the globe. It only shows what can be accomplished with perseverance and first-rate organization. The mountain men apparently subsist entirely upon their plantations; but how they originally reached the district they are now in, unless their antiquity is immense, is a mystery. That they are acquainted with the Tapiro pygmies, discovered by the Mimika Expedition, is clear by the similarity of dress, ornaments, architecture, and weapons of the chase, and still more so by the fact that they can count up to ten—a feat of arithmetic far beyond the powers of the plainsmen. Since the two tribes are so alike in these points, I think we may presume that the women of the Tapiro pygmies, of whom we failed to obtain a glimpse, are in like manner clothed in a girdle of leaves. Their bodily characteristics, however, are so dissimilar that it will not be easy for anthropologists to connect the two, and it raises one more conundrum which scientific men will find it hard to solve. I am glad that Mr. Wollaston has been able to bring forward further evidence of the terrific steepness and immensity of the southern face of the main range, and, in addition, has been able to obtain a telephoto of the precipice to the south of Mount Leonard Darwin. Mr. Wollaston still considers it possible that mountains of even greater altitude lie to the north of Mount Carstensz, and we must all sympathize with him in his disappointment at being baulked of his wish at the last moment; but in my own mind I am more convinced than ever, now that I have seen the photographs and have looked into the strata of the rocks, that the country to the north consists of great parallel ranges, steadily dwindling in altitude and with no peak surpassing Mount Carstensz in height.

PHYSICAL CHARACTERISTICS OF THE SIACHEN BASIN AND GLACIER-SYSTEM.*

By WILLIAM HUNTER WORKMAN, M.A., M.D., F.R.G.S.

THE term "glacier" is not sufficiently comprehensive to designate accurately the immense and, in arrangement, complicated bodies of snow, *névé*, and ice collected in the great rock-basin extending north-west from the source of the Nubra river to Peak 23 (Hidden peak), 78·4 kilom. (49 miles), with an east and west average width for a considerable distance of 32 kilom. (20 miles), and having an area, approximately, of 2400 sq. kilom. (over 900 square miles).

The basin is crossed in various directions by many glaciers of the first order and innumerable lesser ones, fed by snow precipitated upon the mountains and slopes of its watershed, all converging on a great central trunk averaging 4 kilom. (2·5 miles) in width, that stretches the length of the basin in a north-west by south-east direction and discharges from its tongue water derived from the snow collected in all parts of this extensive region to give birth to the Nubra river. This central trunk with its multitude of affluents resembling a river-system is more fittingly styled the Siachen glacier-system. The four other great Karakoram glaciers, as well as many smaller but by no means insignificant ones, are fashioned on the

* Royal Geographical Society, November 24, 1913. Map, p. 232. Read after the paper on the same date by Mrs. Bullock Workman. For discussion, see p. 142.

same plan. This type is peculiar to the Karakoram, being conditioned on the configuration of its valleys and the arrangement of its peaks. For this reason, as well as on account of certain structural features referable to existing conditions, all these glaciers merit the designation of glacier-systems or glaciers of the Karakoram type.

The Siachen basin is separated by its enclosing walls, on the east, from an unexplored region containing the Remo basin, with which the Siachen probably communicates by an ice-covered pass, possibly two, leading from the head of the Tarim Shehr affluent, and further north a group of snow mountains discovered by us from the east Siachen head that give rise to a large glacier, apparently the Urdok, running north-west into Chinese Turkestan; at the north end, from a glacier-basin leading north-east from the Gasherbrum massif; and on the west from the Baltoro, Kabery (Kondus), Sher-pi-gang, Dong Dong, Bilaphond, and Chumik basins, with glacier-passes connecting with the Bilaphond and Kabery, the last first discovered and crossed by our expedition in 1912.

The enclosing barriers of the Siachen consist of granite, gneiss, crystalline schists, slates and shales, sandstones, amorphous and crystalline limestones, and conglomerates, with some igneous intrusions. These rocks alternate with one another at short intervals, and are in places intimately intermingled and interfolded. They are extensively foliated, friable, and easily disintegrated by frost and weathering. Even the granites, largely of the biotite variety, are divided into small sections by joints crossing one another, and intersected by bands of quartz, feldspar, schists, and shales, in consequence of which they split up easily into fragments. The physical condition of the gneiss and crystalline schists would suggest to the ordinary observer that they were formed largely by metamorphosis of sedimentary deposits. But whether this be the fact, or whether it be that they originated as primary granites and were afterwards metamorphosed by folding, they are brittle, and present in the one case an immature appearance as if incompletely developed, or in the other a decadent one, as if the original structure had been overwrought and disorganized by strain and violence in the upheaval of the great ranges of which they form constituents.

This fragile condition of the rocks accounts for the irregular, jagged outlines of the mountains of the region, especially of the granite peaks, many of which are greatly serrated, and for the vast detritus-deposits that load the glaciers and play an important rôle in the development of their structural features. Owing to the amount of snow covering the mountains and the staining and weathering of the visible rock-surfaces, it is often difficult, even from a short distance, to distinguish the character of the rocks composing a mountain, so that the observer, particularly if he is not a trained geologist, may well be in doubt as to what formation lies before him. The shales and slates, the latter largely of very dark colour, are the most easily distinguished.

The north-east wall of the Siachen trunk resembles in structure and extent that which, with an unbroken length of 63 kilom. (39 miles), forms the upper portions of the southern Hispar and western Biafo barriers.* Starting at the north-east head, it extends west 4·8 kilom. (3 miles), then turns south-east and continues on 22 kilom. (14 miles) to the Tarim Shehr affluent. Here it turns east and forms the north wall of the Tarim Shehr for 27 kilom. (17 miles) to its sources, making a continuous, unbroken wall 53 kilom. (33 miles) long. The upper 20 kilom. (12 miles) of this wall is, and the remainder appears to be, a part of the main watershed between Turkestan and the Indus, and as such it probably continues on from the head of Tarim Shehr tributary to the Karakoram pass.

A second portion continuing around as the south wall of the Tarim Shehr glacier and extending west to the Tarim Shehr promontory there turns south-east and forms the remaining portion of the north-east wall of the trunk to its end, having a length of 53 kilom. (33 miles). Stated in another way, the north-east Siachen wall stretches from the north head of the trunk south-east in a nearly straight line for some 72 kilom. (45 miles), being pierced only by one small and two large affluents.

The south-west boundary of the upper half of the trunk can scarcely be called a wall. It consists of numerous mountains of irregular outlines, scattered about in an irregular manner, enclosing vast reservoirs of snow and ice that communicate with the main glacier by large secondary glaciers, the whole forming an ice-bound labyrinth that defies description. Still, the mountains and affluents stand in such relation to the main glacier that lines drawn from one headland to another suffice to mark the limits of its bed with sufficient accuracy. From the Peak 36 tributary to the tongue, a fairly continuous wall exists which is pierced by several large affluents.

The structure of these walls may be stated in general terms as follows †: The mountains enclosing the Indira Col and the north-east col, at the northern extremity, are composed of slates and shales, light and dark in colour with, possibly, some limestones. Thence down the north-east wall to within about 6 kilom. (4 miles) of the Tarim Shehr opening mostly of light coloured limestones and shales with some conglomerates and at least one igneous intrusion. The limestones are strongly in evidence in the moraines fed by this section. The rocks are soft and the peaks and ridges broken and jagged in outline. From a point shortly north-west of Teram Kangri, the wall and its peaks, including that summit, quite to their tops, forming the north barrier of Tarim Shehr glacier to its end, appear to be almost wholly made up of black slate with here and there foothills of lighter-coloured shale or limestone.

* Vide *Geographical Journal*, February, 1910, p. 117.

† It is obvious that not more than a general outline of rock distribution could be obtained amid the exigencies of an expedition of limited duration, with opportunities for investigation restricted by snow and weather-conditions, in an unexplored region of such character and extent as the Siachen basin, where one can come into actual contact with the rocks *in situ* at comparatively few points.

The same is true of the visible rocks on the south side of Tarim Shehr glacier, though some of the ice-covered peaks at its upper end must contain granite and gneiss, as much *débris* of this character appears in the moraines of that side. On the extremity of Tarim Shehr promontory, most of which is composed of brown shale, granite crops out over a considerable area. Thence, beginning with Junction mountain, 6353 metres (20,840 feet), rising above the promontory, ascended by us in 1911, down to the great bend, some 25 kilom. (16 miles), the mountains are of dark brown and black slate with occasional sections of lighter colour broken into jagged points and cleft by deep, ragged ravines. The only granite noticed *in situ* in the whole length of this wall was at Tarim Shehr promontory.

From our camps on moraines opposite this wall, the view toward it was most forbidding. The foreground was occupied by the huge black hillock-moraine coming from the Tarim Shehr affluent, the towering hillocks of which, resembling vast heaps of coal piled up at random in a Cyclopean coalyard, shut out from sight the white ice of the glacier beyond, while the background was formed by the succession of black peaks hard in outline and destitute of grace, rendered more desolate by contrast with the snow capping their tops, the whole constituting as sombre and depressing a landscape as could well be imagined, far eclipsing the most fantastic conceptions of Boecklin and casting an uncanny shadow over the soul.

On the south-west side of the trunk a similar variety of formation occurs, but granite is more and limestone less in evidence. The last three peaks of the King George V. group ending the massive mountain-tongue, interposed between the heads of the Baltoro and Siachen glaciers, which form 11 kilom. (7 miles) of the upper south-west Siachen wall, appear to be mainly composed of granite and gneiss, though on an eastern spur and near its south-east extremity the granite passes over suddenly without discontinuity of outline into black slate.

South of this tongue at the entrance of the upper western tributary into the Siachen, the Hawk, a graceful pointed spire of granite, soars from a circle of black slate peaks and ridges to an altitude of 6768 metres (22,200 feet). From this peak downward for 35 kilom. (22 miles) to the great bend, the south-west wall is largely, if not wholly, composed of sedimentary rocks, prominent among which are black slates. Just at the bend, two elevations, the ends of spurs descending from Peak 8, have the appearance of granite. The greater part of the south-west wall, as we observed it, does not, therefore, conform to the granite structure assigned to it by Dr. Longstaff.

Sixteen kilometres (10 miles) west of the trunk the impressive granite massif of the twin Peaks 35 and 36, 7743 and 7707 metres (25,400 and 25,280 feet) overtopping all mountains of the region south of Peak 23 and forming a salient landmark, gives off the large Peak 36 affluent to the Siachen on the east and the Dong Dong glacier on the west. Granite and

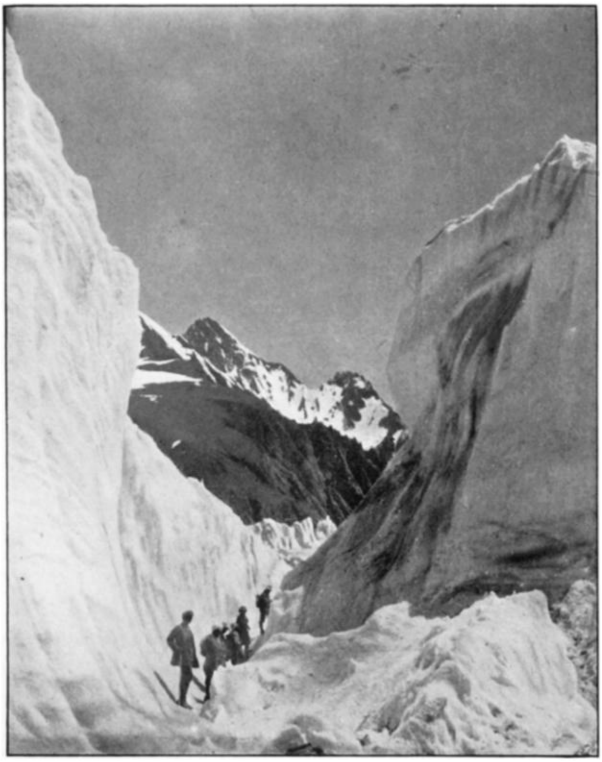

FIG. 3.—TWO GIGANTIC SERACS AND PASSAGE BETWEEN THEM ON SIACHEN. LARGE AREA OF SIACHEN SURFACE AT AND BELOW TARIM SHEHR JUNCTION BROKEN UP BY PRESSURE IN THIS MANNER.

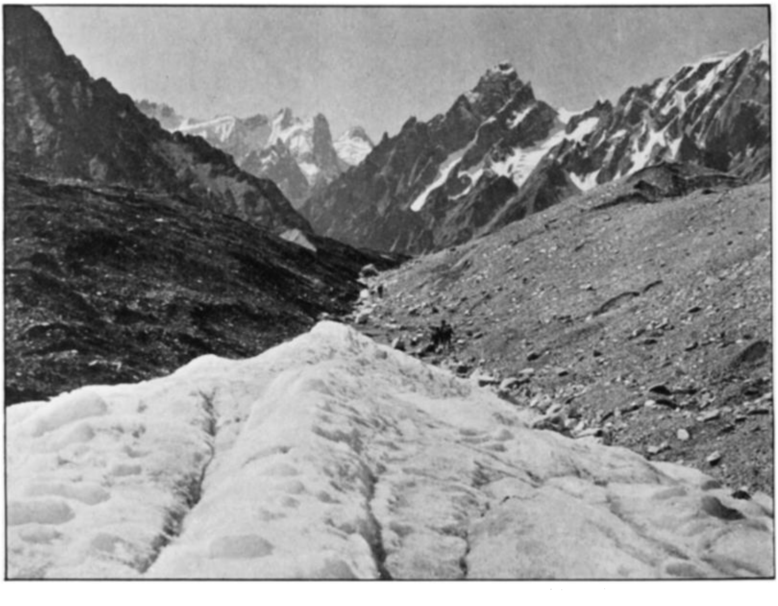

FIG. 4.—CONVERGING BLACK AND GREY MORAINE STREAMS COMING TOGETHER AND STRANGLING IN THEIR GRIP ATTENUATED EXTREMITY OF WHITE STREAM. PROPORTIONS OF LAST DISTORTED BY POSITION OF CAMERA. WIDTH IN FOREGROUND, 10 METRES (32·8 FEET). LENGTH TO APEX, 60 METRES (ABOUT 200 FEET). NOTE THAT MORAINE-STREAMS CONTINUE ON WITHOUT INTERMINGLING.

FIG. 1.—BIRD'S-EYE VIEW OF 48 KILOMETRES (30 MILES) OF TRUNK OF SIACHEN GLACIER, SHOWING WHITE AND MORAINE STREAMS, THE NARROWING OF FORMER AND INCREASE IN SIZE OF LATTER AS THEY DESCEND, AND DEFLECTION OF BOTH BY AFFLUENT PRESSURE. AT LOWER RIGHT-HAND CORNER TARIM SHEHR AFFLUENT ENTERS, TURNING THROUGH ANGLE OF 140° AROUND POINT OF ROCK PROMONTORY, FLANKED BY MARGINAL BLACK SLATE MORAINE, WHICH, BENDING AROUND IN SYMMETRICAL CURVE TOWARDS CENTRE OF SIACHEN, DESCENDS AS MEDIAN MORAINE.

FIG. 2.—SECTION OF BLACK SLATE HILLOCK-MORAINE WHICH, DESCENDING TARIM SHEHR GLACIER AS MARGINAL MORAINE, CONTINUES ON DOWN SIACHEN AS MEDIAN MORAINE, HAVING TOTAL LENGTH OF SOME 50 KILOMETRES (31 MILES). ITS HILLOCKS, SEVERAL ABREAST, RISE 100 TO 150 METRES (328 TO 392 FEET) ABOVE DEPRESSIONS AT THEIR BASES. WIDTH APPROACHES HALF KILOMETRE (ABOUT 1600 FEET).

FIG. 7.—PYRAMIDAL ICE-PINNACLES, LAST REMNANTS OF EXTINCT WHITE STREAM, FORMED BY MELTING AWAY OF SOFTER PARTS OF HIGH ICE-RIDGE CROWDED UP BY PRESSURE, AND CUTTING DOWN THROUGH RIDGE OF THIN DÉBRIS-DEPOSITS HEATED BY SUN. DÉBRIS-COVERED SURFACE AROUND PINNACLES FREE FROM CREVASSES. HEIGHT OF HIGHEST PYRAMIDS 11 METRES (36 FEET).

gneissoid rocks crop out, doubtless, at various other points of the Siachen basin that were not within range of observation. No conglomerates *in situ* were noticed.

Thus it will be seen that, while slates and shales constitute, perhaps, the greater part of the rocks of this region, they have mingled with them a very considerable proportion of limestones and conglomerates appearing in the moraines, and also of granite, gneiss, and crystalline schists. No single formation continues uninterrupted for any great distance. One mountain may be of granite and the next of shale or limestone, or the same mountain may consist of two or more rock-varieties more or less intimately mingled. This composite arrangement, as I have had opportunity to observe in an almost continuous line from the Siachen to Hunza, exists throughout the Karakoram. The opposing walls of its valleys, large and small, both those running east and west and those north and south, are often composed of different varieties of rocks, perhaps granite on one side and shale or other sedimentary rock on the other, or a given wall may vary at different points in the same manner. The various rock-formations not only of the Siachen region, but also everywhere that I have been in the Karakoram, are so distributed and intermingled that it does not appear to me possible to draw any reliable inference from them as to the existence of parallel ranges of dissimilar structure.

In the June, 1910, *Geographical Journal*, p. 646, Dr. Longstaff states that the Duke of the Abruzzi's expedition discovered that "this (Broad peak) and the four Gasherbrums are composed of marbles and conglomerates." He adds, "The massif of Teram Kangri is a continuation of this (Gasherbrum) range; its base appears to consist of schists and slates and its peaks of marbles and calcites." After careful study of the published accounts of the expedition referred to, I have been unable to find any authorization for the statement that Broad peak and "the four Gasherbrums are composed of marbles and conglomerates." In the December, 1910, *Alpine Journal*, p. 344, Dr. de Filippi states that moraines seen on the Baltoro "consist of beautiful polychrome marbles and conglomerates, originating from Hidden peak and the Golden Throne," but this is far from "discovering" that Hidden peak, as a mass, and still less the other three Gasherbrums are composed of such rocks.

As already stated, the last three high mountains of the King George V. group, ending the spur and interposed in direct line between the Gasherbrums and Teram Kangri, appear to consist mainly of granite and gneissoid rocks. We passed directly beneath and camped almost in the shadow of the high vertical precipices of their eastern and southern flanks, of which we had a near view. Also the upper portions of the Gasherbrum peaks, as seen from the high Silver Throne plateau to the south-east, appeared to have the shape and general aspect of granite peaks, though we were not sufficiently near them to distinguish their structure. However this may be, we saw nothing in their appearance to suggest marbles.

Regarding the massif of Teram Kangri, having passed three weeks altogether at various points near and in front of it during late summer, both in 1911 and 1912, when the snow was largely melted away, we had considerable opportunity to study it. As we saw it, it appeared to consist of black slate quite to its top, and no evidence of the existence on it or any of the adjoining peaks of "marbles and calcites" could be detected with a powerful field glass. Further, no calcite or marble was found on moraines the origin of which could be traced to Teram Kangri, which does, however, throw off an immense quantity of black *débris* upon the glacier. Therefore the argument based on similarity of structure in support of the view that the massif of Teram Kangri is a continuation of the Gasherbrum "range," so far as can be judged from our observation, falls to the ground.

The topographical objection to this view is quite as strong, if trend and continuity of elevation are criteria, in determining whether two mountain sections are parts of the same range. The Gasherbrum "range," if the comparatively short south-east spur from which Broad peak, the Gasherbrums, and the three last peaks rise can be called a range, ends abruptly in the icefields of the upper Siachen, and has no connection above the ice with the north-east Siachen wall, of which Teram Kangri forms a point, being separated from it at every part by the whole width of the glacier.

On the contrary, the north-east wall continues on directly over the Indira Col at the north Siachen head into Turkestan, with a precipitous drop of *circa* 2000 metres (6562 feet) at the col, running thence north-east as a line of pointed, ragged, dark, slaty peaks, which form the south-east wall of the Gasherbrum glacier issuing from the Gasherbrum peaks. This wall, taken as a whole, constitutes the eastern barrier of an Oprang-Nubra depression, of which the highest point occurs at the Siachen head on the watershed between the Indus and Turkestan, whence the gradient drops north-east toward the Oprang and south-east to Nubra.

The discussion by Dr. de Filippi in "Karakoram and Western Himalaya" of the structure of Broad peak and the Gasherbrums involves the, geologically, interesting and important question touched upon in the preceding pages of the distribution of rocks in this region. On page 227, he says, "From an examination of the moraines that have their origin in the various mountains, we were able to ascertain that the whole chain of Broad peak and the Gasherbrums, including Hidden peak and the Golden Throne as well, is a sedimentary formation."

Not having seen Broad peak or the western faces of the three northern Gasherbrums, which rise from the spur extending south-east from the north Baltoro wall and ending among the upper reservoirs of the Siachen, I would not venture to assert that Dr. de Filippi's inference regarding their structure is not correct, but analysis of the evidence on which it is based does not appear to me to warrant so positive a statement as he makes.

With due deference to the interesting and able treatment by Ing. Novarese of the material supplied by the expedition, although some of the geographical deductions based on it were shown by our later Siachen expedition to disagree with actual conformation, I would ask geological experts, whether a definite conclusion as to the structure of the great inaccessible peaks far removed from direct inspection forming the central and highest portions of the mountains mentioned could be drawn from moraine material lying at a distance on the Baltoro? Might not the sedimentary *débris* here found originate largely or wholly in the lower, outer buttresses of the massifs, or in the outlying mountains between them and the Baltoro forming the immediate walls of the latter? Because such *débris* existed in moraines extending out from these peripheral elevations, does it follow that granite or gneissoid rocks can be excluded as components of the high central uplifts beyond?

My reasons for asking these questions are the following:—

(1) It is a fact which may be observed almost anywhere in the Karakoram, and nowhere more than in this region, that a mountain may be composed of different varieties of rock, the central portions being, perhaps, of one variety and the peripheral of another or several varieties. This is well illustrated in the very spur in question by Queen Mary peak, Mount Hardinge, and the last peak ending it, which consist, apparently, chiefly of granite and gneiss with outlying sections of black slate; by the marble peak on the Baltoro opposite Broad peak, mentioned by Dr. de Filippi as rising from a mass of black rock in the midst of a granite region; and again a short distance south-east on the Siachen by the sharp, grey granite crest of the Hawk towering above a surrounding mass of black slate mountains.

(2) It is also a fact, which I have noticed in various Karakoram localities, that a large surface-moraine may originate in a rock-shoulder or section intercalated in a formation of wholly different character, so that an opinion based on the *débris* found in the moraine might assign to a large massif a formation entirely foreign to that of its greater part and thus be wide of the truth. Moraine *débris*, as such, demonstrates the existence of given rocks without indicating their location or extent. It can only have a positive value in determining the distribution of those rocks when traced to the sources from which it springs. The sedimentary *débris*, found by Dr. de Filippi on the Baltoro moraines, shows that sedimentary rocks exist in the mountains at the head of the glacier, but it does not indicate their exact location or limits, nor does it exclude the presence in these mountains of other rocks. His account does not make it clear whether these moraines do not contain also granitic *débris*, as would appear probable from Conway's earlier observations. The sources of these moraines seem to have been judged of, chiefly, by their trend towards the bases of certain mountains, but it is evident that the *debris* on them was not and could not be traced to an origin in the central highest peaks far

behind. Further, in the above quotation he includes among the peaks, the structure of which he "ascertained" from examination of these moraines, Gasherbrum II. and III., which, according to the map published with his book as well as those of Sir Martin Conway and the Indian Survey, have no direct connection with the Baltoro, and from which, therefore, no *débris* of any description can reach the Baltoro moraines.

(3) Dr. de Filippi mentions the grey colour of the higher parts of Broad peak and the Gasherbrums as distinctive of limestone. The colour of the three last granite or gneissoid peaks of this spur is also grey. This colour, in the presence of Himalayan weathering, is at least as characteristic of granite as of limestone.

(4) Also the broad strata of Broad peak, cited as distinctive of sedimentary rocks, are very commonly seen in Himalayan granite, gneiss, and crystalline schists. The face of K2 asserted to be a granite massif presents in panorama E. of "K. and W. Himalaya," an appearance very like that of a banded formation.

(5) Likewise the forms of the compact pyramids or obtuse cones with smooth outlines of Peak 23, and the other three Gasherbrums strongly resembling those of granite spires in the Bilaphond, Kabery, and Saltoro regions, suggest granite quite as much as sedimentary formations, as do also the rounded summits of Broad peak as seen in the Sella panoramas. The summits of Broad peak parallel closely in shape those shown of its next northern neighbour, Staircase peak, stated by Dr. de Filippi to be granite, *cf.* panoramas C and G. As granite appears to form the mass of the three south-east peaks of the same spur on the other side, according to Dr. de Filippi's inference Broad peak and the Gasherbrums are a *high sedimentary group* flanked on either side by *lower granite mountains*, the first exception, I believe, reported to the rule enunciated by the Indian Geological Survey that the upper portions of very high Himalayan peaks are of granite. Can this inference as to structure be accepted on the evidence given ?

From these considerations, without expressing a positive opinion, I would suggest as an alternative proposition for investigation by future explorers, particularly geologists, who may have opportunity to examine this region more carefully, that the whole spur heading the Baltoro on the east from Staircase peak, so called, to its termination in the snows of the Siachen consists of a lofty central vertebra of granite and gneissoid rocks flanked on both sides by lower sedimentary slates and limestones, which last form the source of the limestone *débris* found by Dr. de Filippi in the Baltoro moraines and of similar *débris* observed by our expedition in 1912 on the Kabery glacier moraines south of the Golden Throne.

The great altitude of the mountains and ridges surrounding the heads of the Siachen, and spread over the region west of it almost to the extremity of its tongue, ensures the accumulation of enormous quantities of snow upon them and in the labyrinthine recesses between. The whole region for many kilometres back from the main glacier constitutes a great reservoir, that sends forth its icy contents by affluent after affluent to build one large central trunk. The north-east wall, much less ice-clad than the south Hispar wall, contributes a relatively small quantity of ice to the trunk, but the ice-streams from it are loaded with a vast amount of rock-detritus from its crumbling crags, which deposited upon the glacier exercises an important influence on the glacier-economy. Through this wall, about midway between its ends, enters from the east the largest affluent, the Tarim Shehr, contributing to the main glacier ice from a wide eastern area.

The ice thus poured into the main trunk is sufficient to keep it at a maximum volume so as to cover completely the floor of the valley it occupies, leaving no free space between it and the valley-walls. No passage exists by the side of the glacier or over the precipitous valley-walls. The explorer is obliged to find his way over the glacier itself, an undertaking as arduous and dangerous as the ascent of high snow-clad mountains, the nature of which is not appreciated by those unacquainted with Himalayan glaciers. In this respect the Siachen resembles the Kondus system of glaciers, but differs from the Biafo and Chogo Lungma, which do not fill their valleys. These last can be penetrated for long distances by the sides of the glaciers upon lateral moraines or over maidans and slopes covered with grasses and flowers.

A bird's-eye view of the Siachen trunk from Junction mountain above Tarim Shehr, 6353 metres (20,840 feet), shows it to be composed of a number of sharply defined, parallel, longitudinal sections of streams, some consisting of white ice, others covered with moraine material, running side by side for many kilometres, the largest for above 50 (30 miles) without intermingling. These I will distinguish from one another in this paper by the names white and moraine-streams from their surface appearance, and I will also apply the term "white ice" to those parts of the glacier which were comparatively free from detritus without regard to the physical distinction between surface white ice and the blue or black ice of the glacier-body beneath.

These streams, which can be traced upward toward the ultimate sources of the trunk and affluents, are seen to represent the ice-masses contributed by the initial reservoirs compressed and narrowed into ribbon-like bands by the tremendous lateral pressure developed by the crowding of vast bodies of ice coming from different directions into the comparatively small space between the mountain walls occupied by the trunk.

This lateral pressure is increased by the entrance of each successive affluent. Any affluent sufficiently large and powerful to add its own streams to those already existing in the trunk must do so by crowding the trunk out of its path over toward the opposite side of the glacier-bed and by inserting its own streams into the side-space thus created. This yielding of the trunk, which previously to the entrance of the affluent completely filled its bed, is an indication of an increase of lateral pressure proportioned to the size of the affluent, which must result in a further compression and narrowing of the trunk-streams. This is seen in the bird's-eye view to be exactly what happens to the Siachen streams, especially the white streams, which, broad and greatly exceeding the moraine-streams in width in the upper parts of the trunk, gradually become narrowed under lateral pressure until they finally die out and disappear at various distances from their sources.

Pressure is not, however, the only factor involved in this result. Descending to the glacier and crossing it at points above the Tarim Shehr junction, where its surface is fairly smooth, one finds the centres of its white streams in transverse section elevated considerably above their edges, and the streams themselves symmetrically arched or crowned so as to resemble a series of perfectly constructed, metalled, and crowned roadways placed side by side. So high is this crowning that, standing on moraine-ridges in the centre of the trunk, 6 to 10 metres (20 to 33 feet) above the adjoining white ice, I could not see the edges of the glacier on the sides nor, perhaps, halfway to them.

This crowning is connected with the thinning and disappearance of white streams. Its presence indicates that the pressure which diminishes their width also crowds them upward without disorganizing their structure or causing them to mingle with one another, and that, the lateral pressure being applied on both sides, their ice yields most along the central line, which is thus crowded highest. Rapid ablation of the raised portions occurs through melting, which, on this glacier, is very marked in the course of a summer. Ten metres is probably a conservative estimate of its amount. This diminishes the depth and volume of the stream, with the result that it becomes constantly less resistant to pressure and more easily compressed and elevated. The interplay of lateral pressure and ablation, finally, so reduces the size of the stream that it is unable to offer further resistance, and is strangled in the grasp of its more powerful neighbours (moraine-streams), disappearing henceforth from view.*

As the streams become thinner and weaker they are pressed up higher with more abrupt sides, and their tops are broken into superficial séracs, as occurs on the Tarim Shehr and lower portion of the Siachen. Symmetrical crowning here disappears. Crowning can, on the contrary, be traced upward into the reservoirs, where I observed it among the vast snow and ice expanses at altitudes of 6400 metres (21,000 feet). The greater the width and volume of streams and reservoirs the more generally are the effects of pressure diffused throughout the mass and the more gradual are the resulting curves. In the reservoirs, crowning displayed itself in wide elevated ridges sloping gently away to lower levels, orienting

* For a detailed consideration of pressure-effects *vide* "Features of Karakoram Glaciers connected with Pressure," Workman, *Zeitschrift für Gletscherkunde*, Dec., 1913.

at right angles to the direction of pressure. It is easy to understand how here vast masses of snow and ice descending the steep opposite sides of a narrow valley and meeting at the central line would crown upward.

With moraine-streams the case is quite different. They, usually, first appear as small accumulations of *débris* at places where *névé* has melted mostly or wholly away, but they increase in size and height as they move down a glacier, till at length they exceed in volume the white streams between them. Those occupying the glacier-edges constitute latero-median or marginal moraines, but when, after coming in contact with affluents, they are pushed away from the edges toward the centre they become median moraines, affluent streams being interposed between them and the sides of the glacier-bed. They increase in size not only through their mass below the surface, being crowded higher by increasing lateral pressure, but also through union with them of marginal moraines of incoming affluents.

Relatively to the white streams, their visible portion becomes also constantly greater from the fact that, being heavily covered with *débris*, ablation of their substance through melting is reduced to a very small amount, so that they, practically, retain the elevation and bulk they receive through pressure, while the rapid lowering of the surface and diminution in volume of the adjoining white streams through melting expose a still greater extent of their sides and actually add to the difference in height between the two. As a result, the moraine-streams, which at their points of emergence in the upper parts of a glacier may be on a level with the white, soon acquire a decided elevation above them, which, lower down on the glacier, may become as great as 100 metres (328 feet) or over. Further, as the glacier-bed narrows, the moraine-streams under the influence of lateral pressure thus occasioned converge upon one another, occupying the space left vacant by the wasting white streams, till they come together and swallow up the attenuated remnants of the latter.

Where the last white streams finally disappear the orderly arrangement, which up to this point usually characterizes the moraine-streams, may cease, and the latter, crowded directly against one another, may mingle together, becoming converted into a confused mass of elevations and depressions, with which condition of its surface the glacier-tongue moves on to its extinction. The final disappearance of white streams occurs on different glaciers at different distances from the extremity of the tongue. According to my observation, the last white stream of the Chogo Lungma was blotted out at 14·4 kilom. (9 miles), of the Hispar at 16 kilom. (10 miles), of the Kabery, first descended by our expedition in 1912, at 18 kilom. (11·25 miles), of the Biafo at about 5 kilom. (3 miles), whilst on the Siachen the central white stream persisted to within 2·4 kilom. (1·5 miles) of the end of the tongue.

A peculiar feature of the effect of lateral pressure on moraine-streams is that it often presses them up into a series of rounded or angular elevations or hillocks covered with *débris*. These have a size varying according to the pressure and amount of ablation of exposed ice from a few to over 100 metres in height, and once produced they persist for a long time. This subject was mentioned in a paper read by myself before this Society on December 6, 1909, and printed in the *Geographical Journal*, February 10, 1910, *vide* pp. 117, 121.* To moraines exhibiting this formation I have given the name *hillock moraines*. All the above characteristics and others besides are exemplified in the moraine-streams of the Siachen, which are remarkable in size, perfection of structure, and arrangement, and constitute by no means its least interesting feature. Its trunk is banded by numerous streams of this kind, eight to ten at any point below Tarim Shehr, most of which originate in affluents, though some crop out near its centre, and one of the largest springs from the north-east wall. Among these the three largest deserve special mention.

(1) The black hillock-moraine.

This, the most prominent moraine of the glacier, is an enormous hillock-moraine covered with black slate *débris*, coming from the Tarim Shehr affluent. Gathering into its embrace detritus shed off, principally, from the northern black slate barrier, though with some additions from the centre, and transformed well up the glacier into a hillock-moraine, it finally descends along the northern edge of the Tarim Shehr as a marginal moraine, turns with this affluent into the bed of the Siachen trunk, and, crowded by the enormous pressure well over towards the centre of the latter, with the Tarim Shehr white streams between it and the north-east Siachen wall, passes down the Siachen as its largest median moraine almost to its end. Its total length is over 50 kilom. (32 miles).

At its line of first contact with the Siachen, its bulk is increased by the addition of a large, black slate-moraine and a smaller one issuing from gorges at the base of Teram Kangri. Below its junction with the Siachen, its width exceeds half a kilometre, and its hillocks, three and four abreast, reach huge proportions, rising over 100 metres (328 feet) above the depressions at their bases. I saw a number the height of which appeared to be nearly if not quite 150 metres (492 feet). Seen from the ice outside it, this moraine resembles a range of large black hills stretching down the centre of the glacier. Many of its depressions are occupied by lakes. It is the largest moraine I have met with in the Karakoram, and it does not appear likely that its equal can be found anywhere else on a valley glacier.

(2) The great limestone moraine.

Beneath some orange-coloured peaks of the north-east wall, shortly below the extremity of the King George V. ridge, where the *névé* of the north Siachen reservoir disappears in late summer, a mass of small rock-fragments presented itself to view, covering the ice for some distance from the mountain-wall. Part of this is, doubtless, brought down by the ice

* *Vide* also *op. cit.*

FIG. 5.—CAMP AT ABOUT 3800 METRES (16,300 FEET) ON GREY LIMESTONE MORAINE AT BASE OF LIMESTONE BOULDER: SIZE OF BOULDER CAN BE SOMEWHAT ESTIMATED BY COMPARISON WITH TENTS.

FIG. 6.—END OF ROCK-PROMONTORY PROJECTING INTO EDGE OF PEAK 36 GLACIER AT ALTITUDE OF 5366 METRES (17,600 FEET), WITH LAKE AND STEEP CURVING ICE-WALL FORMED BY MELTING OF ICE BY HEAT REFLECTED FROM ROCK-PROMONTORY.

FIG. 8.—LINE OF PRESSURE-SERACS SHARPENED OFF BY MELTING INTO POINTED PINNACLES (SERAC-PENITENTE) ON TARIM SHEHR GLACIER. HIGHEST, 11·5 METRES (36 FEET).

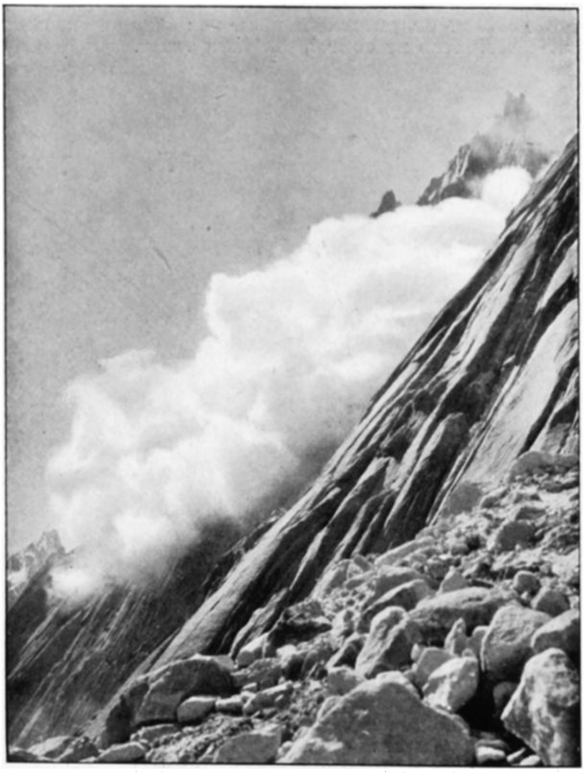

FIG. 9.—CLOUD FROM AVALANCHE FALLING IN COULOIR BETWEEN TWO GRANITE PEAKS ON BILAPHOND GLACIER. BROKEN ROCK-SURFACES HERE SEEN CHARACTERISTIC OF THE GRANITES OF THIS REGION.

from the glacier higher up, and part is derived from the wall directly above. This, as it moves down with the ice, soon takes the form of an elevated moraine, which, under the pressure of the large West Head or first western affluent entering opposite, is converted next the wall into a hillock-moraine and on its glacier-side into a raised moraine-shelf.

Receiving constant accessions of *débris* from small tributaries from the north-east wall, it gradually spreads out from the edge until it attains a width of some 400 metres (·25 mile). This moraine is composed of small fragments of limestones, marbles, and breccias of various colours, some calcite, different-coloured shales, and conglomerates. Granite, if present, is very scantily represented. I find in my notes no mention of any having been noticed in the 43 kilometres (27 miles) we followed its course. Comparatively few *débris*-masses were seen on it worthy of the name of boulders. The general colour of the moraine is grey.

Many limestone fragments contain markings in white resembling ribs with articulating heads, and vertical sections of heart shape resembling two ribs joined by a vertebra enclosing a dark centre as of some animal like a serpent or reptile. They probably represent the remains of some bivalve mollusc. They have diameters averaging 15 cm. (6 inches). They are intimately associated with the limestone and cannot be separated from it as fossils, and were only seen in transverse section. No actual fossils were found.

This moraine descends along the eastern edge of the trunk some 13 kilom. (8 miles) to the entrance of the Tarim Shehr affluent, by the pressure of which it is then deflected westward nearly to the centre of the trunk-bed and henceforth becomes a median moraine. As it turns west, its volume is increased by the accession of a moraine of considerable size, elevated 6 or more metres (20 feet) at its centre, issuing from a nala lying behind a projecting shale ridge of the north-east wall shortly above the base of Teram Kangri. This moraine consists wholly of a soft, grey limestone of a texture not sufficiently firm to merit the name of marble, mottled with black masses suggestive of fossil remains, though distinct forms are not evident. Its central ridge is crowned by a succession of immense boulders of the same limestone.

At the Tarim Shehr-Siachen junction, the main moraine meets the gigantic black hillock-moraine of the former, the two crushing out of sight a good-sized white stream caught between them, and descends side by side with it without intermingling to within a short distance of the glacier-end. Below the junction its hillocks increase in size till they rival those of the black moraine.

(3) The granite moraine.

The third large moraine first appears high up on the south side of the Peak 36 affluent, in front of the granite massif of that name, at the junction with it of a secondary affluent, as a line of discrete, oblong hillocks 4 to 8 metres high, their bases separated by ice-surfaces. As these move downward towards the Siachen trunk, they are crowded up higher by the increased pressure of other affluents till their bases unite and they form a continuous hillock-moraine, which descends as a median moraine to the Siachen, where it is amalgamated by pressure with a marginal moraine, which has descended alongside it.

Still farther reinforced by contributions from the south-west wall, it acquires a width of nearly 500 metres (1640 feet), and for the next 5 kilometres (3 miles) occupies the edge of the Siachen trunk. On meeting the Lolophond affluent descending from the Bilaphond La, its size is further augmented by junction with it of the north marginal moraine of that glacier, by which it is pushed strongly over eastward into the Siachen bed. From this point it passes far down the Siachen as a median moraine.

This moraine is composed largely of granite and crystalline *débris* mixed with shale. On its eastern edge great blocks of striped and variegated limestone were scattered about, the source of which was not evident. This was also the case with a smaller shaly moraine striking over from the centre of the glacier and joining it.

In the upper reservoirs and higher portions of trunk and affluents covered by *névé*, no signs of moraines are visible. One may walk over these for many kilometres where the virgin white expanse is unmarred by the presence of a single boulder or rock-fragment. This fact does not preclude the possibility of the existence of large quantities of rock-*débris* in the deeper portions of the ice, or the probability that the marginal portions are packed with detritus that comes to light in the moraines lower down.

As the Siachen fills its bed so completely and its enclosing walls rise from it so abruptly, there is little room for lateral moraines to be deposited, and they are only found here and there for short distances. Just above the Lolophond affluent, on west edge of glacier-bed, a huge one exists, but only for a few hundred metres.

The larger Siachen affluents join the trunk at accordant grade at angles of 90° or over with its axis in the usual manner ; but the junction of the great eastern affluent, the Tarim Shehr, involves phenomena especially noteworthy. Here probably the largest existing valley tributary outside the Polar regions unites with the largest known valley glacier. The Siachen just above the junction has a width of 4·4 kilom. (2·75 miles) and completely fills its bed. The Tarim Shehr, with a width of 3·2 kilom, (2 miles) and a length of over 27 kilom. (17 miles), and falling nearly 1000 metres (3281 feet) from an altitude of 5883 metres (19,300 feet), impinges on the Siachen at an angle of 40° with its course with a shock so great that the Siachen trunk is compressed and driven over toward the opposite side, to an extent, that permits the Tarim Shehr to turn around the pointed extremity of the granite and shale Tarim Shehr promontory through an arc of 140° and take its place as a constituent part of the trunk.

The width of the glacier-bed just below the junction is again 4·4 kilom. (2·75 miles). The amount of pressure exerted by the oncoming Tarim Shehr on the Siachen may be gauged by the fact that two immense ice-bodies of unknown depth, together 7·6 kilom. (4·75 miles) wide, are crowded into a space only 4·4 kilom. (2·75 miles) wide. The plasticity of ice could not be better illustrated than by this result. The severity of the struggle incident to its accomplishment may be seen not only in the displacement of the vast Siachen ice-mass and its compression to less than three-fifths its former width, but also by the disturbance of structure in the affluent, the surface of which, as it turns around the pivotal promontory, is broken into a long line of gigantic séracs, and elsewhere rent asunder and twisted into a tortuous labyrinth of huge ridges and elevations surrounded by profound depressions, some of them occupied by large lakes. One wishing to acquire a knowledge of the difficulties and dangers of glacier-exploration could nowhere find a better opportunity than here in crossing the black hillock-moraine and pushing a couple of kilometres (1·25 miles) up the Tarim Shehr.

The periphery of the arc described by the Tarim Shehr in its change of direction is formed by its great, black hillock-moraine, that, as seen from Junction mountain above, sweeps around in a magnificent, symmetrical curve interposing a broad, black, billowy belt between the white streams on either side, from which it stands out in striking contrast. The view it presents fascinates the eye and excites the imagination, marking as it does the extent of the battleground covered in the struggle for supremacy between these two monster glaciers.

An anomalous and most interesting formation, such as in a wide experience in glacier-exploration I have nowhere else seen, occurs at Tarim Shehr promontory. About 6 kilom. (4 miles) above its extremity, a sharp shale shoulder projects like a ploughshare into the Tarim Shehr glacier. This shoulder intercepts the moraine-covered glacier-edge and part of an adjacent white stream and turns them aside over the base of the promontory as an offshoot or *true branch* some 0·53 kilom. (0·33 mile) wide, which descends towards the Siachen across the foot of Junction mountain.

As a rule, from the conditions of its existence, a glacier-trunk occupies the lowest line of drainage or flow in a valley, and ice gravitates toward and not away from it. In this case, the tremendous pressure of the great affluent forces the two ice-streams intercepted by the shoulder to overleap their natural lateral barrier and separate themselves from the main body. So great is the force exerted that the whole mass of the white stream, which impinges directly on the shoulder, is split up into séracs which, pointed off by melting, descend the declivity of the promontory as a cascade of glistening white pinnacles (sérac-penitente), forming one lateral half of the detached offshoot or branch. The other lateral half consists of the marginal moraine-stream having a smooth, dark, *débris*-covered surface.

This branch at some former period crossed the entire base of the promontory and joined the Siachen, thus making a nunatak of the promontory; but it has receded 500 to 600 metres (1640 to 1969 feet) up the slope, leaving a large amphitheatre streaked by old moraines, dotted with weathered and lichen-covered boulders, and clad with grasses, burtsa, and flowering plants, a resort of ibex of gigantic size and other animals. This is the only vegetation-clad oasis in a wilderness of ice and rock extending for scores of kilometres in every direction, and, as affording a refuge to the wanderer from the rigours of the savage expanse around, it merits the name of Tarim Shehr (Oasis-City) bestowed on it by the natives.

At various places along the course of the trunk and affluents where rock-promontories project into the glacier-bed, the glacier-edge opposite these consists of a smooth, vertical or steeply slanting wall curving around to correspond to the shape of the promontory-end, and removed from it by an interval of 20 to 40 metres (66 to 131 feet). The interval is occupied by a lake. This formation only occurs in connection with such promontories. It is caused, apparently, by the melting away of the glacier-edge by the heat radiated from the rock surfaces, and the ice melts back until a high, smooth or fluted wall is formed, and downward until a deep basin is excavated, which receives and retains the resulting water.

Such formations were found near the head of Peak 36 affluent, and of the main trunk at altitudes as high as 5365 metres (17,602 feet) and 5601 metres (18,372 feet) respectively. We were able to utilize three promontories giving rise to these for camps, in each case only after the coolies had worked two to three hours under our direction in building, with rock-fragments, retaining walls and terraces to support the tents. Although these promontories afforded but little elbow-room outside the tents, they served as most welcome situations for camps in regions otherwise deeply covered with ice and snow. Access to them was not easy. They could not be reached from the front on account of the steep, treacherous ice-walls and lakes. The only approach was by dangerous ice-slants some distance above their ends sloping sharply down to the lakes, where a mis-step would precipitate one into an icy bath, that would speedily prove fatal unless one could be immediately rescued, which might not always be possible. In one such instance, prompt assistance undoubtedly saved a coolie's life. It was not safe to approach the edges of the ice-walls at any point, as during the day they became soft, and being often undermined they broke away and slid into the lake below.

The following table shows the lengths of the five great Karakoram glacier-systems, the altitudes of the col, initial bergschrund, or highest glacier-surface, that may be considered to form their heads, altitudes of extremities of tongues, their total and average fall in metres and feet omitting fractions :—

	Length.		Head.		Tongue.		Total fall.		Average fall.
	kilom.	miles.	metres.	feet.	metres.	feet.	metres.	feet.	
Siachen	72*	(45)	6400	(20,998)	3713	(12,182)	2687	(8816)	1 to 26
Chogo Lungma	48	(30)	5800	(19,029)	2896	(9,502)	2902	(9521)	1 to 16
Biafo	59	(37)	5333	(17,497)	3201	(10,502)	2132	(6995)	1 to 36
Hispar	58·5	(36·4)	5333	(17,497)	3209	(10,528)	2043	(6703)	1 to 28
Baltoro	57·6	(35·8)	5072	(16,641)	3352	(10,998)	1708	(5604)	1 to 37

From this it will be seen that the Siachen trunk lies at a considerably higher level than those of the other four systems, and that the average gradient of the Chogo Lungma is the sharpest. The gradients of all the trunks vary greatly in different portions, being steepest in the first few kilometres from their origin, comparatively slight for the greater portion of their course, and on some stretches of several kilometres practically level. It is scarcely necessary to add, that all the trunks are fed from reservoirs lying at considerably greater altitudes than those assigned to their heads.

The gradient of the Siachen trunk and of most of its largest affluents below their sources is gentle and remarkably even. Their surfaces are not disturbed by ice-falls, certainly not by such as split up the Choge Lungma in its upper third, extending across its whole width. The few ice-falls that exist are of small extent. On the contrary, crevasses in the upper parts are frequent and dangerous, being concealed by snow until late in the summer. The upper Tarim Shehr plateau, for some 8 kilom., is seamed in every direction with great crevasses and openings, which were found so dangerous that we did not feel justified in attempting to penetrate it with coolies.

The amount of ablation of the white ice through melting during a summer is great. This is made evident by the large quantity of water bathing the surface. In the upper portions, where its free movement is hindered by the presence of *névé*, it lies in great sheets, as we also found it on the Biafo and Kanibasar glaciers. Its surface freezes at night into a slushy sodden ice, that furnishes a treacherous bridging to those compelled to cross such water-areas. They were mostly negotiated by crawling on hands and knees, but this apology for ice often proving too weak to support the weight of a man even in this position, we were obliged to make *détours* to get around them.

Lower down where water can flow unhindered it courses over the surface in rivulets hurrying to escape by the lowest passages. Owing to the crowning of the white streams, the rivulets run off transversely from their centres towards the sides, ever increasing in size by coalescence with

* The length of the Siachen is somewhat difficult to define. If, as in this table, the Indira Col be taken as its head its length may be called 72 kilom. It, however, extends upward on the flank of Peak 23 some 3 or 4 kilom. farther in a great ascending snow basin.

others, till they reach the lowest line of the longitudinal angular depressions formed by the apposed edges of contiguous ice-streams. The water accumulated here from the combined rivulets forms powerful torrents which, cutting channels 2 to 10 metres (6·5 to 33 feet) wide and often over 10 metres (33 feet) deep along the lowest levels of the furrows between the ice-streams, rush seething downward to perform their mission in the scheme of glacier-evolution.

Torrents of this kind are a feature of the Siachen, and are met with in nearly all the longitudinal furrows mentioned. Some eight to twelve have to be passed in crossing the central portions of the trunk, which, as they are often impassable except where covered with *névé*-bridges or at points where the channel-walls approach sufficiently near each other to permit of leaping over them, offer a serious obstacle to the exploration of the glacier. One coolie lost his life and several others were injured by falling into them in 1912.

Séracs are a common feature of the steeper parts of most large glaciers, being usually associated with ice-falls. They are, in most cases, due to the splitting asunder of the ice under tension caused by the bending of a glacier over sharp increases of gradient in its bed. The resulting projecting ice-masses whitened by exposure to heat give the surface the appearance of ice-cascades.

Only a few unimportant sérac-areas due to this cause exist on the Siachen and its larger affluents. There are, however, extensive sérac-areas on the Tarim Shehr and on the Siachen trunk above and below their confluence, that are formed under entirely different and exceptional circumstances, where the glacier-bed is smooth and the gradient gentle. The cause of these is the enormous pressure developed around the junction, which forces the white ice-streams strongly upward and fractures their surfaces into large fragments or sérac-masses 10 to 30 metres (33 to 98 feet) high separated by intervals of greater or less width. These intervals which take the forms of crevasses and gullies are superficial, extending only to the bases of the séracs, the deeper portions of the glacier remaining in solid contact, thus differing from intervals between tension-séracs which usually penetrate the glacier-substance below what may be termed the sérac-bodies. Large numbers of these séracs are sharpened by melting into pointed pinnacles, constituting what I have classified as sérac-penitente, of which they form beautiful examples.

Another variety of pinnacle analogous to the last, which, from the fact that its final shape is chiefly determined by melting, may be regarded as a gigantic form of ice-penitente, is seen at places, usually at the central and lower parts of glaciers as well as also in the upper portions of low-lying glaciers, where moraine-streams greatly overbalance the white, and where the latter, having become much attenuated, are about to disappear. At these places, pinnacles 5 to 12 or more metres (16 to 39 feet) high of white ice having the form of pyramids, wedges, or crested combs, with steep sides, and standing almost touching one another or some distance apart, project upward in lines from smooth, moraine-covered surfaces free from crevasses, their glistening, white forms contrasting strongly with the dark moraine-surfaces around them.

They appear to be developed as follows. The lateral pressure, which farther up the glacier where the white streams have greater volume only causes them to crown up in the centre, here where they have become reduced by pressure and ablation to slender filaments, crowds them up between the converging moraine-streams as high, narrow, white ridges with more or less broken summits and vertical or steeply slanting sides. Melting then causes the softer and thinner portion to disappear, leaving the more massive and resisting ones standing detached from one another as the ice-pinnacles in question. Sometimes these pinnacles are at such distance apart that relationship between them is not obvious at first sight. In other words, resisting centres being present in the elevated ice-ridges, the formation of pinnacles or gigantic ice-penitente from these occurs on exactly the same lines as that of penitente-pinnacles of any other variety. The presence at various points on the surface of the ridges of thin *dêbris*-deposits, which rapidly melt their way downward through the ice, accounts for a great deal of the segmentation that divides the ridges into detached pinnacles. This *dêbris* is usually seen covering the ice between the bases of the latter. This variety, while resembling sérac-penitente in some particulars, differs from it in that its pinnacles are not separated by crevasses, but are surrounded by smooth moraine-covered surfaces. They are also more regular in shape and rise less abruptly.

Such pinnacles were met with on the lower portion of the Sachen near the central line, and at several places on the Kabery glacier at the points of disappearance of expiring white streams. Also in great size and perfection on the low-lying Gasherbrum glacier at about 4570 metres (15,000 feet). Here they ran in two parallel lines one on each edge of a central moraine-stream. The ice-pinnacles mentioned by the various explorers of the Baltoro (the origin of which none of them has adequately accounted for, though Dr. de Filippi's suggestions accord with what I regard as the correct explanation above given), and seen in Sella's photograph opposite p. 21 of *Geographical Journal*, January 1911, and also in panorama N, on pp. 208–9–10, and opposite p. 288 of 'Karakoram and Western Himalaya,' correspond to this variety, which appears to be strikingly represented on the Baltoro.

Large areas of the glacier-surfaces were covered with the smaller varieties of nieve-penitente above the *névé*-line and with ice-penitente below it, the pinnacles succeeding one another as closely as wavelets upon water ruffled by wind and making even level surfaces difficult to move over. The most numerous and, in many respects, interesting were those of the thin *dêbris* or pocket variety, Var. iv. of my classification. These pinnacles of all kinds, by breaking up the surface and greatly increasing the amount of it exposed to heat, contribute materially to ablation of the glacier. Many new features were observed regarding penitente formations, or surface projections due to melting, which will be considered in detail elsewhere.

The entrance of the Tarim Shehr affluent divides the Siachen trunk into two parts, an upper and a lower, which differ from each other in their features as essentially as might be the case with two separate glaciers. The surface of the upper portion aside from its hillock-moraines is smooth, and, except for pocket-penitente, watercourses at the lines of junction of its streams, and crevasses in the higher parts, is easy of ascent.

With the lower portion the case is different. The compression of two great ice-bodies of a combined width of 7·6 kilom. (4·7 miles) into a channel 4·4 kilom. (2·7 miles) wide must effect changes in the arrangement of their constituent parts. The evidences of pressure now become more pronounced. All ice-streams, but especially the white, are narrowed and crowded higher. The regular symmetrical crowning of the upper white streams disappears, and the ice is forced up into great ridges with high, abrupt, and, in many cases, vertical sides enclosing deep ravines through which torrents rush seething downward with hollow roar. The great white body of the Tarim Shehr is elevated considerably above the level of the rest of the trunk, and its surface converted into a labyrinth of huge séracs towering to a height of 30 to 40 metres (98 to 131 feet) separated by intricate, winding gorges.

The hillocks of the hillock-moraines, previously of modest dimensions, assume gigantic proportions and lift their heads more than 100 metres (328 feet) above their bases. The depressions between them become more profound, thus adding to their height. The lakes occupying the depressions increase also in size. Notwithstanding these changes, the individuality of the larger ice-streams is not greatly disturbed until the general breaking up into chaos occurs about 2·5 kilom. (1·5 miles) from the end of the tongue.

In view of the great moraine-hillocks with dangerous precipices, enormous séracs spiked with ice-pinnacles, ravines, glacier-torrents, high ice-ridges honeycombed with water-pockets and bristling with pocket-penitente, locomotion on this part of the trunk is neither easy nor safe, especially in crossing the glacier. Its exploration demands an outfit adapted to its conditions, an intimate knowledge of ice-craft, and fertility of resource.