July 18 and August 17, 1903, at altitudes from 14,067 to 18,811 feet, ranged from 183° to 204° Fahr., the corresponding shade temperatures ranging from 47° to 60° Fahr. The average of these ten observations gives 190·75° Fahr. in the sun and 56·4° Fahr. in the shade.

Compare these with the highest sun and shade temperatures recorded during the summer of 1903 at two stations not much above sea-level in the plains. The figures were kindly given me by Sir John Eliot, M.A., F.R.S., K.C.S.I., Meteorological Reporter to the Government of India and Director-General of Indian Observatories. At Alipore, near Calcutta, the highest sun temperature was 161·9° Fahr. on May 22, the shade temperature being 106·2° Fahr. At Lahore the highest sun temperature was 172·6 Fahr. on May 31, the shade being 113° Fahr. The highest recorded sun temperature at these two representative stations in the plains was therefore 10·4° lower than the lowest maximum above 14,000 feet, and 31·6° lower than the highest.

The obvious deduction from these figures, and also from the physiological effects stated above, borne out by other observations, which want of time forbids me to cite here, is, that the higher the altitude and the thinner the air, the greater the energy with which the sun's rays strike the earth. The sudden change from great heat by day to severe frost at night is undoubtedly an important factor in the rapid disintegration which is taking place in the exposed rocks of these high Asiatic mountains. Nearly all the surface rocks of the mountains I have climbed in Baltistan have been found rotten and crumbling, the constituents of the sandstones and quartzites in particular having often so lost their cohesion that they could be rubbed to sand between the fingers.

The temperature of 204° Fahr. was registered at an altitude of 17,322 feet, the shade temperature being 56° Fahr. I do not consider this temperature abnormally high. The same figure was recorded at about the same altitude in 1902. It will be noticed that our maxima were obtained the latter half of July and the first half of August, at a time when the sun's rays had passed their greatest power, and that the much lower maxima at Alipore and Lahore were actually the highest records of the whole summer. On June 14, 1903, the sun temperature at Shigar, at an altitude of about 8500 feet, was 206° Fahr. I have no doubt that, had the weather been more favourable, so that observations could have been taken at high altitudes in June and early in July, still higher readings would have been obtained. The thermometer used was compared and found to correspond with the most reliable one at the Government station at Lahore.

The tree-growth in the Chogo Lungma valley is scanty, consisting chiefly of willows and cedars, and these are found only on the north or left side. Willows cease at a height of about 11,600 feet, while cedars are scattered over the mountain slopes to about 12,800 feet. We found, cut up, and used for fuel many cedar trunks which had lain prostrate for an unknown period, larger than those of most of the trees now growing. The coolies, when not otherwise employed, were kept busy in transporting the fuel so obtained to our base camp above tree-growth.

Besides trees there is a species of bush, the name of which I do not know, which is found to a height of 14,400 feet, though stunted above 13,000 feet. This at its best attains a height of 10 to 12 feet. Its wood is hard, and it makes a much better fuel than the willows and cedars. Grass and some Alpine flora are found to about 15,000 feet in favoured spots. Above this is the domain of rock and ice.

Let us assume the snow-line to be at the altitude where the ordinary winter accumulation of snow remains on the ground at all seasons of the year. The determination of this line is difficult in a region like that around the Chogo Lungma, split up into irregular, ragged, towering peaks and deep, tortuous valleys. Many of the mountains far above the snow-line have such sharp slants and perpendicular faces that snow will not lodge on them, and these remain bare of snow at all times, while snow accumulates in their ravines at comparatively low altitudes to such an extent, that the heat of half a dozen summers would not melt it.

Snow-beds of this character are not unfrequently seen lying exposed to the sun throughout the summer as low as 12,000 feet. Glaciers, deep snow-beds, and perpendicular rock faces have to be eliminated from the problem, and the solution sought on even regular slopes, where the depth of snow represents the average snowfall. Such slopes near the snow-line are not easily found on the Chogo Lungma. But even with such the snow-line varies with the exposure, being higher on southern than on northern slopes, and it also varies with the season, being considerably lower after severe winters with great snowfall and in cold stormy summers, when snow covers the hills during every storm to points far below the actual snow-line. The snow-line is usually highest in this region about the end of August.

In August, 1902, in ascending the south side of a mountain 17,814 feet high, with a broad snow-capped top, we first encountered snow at 17,400 feet. The north side of this mountain was covered with snow as low as 16,000 feet. On another peak not far from the Chogo Lungma of 17,600 feet, we found in July no snow except in small patches till the top was reached, and then only on the north slope, where it extended downward in a large snow-field. In July, 1903, both these peaks were snow-covered on their south sides for a long distance below their summits. The snow-line must therefore be considered indeterminate, and may be said to vary from 16,000 to nearly 18,000 feet according to season and exposure.

Measurements were made by Mr. Hewett at two stations to determine the movement of the glacier. The first station was on the north bank 15 miles above the termination of the glacier. The movement in twenty-four hours—

At a point	1583	feet from the station	was found	to be	1·59	feet.
"	1902	"	"	"	3·16	"
"	2828	"	"	"	2·40	"
"	4084	"	"	"	3·29	"
"	5021	"	"	"	2·45	"
"	5094	"	"	"	3·08	"

The second station was on the south bank 3 miles higher, just below the entrance of the Haramosh glacier. The movement here in twenty-four hours—

At a point	1302	feet from the station	was found	to be	1·40	feet
"	1502	"	"	"	1·83	"
"	3140	"	"	"	2·42	"
"	3305	"	"	"	2·69	"

These observations are not carried sufficiently far to permit of any extended deductions being made from them. They appear to show that at certain points on two lines running transversely across the glacier, the ice was moving at different rates, varying from 580 to 1200 feet per annum, which indicated the existence of different ice-currents moving at different speeds. How far the speed observed for a given point would be preserved is uncertain. Could the same points be identified farther up or down the glacier, probably their rates of movement, both actual and relative, would be found quite different from those observed.

The first set of figures are so irregular among themselves, that no conclusion as to the movement of the glacier as a whole can be drawn from them. It is possible that the lateral pressure of the Haramosh glacier, which even here must be considerable, together with that from other branches, might cause the ice-currents of the left half of the glacier to move among themselves with the velocities indicated; but this is mere supposition.

On the contrary, the points on the second or upper line have an increasing rate of movement from the station towards the centre of the glacier, showing that they were moving on the radius of a curve,

FIG. 11.—SNOW-CAPPED SÉRAC OF BLACK ICE NEAR EDGE OF GLACIER. STEEP MOUNTAIN-SIDE IN BACKGROUND, ON WHICH PATH MAY BE SEEN. ON ONE EXPEDITION WE GOT UPON THE GLACIER BY THREADING THE SÉRAC LABYRINTH JUST ABOVE THIS, BUT, ON OUR RETURN FOUR DAYS LATER, FOUND OUR BRIDGES WRECKED BY MOVEMENTS OF GLACIER, AND HAD TO FIND A NEW PATH, THROUGH SÉRACS LIKE THOSE HERE SEEN BELOW IT.

FIG. 12.—ON PEAK OF 17,814 FEET ASCENDED IN 1902. RISING FROM THE SAME RIDGE MASSIF AT DISTANCE OF SEVERAL MILES ARE TWO PEAKS OF 21,500 FEET, NAMED MOUNT CHOGO, 22,568 FEET, NAMED MOUNT LUNGMA, ASCENDED IN AUGUST, 1903, AND A PEAK OF OVER 24,500 FEET, ASCENDED TO A HEIGHT OF 23,394 FEET.

which represents just what was happening, the station being situated where the Haramosh glacier sweeps around in a great curve to force itself in on the right of the Chogo Lungma.

The opinion has often been expressed of late years that mountain sickness may be largely or wholly avoided by a gradual approach to high altitudes, so as to permit the system to become accustomed to diminished pressure and oxygen. Without discussing this opinion at length, I would cite a few facts bearing on it, which came under my notice during our expeditions in this region.

I have climbed in the Himalayas with eight other Europeans—nine in all. Of these, seven have reached altitudes of 21,000 feet, five an altitude of over 22,500 feet, and three that of practically 23,400 feet. No one of the nine, so far as I know, ever suffered from mountain sickness. We have ascended comparatively rapidly, usually reaching heights of 17,000 to 18,000 feet within a month after leaving sea-level. Much of our work above that height has been done within six weeks, and our highest at two months and a half.

In crossing the Skoro La in 1899, we took with us thirty-five coolies, who had lived all their lives at an altitude of about 8500 feet, and most of whom had crossed the 17,000-feet Skoro La to Askole more than once. The first day they made a light march of only three hours. The second day, at an altitude of about 15,500 feet, half of them were so prostrated by mountain sickness that we were obliged to encamp on a steep and exposed mountain-side.

In 1902, while ascending the Chogo Lungma, my instrument coolie, who had always lived in Arandu, 9500 feet, became very ill at 12,500 feet, and continued so for two days, after which he recovered and went with us to 19,000 feet without further trouble. The following year, after staying idle at our base camp at 14,000 feet for two weeks, he became severely ill again at 15,500 feet.

In 1903, out of twenty-two coolies from villages at altitudes of 9000 to 9500 feet, who were in excellent condition, having lived a life of ease for a month at our 14,000-foot base camp, during which time they had all put on flesh from the consumption of double the rations they would have used had they been obliged to furnish their own provisions, eight became so ill at 19,600 feet, that they lay like logs on the snow, oblivious to all attempts short of actual violence to induce them to move.

Whatever may be the effect of a prolonged sojourn at high altitudes as a modifier or preventive of mountain sickness, it is certain that a large proportion of our coolies, who had a lifelong advantage over us of 8500 to 9500 feet, besides that of being on their native ground, suffered severely from this affection, while the nine Europeans escaped entirely.

It seems to be the case with mountain sickness as with sea sickness, the symptoms of which two maladies are practically identical, though the causes differ, (1) that some persons are immune to it at any altitudes that have been reached and under all circumstances; (2) that others are affected at given altitudes on some occasions and not on others, according to the amount of fatigue undergone and the condition of their bodily health; (3) that still others always suffer at certain elevations, just as some persons always become sea-sick on moderately rough water. How far the last two classes may be benefited by a prolonged sojourn at high altitude can only be determined by further experience.

The weather in this region, from the middle of June to the last week in August, is extremely uncertain. The monsoon makes its influence felt with prevailing winds from the south and west and a large number of stormy days. During the summer of 1902, there were rarely more than two clear days in succession, and only on one occasion did the number amount to four.

In 1903, with one interval of three fine days early in July, and five from August 8 to 12, there were only a few days when it was not stormy or the sky covered with heavy clouds. Much good work can be done on glaciers up to 17,000 feet in spite of unfavourable weather conditions; but it is not safe to attempt high-mountain climbing, where snow-camps must be made and several successive clear days are an absolute necessity.

In both seasons the weather became fine the last week in August, and continued so till September 12. So far as the weather is concerned, this seems to be the best time for high-snow exploration, but the disadvantage of short days and long nights, with increased cold, has to be incurred.

Exploring in these high regions is extremely fascinating, involving conditions not met with lower down. Were the available transport means, now so uncertain and unsatisfactory, at all adequate to the work in hand, many interesting questions connected with nature at high altitudes might be thoroughly investigated, which, as matters now stand, can only occasionally be touched upon.

In closing, I show a telephotograph of one of the most beautiful and striking of the Chogo Lungma peaks. We parted with the glacier and its mountains with regret after two seasons of most interesting association, during which we had studied them in their different moods, feeling that bonds of friendship with them were being severed which had been cemented by the vicissitudes of sunshine and storm.

NOTE.—In the autumn of 1903, after reports of our Baltistan expedition reached Europe, Major Max Schlagintweit published a statement in the *Mitteilungen*, that his brother, Adolf Schlagintweit, was the first to explore the Chogo Lungma region in 1856, and referred to vol. i. of the travels of the brothers Schlagintweit in support of this contention.

A careful examination of the books by the brothers Schlagintweit in the Library of the Royal Geographical Society in London and in the Royal Library in Munich, as well as in that of the D. O. A. V. in Munich, including the work mentioned, fails to discover any mention whatever of the Chogo Lungma glacier or even of Arandu at its termination. Further, neither the Chogo Lungma nor Arandu is indicated on the elaborate maps which accompany the large work of the brothers Schlagintweit. Had Adolf Schlagintweit visited even the termination of so important a glacier as the Chogo Lungma, he certainly would not have failed to mention it in his writings and show it on his maps.

Before the reading of the paper, the PRESIDENT said: I have now great pleasure in introducing to the meeting our friend Dr. Hunter Workman, who will give us an interesting account of the exploration of some of the Himalayan glaciers.

After the reading of the paper, the PRESIDENT said: There are many things in Dr. Workman's interesting paper which might lead to discussion, and we have present with us this evening a most distinguished member of the old Indian Survey, whom I regret to say now seldom favours us with his presence, Colonel Godwin Austen, who is, I believe, the only surviving member of what I consider to be one of the most brilliant and accurate geographical pieces of work that ever was performed, namely, the Kashmir Survey. I hope Colonel Godwin Austen will now address us on the subject of Dr. Workman's paper.

Lieut.-Colonel GODWIN AUSTEN: It is almost superfluous for me to say how very much I have enjoyed looking at the beautiful series of photographs which Dr. Hunter Workman has shown us this evening. I have no doubt you have enjoyed looking at these photographs of Alpine scenery, to me it has even been a greater pleasure, because in the years 1860 and 1861 I was surveying these magnificent mountains. No one can imagine the magnificence of that scenery. I have had the privilege of reading Dr. Workman's paper. Early in his discourse he mentions the Indus valley and the wonderful effects of water-action and erosion on the hills on either side. That is perfectly true. The portion of the Indus valley, from the junction of the Dras river down to Skardo, is a wonderful gorge. You see there the action of former glaciation and beds of gravel and sand at an enormous height above the present level of the rivers; in fact, the glacial scenery you have been looking at this evening is only the remnant of the great glaciers that once filled those valleys. One of the pictures that you saw on the screen was the rock of Skardo that stands up in the middle of the valley. My work took me to visit the trigonometrical station at the top of that rock. There is an enormous transported block which has been left lying on the summit of that hill, and you have only to look round the sides of the valley of Skardo to see the enormous accumulation of gravel and sand that once filled the valley. The fact is that the history of the Indus valley has never been written. It goes back long into Tertiary times, and it has not only been excavated, but it has been filled up high with detritus, which has all been swept clean out of it again, and you only see now the remains of forces that were once in action. Perhaps one of the most interesting points is the end of the Arandu glacier. It is evident, from the photographs shown us this evening, and from Dr. Workman's description of it, that it has very much changed in the forty years since I was there. I have brought up with me a water-colour sketch of the end of the glacier, which I made in the year 1861. It shows quite a different outline from what it is at present. Again, the north bank of the glacier all the way up shows it has receded very much from the side of the mountain from what it was in 1861. At that time it abutted against the mountain-sides the whole way down, cutting off the drainage of the side valleys and formed a series of small lakes, all of which have disappeared since that time. The Arandu glacier, which we have heard about this evening, was first visited by Mr. G. T. Vigne in the year 1835. He was the first Englishman who ever went into Baltistan, and he was the first to give an account of the large size and form seen from Arundo, but he never went up the glacier. He was followed by one or two others—I think Dr. Thompson was one—but they never went up the glacier any distance. The main trunk is pretty well known. I followed it up for about 22 to 25 miles, not in direct line. Frederick Drew, about three years after I was there, got, perhaps, a little further than I did, because he crossed to the centre. I did not go across the glacier, but made the attempt where the principal tributaries join; however, the glacier was terribly fissured, and I made such slow progress that I saw there was no hope of doing anything. I had a great deal of survey work to finish elsewhere, and I came back. It has remained for Dr. and Mrs. Workman's party to explore the recesses of this great glacier. It was very brave for Mrs. Bullock Workman to face all the discomforts of heat and cold and snow and exposure which work of that sort entails, and I am only glad to find there are travellers who will spend their time so admirably and so beneficially for us who live at home, and for all who are interested in great physical features — who spend their time on work of that sort, and come back with such beautiful photographs as we have seen to-night. I might say a great deal more about what you have seen this evening, but there is one thing I should like to mention. I think the word "la," at the end of the name of the Rajah of Kashmir (Pratap Singh La) is not correct, and also in the case of the Amar Singh La, because the term "la," which is in general use throughout the whole of Tibet, from Baltistan to Lhasa and Bhutan, means a pass that is used for traffic, the highest portion of a road over a water-parting, and therefore I think it better to call depressions which are not used for traffic "colls," which is a more correct term than the word "la." I will not say anything further, except to again express my pleasure at seeing the photographs which we have had put before us this evening.

Colonel Wahab: Personally I feel that we Indian surveyors, whose work takes us to the higher Himalayas, ought to be able to do more than we have hitherto done to extend our knowledge of glacial phenomena in those regions. Since the days of the Kashmir survey, however, when triangulation was being extended over the north-western Himalaya, very few officers have had the necessary opportunities—for although surveys have been pushed up to the snows on the Sikkim, Kumaon, and Punjab borders in recent years, nothing beyond reconnaissance work on small scales has been attempted in the remoter regions; the occasional political missions, also, which have crossed the high ranges, have not given time for any adequate mapping on scales large enough to illustrate the glaciation of the country.

Detailed surveys of the higher Himalaya have, in fact, never been regarded as within the scope of the Indian survey, nor, while so much work of importance elsewhere remains undone, is it to be expected that they should. For this reason, while we as Indian surveyors regret that we cannot ourselves take up work of such interest, we welcome travellers like Dr. and Mrs. Bullock Workman, who are prepared to place their experience and resources at the disposal of science, and to undertake what a utilitarian Government naturally does not feel justified in attempting. What is required to illustrate glacial phenomena is an accurate examination of a definite area, such as that of the Chogo Lungma and its tributary glaciers, so graphically described in Dr. Workman's lecture, and a careful re-examination of the area after a few years, so as to determine from actual observation the movement and variation of the glacier. Refined measurements, such as those periodically made on the Rhône glacier, would probably be impracticable at such a distance from civilization; but in a region where glacial phenomena are on so vast a scale as in the Himalaya, rougher methods would no doubt give valuable results.

It is to be hoped that the interest aroused in Himalayan exploration by the journeys of Mr. Douglas Freshfield and Dr. and Mrs. Workman will induce others to follow in their footsteps, and thus add a higher and more scientific value to their journeys and those of their predecessors.

The PRESIDENT: Mr. Freshfield is unable to attend here, but he has written a letter containing some interesting remarks which I am afraid there is hardly time to read at this late hour of the evening, but which will be printed with the paper. So it now only remains for us to pass a very cordial vote of thanks to Dr. Workman for his most interesting paper, and for the entertaining and beautiful views which he has been so kind as to put on the screen for us.

Mr. DOUGLAS W. FRESHFIELD sends the following:—

I very much regret I have been prevented to-night from listening to Dr. Hunter Workman's paper. I have studied it with great interest and sincere admiration, not only of the pluck and perseverance of Dr. Workman as a mountaineer, but also of the powers of scientific observation and graphic description shown by him as an author.

There are several points I should like to have commented on, which I will briefly mention here—

(1) With regard to water-erosion and the pot-holes found high on the mountain sides. Is it possible that these were formed when the slopes were more extensively buried in glaciers by subglacial torrents? These, as we all know, are peculiarly active in the formation of pot-holes, a pot-hole being almost the necessary complement of the *moulin* (or shaft), through which the torrent falls from the surface to the bed of the glacier.

(2) The fact that of two glaciers of which the lower ends are closely adjacent, one should be advancing and the other in retreat, is, as I pointed out at Cambridge, not so surprising as it may appear at first sight. The interval between the date when an increase of material is poured into the reservoir of a glacier and that of the corresponding advance of its snout is regulated by a variety of conditions, of which the chief are the length of the ice-stream, its bulk, and the angle of its bed. To put it in the simplest form of words, short and steep glaciers answer to an increase in their food supply more quickly than long and comparatively level glaciers.

(3) The absence or rarity of great terminal moraines may, I think, best be accounted for by the action of floods in carrying away all but the heaviest blocks.

(4) In general features, the glacier described corresponds to those under Kangchenjunga; in both cases the lowest portion is, as described by Dr. Workman, a desert of torn and splintered rocks. The first surveyors imagined the lowest 5 miles of the Zemu glacier to be moraine, and called it so on their map.

With regard to one of the chief obstacles to Himalayan exploration, the effects of high altitudes on the human frame, I welcome in Dr. Workman's narrative the confirmation by a medical expert of my own experiences. Immunity from mountain sickness, I agree, is not to be obtained by training—by living above 10,000 feet for a period. I have rather found the reverse to be the case; mountain-sickness is very much like sea-sickness: good sailors and mountaineers are more often born than made; that is, the immunity is mainly constitutional.

Again, the discomforts all, or almost all, climbers suffer from are not progressive from 12,000 feet upwards. On the contrary, in many instances they diminish above 15,000 feet.

A few years ago it was argued by very competent Alpine climbers that it was *a priori* impossible for men to climb, at any rate do more than crawl, at 22,000 to 24,000 feet. That argument can no longer be maintained.

Avalanches are a danger which it is, I hold, the duty of every climber who has been in these regions to insist on. They are on a scale wholly different from those of the Alps, and Alpine experience is at first likely to be misleading. Mr. Mummery's fate supplies the most emphatic warning on this point.

A minor but very serious trouble is the inflammation of the lips, mentioned by Dr. Workman. It becomes torture to eat, and men cannot climb without eating. Perhaps Dr. Workman may be able to suggest a palliative. I found boracic ointment useful.

The greatest difficulties in the way of climbers in the Himalaya are weather and transport.

As to weather, I can only suggest that some year luck may reward patience, and a climbing party get the ten consecutive fine midsummer days needed for an assault on a great peak. They must wait on the spot to profit by them.

As to transport, I see little hope until the Indian Government co-operates with an attempt to climb K² or Kangchenjunga, as the Home Government has co-operated with Arctic expeditions; until it puts fifty militarily trained and disciplined mountaineers at an explorer's disposal. Without this help a money grant would be little use; with it a relatively small sum, £1000 or £2000, might accomplish that desirable end—the conquest of the highest mountain in the world. We have heard lately a great deal of the moral qualities called out by polar exploration. I venture to think they are also called out to a great extent in mountaineering at high altitudes. There is surely some reason in the rhyme of the poet—it is true he was a mad poet—Blake—

> "Great things are done when men and mountains meet;
> These are not done by jostling in the street."

BATHYMETRICAL SURVEY OF THE FRESH-WATER LOCHS OF SCOTLAND.*

Under the Direction of Sir JOHN MURRAY, K.C.B., F.R.S., D.Sc., etc., and LAURENCE PULLAR, F.R.S.E.

PART VII.—LOCHS OF THE SHIEL DISTRICT.

IN this paper it is proposed to deal with the results of the work of the Lake Survey among the lochs lying near the borders of Argyllshire and Inverness-shire, viz. (1) Lochs Shiel and Dilate, which drain by the river Shiel into Loch Moidart; (2) Loch Eilt, which flows by the river Ailort into Loch Ailort; and (3) Lochs Màma, na Creige Duibhe, and Dubh, which drain into Loch nan Uamh. The relative positions of these lochs are shown in the index map (Fig. 1). The principal loch is Loch Shiel, lying on the boundary-line between Argyll and Inverness, while Loch Dilate lies in Argyllshire, and the other lochs mentioned are situated in Inverness-shire. Mr. Garrett drew up some notes on Lochs Eilt, Dubh, Màma, and na Creige Duibhe before leaving for Borneo, and these have been embodied in this article.

* Plates, p. 352.