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Sir WILLIAM WILLCOCKS: I think many people who say that Mesopotamia is a poorly inhabited country all go down the Tigris in the steamers and see nothing. If they would only go down the Euphrates from end to end, they would see that the population is very numerous and very energetic and strong. As to the railway to Aleppo, I do not think, when Miss Bell said that was the ancient route, she was correct. Aleppo is the outlet for everything from Mesopotamia westwards; but from Baghdad westwards Tyre and Sidon have been from ancient times the outlet, and will be again. I think the road to Damascus is the best. I am very much obliged for the kind way in which you have received my paper.

JOURNEYS IN BHUTAN.*

By J. CLAUDE WHITE, C.I.E.

BHUTAN is a country hitherto almost unexplored, and I have been more than usually fortunate in making no less than five distinct journeys through it, and it is of these journeys I propose to give a short account this evening.

The first journey, in 1906, was when I followed the course of the Am-mo-chhu from Chumbi to the plains in connection with the proposed construction of a cart-road. The valley is densely wooded and practically uninhabited, and was interesting mainly on account of its fine vegetation and beautiful scenery. The second journey, also in 1906, was made from Gangtak *viâ* the Natu-la to Chumbi, and then *viâ* Hah, Paro, Tashichojong, and Poonakha to Tongsa and Byagha, on the occasion of the investiture of the Tongsa Penlop with the insignia of the Knight Commander of the Indian Empire. The third journey, in 1907, was along the boundary between Bhutan and British India, from the Jaldakha river to the Gadadhar, and from Doranga to the eastern boundary, and again from Doranga across the Dongma-chhu to Kenga, and a further two days' journey up the Kuru river. In 1907, from Dewangiri through Kheri, Tashijong Tashiyangtsi, across the Dong-la to Lingzi and on to Pangkha, Singi Jong and across the Bod-la to Lhakhang Jong in Tibet. From Lhakhang I followed up the western branch of the Lobrak river to Lhalung monastery, and crossing the watershed entered the Chomo-chang-thang lake basin, and thence to Gyantsi. In 1908, from Chumbi *viâ* Phari to Paro, and on to Poonakha by the route I followed in 1906, in order to attend the installation of Sir Ugyen Wang Chuk as Maharaja, and on my return journey I followed a new route from Paro *viâ* Bite Jong and Dungna Jong to the plains, which I entered at Jaigon.

I will pass at once to my second journey, as that through the

* Read at the Royal Geographical Society, December 8, 1909. Map, p. 104.

Am-mo-chha valley calls for no special notice beyond that the scenery and vegetation were both particularly fine.

Throughout the whole length of the central zone of Bhutan, a well-aligned road runs from west to east, and crosses the ridges separating the various valleys by easy passes from 10,000 to 13,000 feet high, and it was along this road that I travelled in 1906. The road from Gangtok to Rinchingong has often been described, but from Rinchingong, where the old road crosses by a substantial bridge to the left side of the Ammo-chhu, no description has been given. The views down the valley were most beautiful, and the trees very fine. Crossing what was marked as the Lang-marpu-chhu, but is really the Kyunka, by a new bridge, we came to what is known as a cave, or rather two overhanging rocks, which lie in Bhutanese territory. Our old maps are wrong; the true Lang-marpu-chhu is more to the north, while the stream marked by this name is really the Kyunka. At the head of the former stream there is said to be a lake and also favourite ground for the shau, the great Sikkim stag, *Cervus affinis.* A narrow track through woods took us up the Kyunka, to our camp at Lhare, a somewhat confined glade close to the stream. Above this, as we ascended the Kyunka, the road improved greatly and the country opened out, though we were twice obliged to cross the stream by strong bridges.

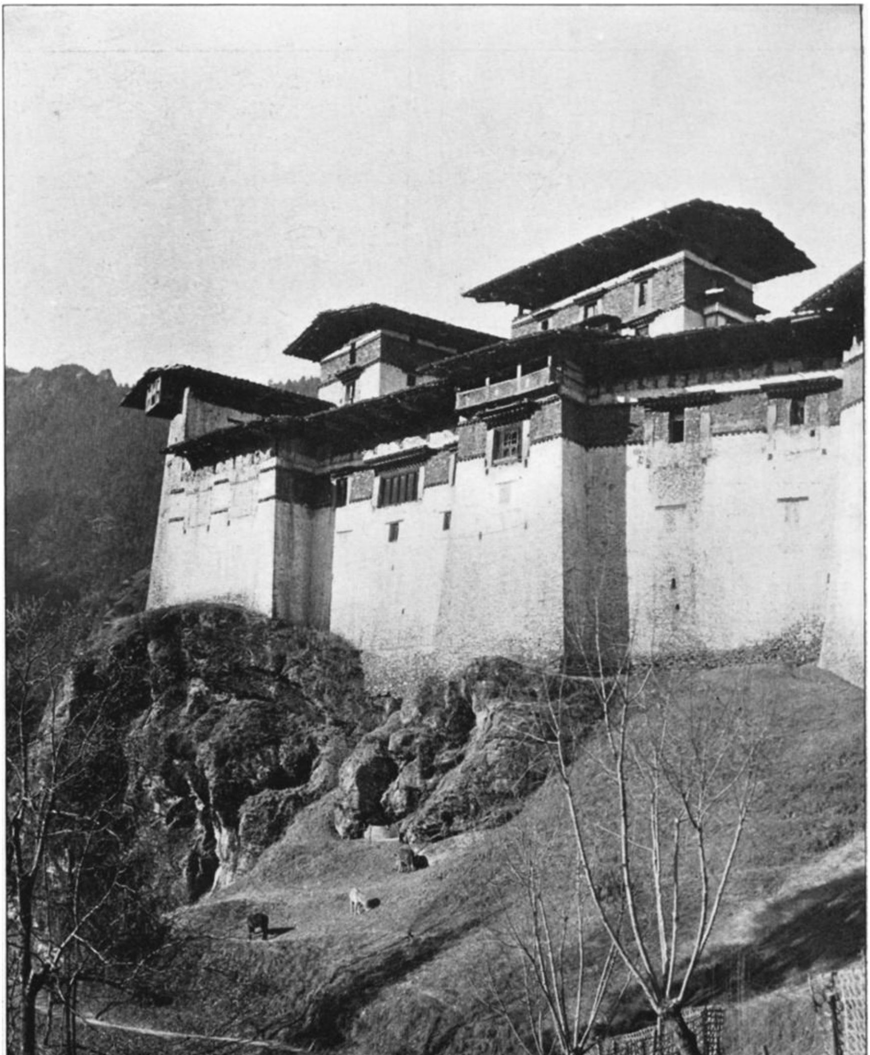
On the other side of the Chalu-chhu (one of the tributaries of the Kyunka) the valley widened out into most delightful glades and upland swards, forming rich grazing-grounds. Here grew in graceful abundance spruce, larch, silver fir, holly oak, various pines and rhododendrons interspersed by grassy meadows, while the view down the main valley had the appearance of a gigantic avenue, leading up to the snowy pyramid of Gipmochi. Out of this a somewhat steep ascent round a grassy knoll leads to the Dongma-chhu, up which runs another track to the head of the Lang-marpu-chhu, and thus by a northerly but difficult path to the Hah road. The main route leads across the Lungri Sampa up a steep and stony way to Tak-phu, a somewhat bare and extensive flat, well within sight of the Kyu-la. Timber was plentiful, and our camp was further protected by the walls of two parallel moraines; the valley, indeed, was full of lateral moraines, forming gigantic spur works to keep the modern river within bounds. At the same time, so far from these moraines being barren stony walls, they were luxuriantly covered by virgin forest right up to the top of the parent ridge. Snow fell, and in our camp, 13,400 feet above sea-level, we passed a very cold night, there being 18° of frost.

Passing through an extensive amphitheatre, bare and devoid of tarns, the Kyu-la, or rather the long ridge which forms part of the pass, was soon reached; but we had to proceed nearly half a mile along it before we could descend into the wilder amphitheatre of rock and snowfields which lies between the Kyu-la and the Hah-la (or Meru-la of our maps). This half-basin forms a veritable death-trap in bad weather, as there is neither fuel nor shelter to be found anywhere within its horns. The view from the Hah-la is magnificent; a particular feature in the panorama being a grand but unknown snowy ridge, which ends abruptly on the south-west in a tremendous precipice, where the Am-mo-chhu probably finds an outlet towards the plains.

On the east we looked down a well-wooded but somewhat deep and narrow valley, and through this we descended by a very rough steep track, which, however, improved greatly when a small open glade was reached. The road here turned slightly to the south, down the main valley. It is impossible to describe the beauty of the scenery: grassy glades, gently sloping, opened on a succession of broad valleys in the far distance; on either side, and at our back, was a deep fringe of fine trees of every age, from the patriarch of the forest to tiny seedlings. From the time we left Rinchingong, we had passed through forests without exception self-reproducing, thus showing that the Bhutanese understood the secret of combining in their forests self-reproduction and unrestricted grazing. A good road brings the traveller into the main valley, which greatly resembled an Alpine scene, of magnificent description, with a temple or a monastery on every commanding promontory. Ke-chuka, the first large village we came to in Bhutan, contained a fine sample of a Chuten or cube of prayer, its rectangular form marking a strong contrast to the cylinders of Sikkim and Tibet, while two flour-mills worked by water bore testimony to the prosperity of the villagers. At Kyengsa a road leads up a side valley direct to Duggye jong, which guards the road from Paro to Phari. Yangthang is a large long village situated on the left bank of the river, but numberless irrigation channels have tempted the Hah-chu to forsake its natural bed, and much stony barren land is the result. The formation of the hills is markedly of crystalline limestone, and there are several mineral springs to be met with. The large village of Tumphiong, the chief station of the district, possessed twin forts of no particular strength or beauty; the houses have once been large and prosperous, but are now in a decayed condition. There are curious holes in the limestone formation on the left bank of the river, which seem to connect the river with some subterranean lake; the villagers place baskets at these outlets, and the rush of water at times brings out a number of fair-sized fish, though none are to be seen in the Hah stream itself. The Hah monastery is situate some way up a side valley and commands a magnificent view; it is in good order, but the Poisoners' Chapel, mentioned by Eden, was neglected, and appeared of little interest.

Our route was over a very good bridle path, rideable the whole way to the Chiu-li-la; but the weather, unfortunately, was very damp and misty, and we obtained only occasional glimpses down the Hah valley,

DUGGYE JONG.



DUGGYE JONG.

which runs fairly straight as far as Do-ri-kha, where Eden camped, and whose route in 1864 we were now supposed to be following. High up on the right was the nunnery of Kyila, built on the face of a very steep precipice, most difficult of approach. No male creature is allowed to remain within the precincts of the establishment, and it is said to contain sixty nuns; but as there were more than twenty-five houses, the majority quite large ones, this estimate of the inhabitants seems much too low. Cha-na-na, a small hamlet of some half-dozen houses in a ruinous state, was our halting-place. Our experience in crossing the Chia-li-la was so different in every respect from Eden's that I cannot but suspect that he was deliberately misled from the proper path on to some mere cattle track.

A little below Cha-na-na the path emerges on a well-wooded spur, with a grand outlook over the courses of the Pa-chhu and its affluents, running through a broad, well-cultivated tract of country which could under good management grow every description of temperate crops. On a distant mountain the monastery of Danka-la has been built in such a conspicuous position that it can be seen even from Poonakka; while Beila Jong, which we subsequently passed on our way from Paro, was visible eastwards. To the north lay Dug-gye-jong, dominating the main road to Phari, and deriving its name from a notable victory over the Tibetans; while at Gorina was the monastery which a former Shabdung Rimpoche used to make his summer retreat. Owing to the more favourable climate and country, the monasteries of Bhutan, unlike those in Tibet, are not confined to one huge building or close cluster of dwellings, but consist of houses scattered over the slopes of the hills, each one surrounded by a pretty garden. The chapel at Gorina was bright, clean, and decorated in good taste; while the frontal hangings, overlaid with an exquisite lacework of brass, were superior to anything to be seen in Lhasa. The chuten was a very fine one, having on one of its faces a large brass plate, with a Buddha deeply embossed thereon.

On the ridge below we were received with a salute fired from iron tubes bound or covered all over with leather, which are probably the leather cannons of which we heard so much in the Chinese Goorkha wars. The Paro Penlow's band and richly caparisoned mules were in attendance. Down to Paro the road passes over a deep red clayey slope, impassable in really wet weather.

What struck me most during the last march was the total absence of rhododendrons, and the change from gneiss first to crystalline limestone, sandstone, and dark shales; then to heavy red clay deeply impregnated with iron; and finally to a blueish-grey limestone.

The fort has been built on a limestone bluff overhanging the river; there is only one entrance from the hillside, and this the third story; the lower stories are only partially existent, as their walls seem in great part to be a mere casing to the solid rock. A heavy bridge over the fosse separating the fort from the rest of the hill leads to a huge gateway, and within this a sharp turn to the left opens upon the eastern courtyard containing the smaller of the two citadels or towers, which is occupied by petty officials. Against the inside of the south and north outer walls are built a series of rooms and verandahs; on the west front directly above the river there is a covered verandah, one story only, from which the balista or catapult, which is still stored there, was worked. The Penlow's quarters are on the first floor in the south-east corner. The reception-room was large, airy, finely decorated, and its walls hung with arms of every description. The opposite corner of the enclosure has a larger suite of apartments reserved for the Deb Raja and other distinguished guests. On the first floor of the main citadel is the public temple or chapel, a very finely proportioned hall with two tiers of well-lighted galleries. All the decorations were good, a hanging lattice of open brasswork being specially effective. In the west corner of the main courtyard was the private chapel of the Ta-thsang or state monks, whose head lama Kun-zang accompanied the British Mission to Lhasa.

Three of the outlying forts, Tazo-jong, Donam-jong, and Suri jong, are existent, though in bad repair, but the very large one of Chubyak-jong is entirely in ruins. Dug-gye-jong is situated some 9 miles up the broad valley of the Pa-chhu, described by Turner "as a fortress built upon the crown of a low rocky hill, which it entirely occupies, conforming itself to the shape of the summit, the slope all round beginning from the foundation of the walls. The approach to the only entrance is defended by three round towers, placed between the castle and the foot of the hill, and connected by a double wall, so that safe communication between them is preserved, even in times of the greatest peril. Around each of these towers, near the top, a broad ledge projects, the edges of which are fortified by a mud wall, with loopholes adapted to the use of bows and arrows, or of muskets. On the north of the castle are two round towers that command the road from Tibet. On the east side the rock is rough and steep; and close under the walls on the west is a large reservoir.

The castle itself is a very substantial stone building with high walls, but so irregular in its figure, that it is evident no other design was followed in its construction than to cover all the level space upon the top of the hill on which it stands. The gateway at the foot of the walls which crown the hill opens upon a flight of a dozen steps, within a narrow passage leading to a semicircular platform, edged with a strong wall pierced with loopholes. A turn to the right leads through a second gateway and along a wide lane, with stables for horses on each side; and a third gateway opens into the interior of the fortress, which forms a large square, with its angles occupied by three suites of rooms.

In the centre of the courtyard is a square citadel several stories high, and containing temples or chapels. The whole place was very clean. The armoury is said to be the most complete in the country, and is contained in a fine room, with a large bow-window facing south, and affording one of the prettiest views in Bhutan. The inner court contained piles of large pine shingles, intended for the repairs of the castle roofs, which have to be done every five years.

The road running from Paro eastwards is very rough and steep up to the Tazo-jong, the curious rounded fort described by Eden as a building formed of two semicircles, one large and the other small, built up one against the other for about five stories high. So far the regular road had evidently not been repaired for many years, but farther on it was good and ascended very gradually to the pass near Beila-jong (8900 feet). On the other side a less gradual descent leads to Pemithang, the seat of a small official, or Penlow.

From Pemithang there are two routes to Tashi-cho-jong—a direct one across the hills *viâ* Pame-la, the other down the Pemi-chhu, and so round by the Tchin-chhu; we chose the latter. The road was good, and the valley thickly wooded and full of flowering pear and peach trees; but on turning eastward up the Tchin-chhu the whole aspect of the country changed to barren hills with sparse and stunted trees. Our camp was at Chali-maphe, not far from the fort of Simtoka. Here was the gigantic cypress, which Eden records as measuring six spans round in 1864. We found it to be 50 feet round the trunk at 3 feet from the ground.

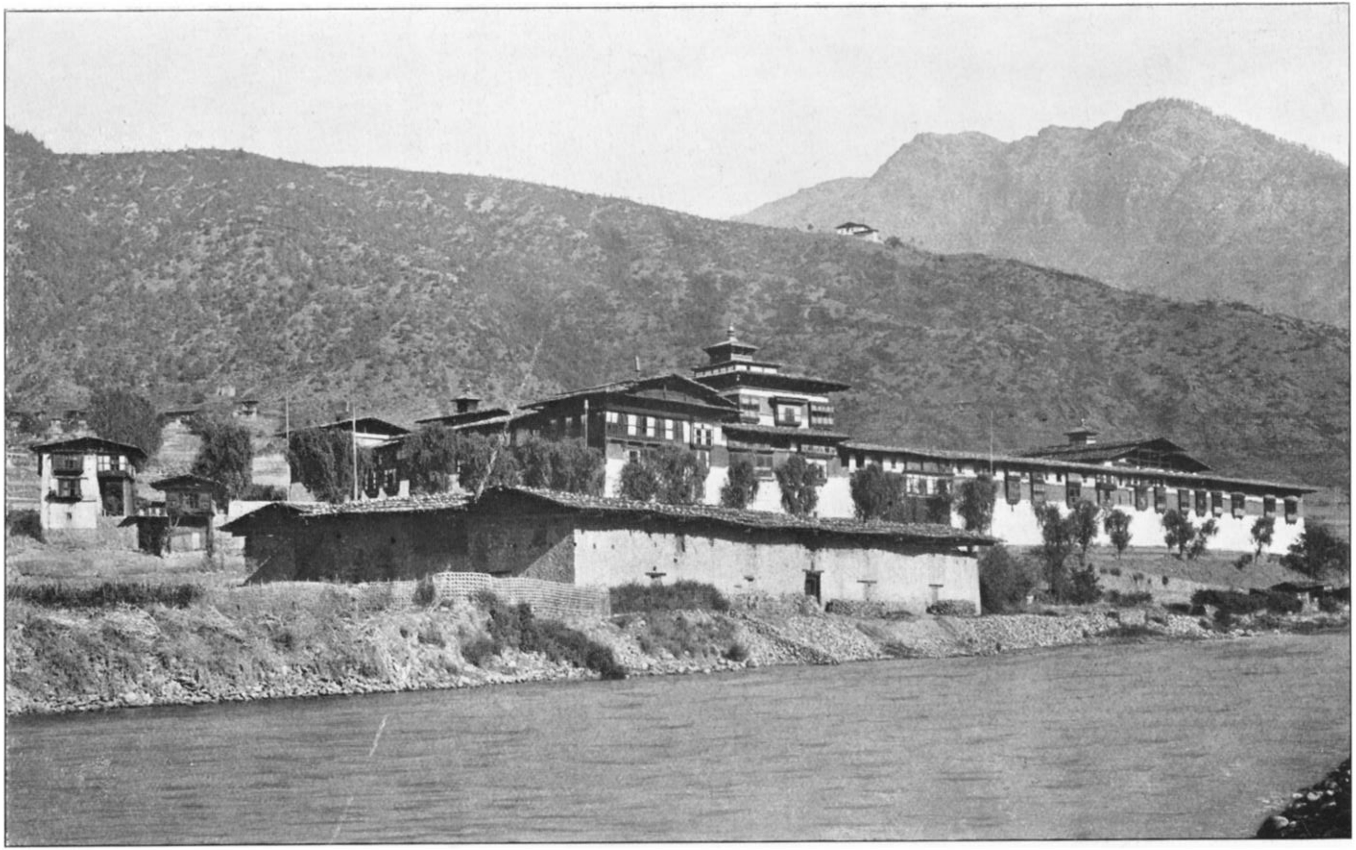
Tashi-cho-jong, the summer capital of Bhutan, lies to the north, up the broad valley of the Tchin-chhu, but as our destination was Poonakha, the winter capital, we took the road leading up the Lhung-tso valley. A short distance above the junction of the two streams, Simtoka fort occupies a projecting ridge, separated by deep gullies from the main hill. The present fort was built by Shabdung Rimpochi in 1873, as the first one, completed in 1870, had been treacherously seized and burnt by his enemies; a scorched pillar belonging to the original building, now almost hidden by elaborate carving, is still pointed out as an object of reverence. In the chapel is the finest statue of Buddha to be seen in Bhutan. It is placed under a magnificently carved canopy, and supported on either side by a number of standing figures more than life-size. Round the plinth of the central tower runs, not a row of prayer-wheels, as is usually the case, but a number of square slabs of dark slate, carved in low relief, with pictures of saints and holy men.

The road up the valley to the Dok-yong-la is a very good one, running through beautiful glades of oaks, willows, chestnuts, and rhododendrons, while on the higher slopes forests of *Pinus excelsa* reappeared, in pleasant contrast to the barren hills of our previous march. On the east of the Dok-yong la we entered a valley, which, in the dampness of its climate, was suggestive of Sikkim rather than of Bhutan; the path to our camp at Lungme-tsa-we and on to the Teo-pa-rong was steep and slippery, and only redeemed by the beauty of a species of rhododendrons and huge pear-trees. From our camp at Jon-chung-dorong, the mission, headed by a picturesque procession of musicians, dancers, gunners, gaily caparisoned mules, etc., started on April 20, with the intention of making a triumphal entry into the capital of Bhutan, in spite of the difficulties caused by the heavy rainfall and the clayey road. The mission remained at Poonakha until May 2, to enable me to carry out the duties for which I had been sent. The Durbar, at which the Insignia were presented to Sir Ugyen Wank-chuk, was most interesting, but a description of the ceremony would be out of place in a geographical lecture.

The castle of Poonakha looks best from a distance, occupying as it does the whole narrow promontory between the Pa-chu and Ma-chu immediately above their junction. It has the usual towers and court-yards, and was built by the first Shabdung in 1577, and designed to hold six hundred monks: their number has increased since then, and the body ecclesiastic now occupy the whole of the southern third of the building. The two rivers are spanned by fine cantilever bridges of the same style as that at Paro. The earthquake of 1897 was felt here very severely, and the destruction then wrought has not been wholly repaired.

The Ta-lo and Norbugang monasteries are situated high up on the mountain to the west. The track, if it deserves even this name, must be absolutely impracticable during rain, as it runs entirely through clay. As far as Norbugang, about two hours journey up, the hillside was bare and uninteresting, but afterwards the path improved and ran through several pretty glades, where the pear and clematis blossoms were beautiful. After three hours of hard climbing, the monastic colony of Ta-lo was reached: small, well built, two-storied houses, with projecting verandahs and painted fronts, were scattered all over the hillside, each in its little garden of flowers and trees, with here and there a chapel or a picturesque chozten, to break anything like a monotony of houses. The great temple above stood sharply out against a sombre background of cypress and pine: while higher up the small but beautiful retreat of the late Dharma Raja formed a fitting crown to the whole group of buildings. In the great temple were many chapels kept scrupulously clean with, strange to say, glass window-panes. The principal objects of interest were the two large choztens containing the ashes of two of the Shabdung Rimpoche's: they were of silver, highly chased and jewelled, the stones being mostly turquoise of large size but little value. The ceremonial implements used by the late Dharma Raja were fine examples of the best Bhutanese metalwork. The carving of the pillars and canopies was excellent, but so much overladen by open metal scrolls that it was difficult to follow in detail. There was a

FARM HOUSES, PARO VALLEY.



TASHI-CHO-JONG: THE SUMMER RESIDENCE OF THE BHUTAN GOVERNMENT.

magnificent collection (both here and at Norbugang) of banners of embroidery and applique work, and before one of the altars an elephant's tusk measuring 8½ feet.

About 2½ miles up the Mo-chhu above Poonakha are the ruins of a small fort called Sona-ga-sa, mentioned by Turner under the name Zemri-gatchi, and formerly containing the great printing establishment of Bhutan and a fine garden house for the Deb Raja. It was totally destroyed by fire about eighty years ago during one of the many local civil wars, and all the records unfortunately lost, and only a few flowering plants remain to represent the garden. Not far off is a sort of cave or arched recess, which has been formed by percolations of lime bonding together the pebbles of a bank, and in which, nearly three hundred years ago, Nagi-rinchen, a saint from India, is said to have lived. The river here is full of fish, and the resort of many cormorants and gulls. The road up its course into Tibet divides above into two branches, guarded respectively by the forts of Ling-zi and Ghassa. It is rumoured that gold has been found on the mountain ridge between the Mochu and Pacho.

The Bhutanese Government removes from Poonakha to Tashi-chojong at the end of April, so after finishing my work I left Poonakha on May 2, in order to visit Sir Ugyen Wong-chuk's seats at Tongsa and Byagha in the east. The road to Angduphodang is on the left bank of the river and close above it, and the descent is very gradual, not more than 25 feet in a mile, through a valley which is well cultivated, and once must have been thickly populated. The abutments of at least two chain suspension bridges not only betoken much former traffic, but also show how long these mountain streams keep to one channel, for no alteration appears to have taken place since Turner's visit to Angduphodang 130 years ago; and yet there are no sufficiently solid rocks nor guiding spur works to restrain the current. When in full flood the river looks very fine. Turner's picture of the bridge and fort holds good up to the present time. The channel which brings water to the upper fort is nearly 6 miles long, and clearly demonstrates the skill of the Bhutanese in irrigation works. The road eastwards runs just below this channel until it joins the Ba-chu near Chapakha. Up to this point the scenery was poor, and the road hot and narrow, but, on crossing the Ba-chhu, a stiff climb brought us to Satengong, a very picturesque flat overlooking both the Ba-chhu and Tang-chhu, and distinguished by a clump of pine trees, a small lake, and beautiful flowers.

The road eastwards was most excellent, and rendered interesting by the constantly changing scenery on the isolated island hill between the neighbouring rivers. The ascent continued gradual up to Tsha-za-la, and then an equally gentle descent led to a curious deeply cut ravine, where the main range begins. The Tang-chhu is crossed at the village of Ra-tso-wok, a name which betokens its Indian origin, and a good and very pretty path is lost at Ridha in a fine open space with plenty of flat ground, above which the village houses are clustered on a knoll. There were fine views up to the snowy range whence the Tang-chhu takes its rise to traverse many miles of a rich valley. The march hither was one of the most beautiful which we made during the tour, for the rhododendrons were in flower, and the oaks, chestnuts, and walnuts, with their young foliage, made delightful colouring in the scene. In every direction there was evidence of better cultivation and more prosperity than in any valley we had traversed. Unfortunately, the inhabitants are said to be very quarrelsome, and constant litigation (which means heavy bribes to the officials called in to decide their cases) has tended to keep the villagers more impoverished than they ought to be. Judging from our experience of the Pele-la, both in going and returning, the main ridge here must be the focus of a wet zone, extending as far as Tongsa, damp being drawn up from the plains through the narrow gorges of the Madu-chu: certainly we had worse weather here than anywhere else in Bhutan. The road, though well aligned, paved in many soft places and corduroyed in others, was, owing to the wet clay, very difficult to traverse. The country on both sides was a succession of wide open glades affording excellent grazing stations, and timber was abundant.

On the eastern side of the Pele-la were several large villages at Rokubi and Chandenbi. Not far from the latter place is a charming patch of sward covered with beautiful cedar pines, and situated in a gorge of the ravine, where the Siche-chhu is joined by another mountain torrent. On this tongue of land thus formed were two mendongs (walls of prayer) and a fine chorten, a copy of the Swayambunath in Nepal. From this spot the road ran at the same altitude through oak, magnolia, and rhododendrons for some miles before emerging at Tashiling on more open country, which continued as far as Tshang-kha, high above the raging torrent of the Madu-chhu. Here we camped. Beyond Tshang-kha the road almost immediately enters very rough country, the gorge through which the river flows narrowing considerably, and being flanked on either side of stupendous precipices. As it descends the road becomes a series of steep zigzags, mostly made up of stone steps, and this kind of path continued to within a short distance of the cantilever bridge, which crosses the Madu-chhu some 900 feet below the castle of Tongsa. Another steep zigzag with many flights of stone steps leads up to a small door in an outlying bastion of the walls of the castle, which blocks the way and overhangs the cliff up which the road runs. Passing through a large stone-flagged courtyard, the traveller emerges through another gateway to the east on a narrow path above a second ravine. It will thus be seen that Tongsa castle completely covers a ridge between two steep ravines, and effectually bars all progress from east and west. We camped for a couple of days on a pretty knoll, which, being clothed in fine trees and provided with an excellent stream of water, running over cascades into a fish-pond, is the pleasaunce of the Tongsa monks. The fort consists of several courts, but suffered from the great earthquake, and the eastern citadel had not been completely restored at the time of my visit. A women's choir formed part of the procession sent to play us into the castle—a curious performance which is mentioned in Pemberton's report.

A steep ascent leads to the outlying fort, which commands the castle itself. A good and easy road runs onwards over the Yo-to-la and down to Gya-tsa, the Faisa of Griffiths, who notes that it is "a good-sized village, comparatively clean, and with houses which were, he thought, better than most he had seen." The country through which we marched had again changed from a system of narrow gorges into a series of broad valleys, the upper ones grazed over by hundreds of yaks, the lower rich with barley, buckwheat and mustard fields. Dotted in their midst were erected temporary huts to shelter the cultivators during their stay in these higher elevations at the time of ploughing, sowing, and reaping, while down in the valley more substantial permanent dwellings proved that the district was better governed and more prosperous than any other we had seen. An easy road leads over a saddle on the Ki-ki-la and down into the valley of Chamka-chhu, where at different elevations are the castle of Byagha in the middle, Sir Ugyen's private house above, and his sister's below at Angducholing. Dr. Griffiths wrote, "The country was very beautiful, particularly in the higher elevations, but we saw scarcely any villages and but very little cultivation." Within the last thirty years this state of things has been remedied, and under the present more stable government conditions have greatly improved. The fort of Byagha was totally destroyed in the great earthquake, and has been rebuilt on a smaller scale—a remark that also applies to the residences of Sir Ugyen and his sister.

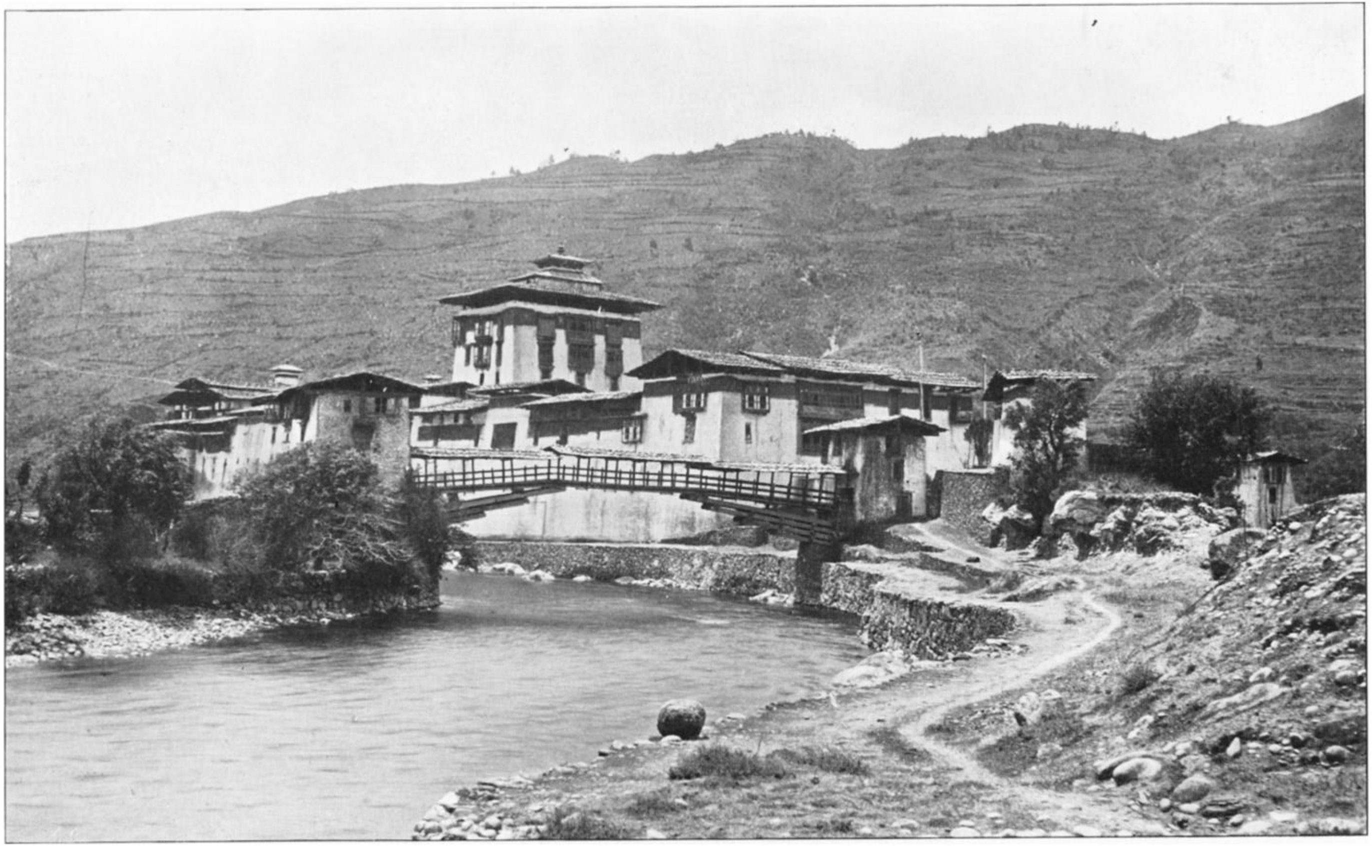
The route to Lhasa past Kulha Kangri lies up the valley of the Pumthang, and in a subsequent journey my baggage had to go by this route, as the direct route from Tashiyangtsi up the Lobrak was not passable. The site of the Sindhur Raja's palace is shown 2 miles above Angducholing. This prince was converted to Buddhism by Padma Jungne early in the eighth century of our era; the saint's resting-place is held sacred, and the depression in the rock, where he leant against it, has been roofed in and made into a gorgeous shrine.

On our return journey to Simtoka the scenery appeared even more lovely owing to the immense number of flowers in bloom—three kinds of yellow roses, clematis, wild pear, and rhododendrons were in wild profusion, while the meadows were literally carpeted with blue-and-white anemones, yellow pansies, and countless primulas. The giant Sikkim primula was in magnificent bloom, some plants having as many as six tiers of flowers. Each day brought out new kinds—a large white rose, a white and a mauve iris, and the giant white lily appeared for the first time. Orchids were abundant, and it seems a pity that the *Cypripedium Tibeticum* does not figure more in our shows, as the flowers we gathered were, as a rule, larger and finer than that figured in 'The Orchids of the Sikkim Himalaya.'

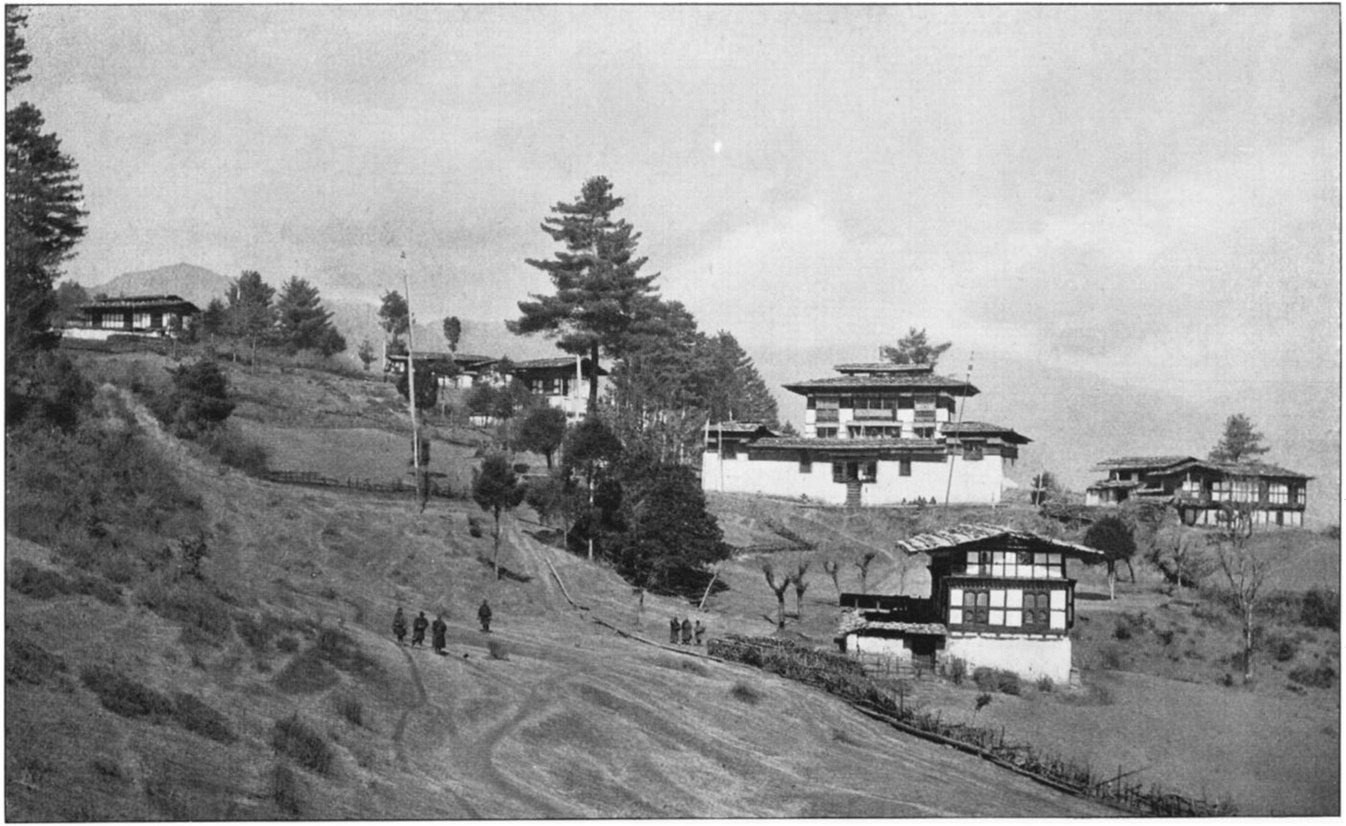
At Simtoka we crossed the Lhung-tso and proceeded up the broad valley of Thimbu-chhu or Tchin-chhu to Tashi-cho-jong, passing *en route* the knoll of Changlingmethang, where, in May, 1885, the then Poonakha Jongpen was killed, Aloo Dorzi defeated, and the supremacy of Ugyen Wangchuk's party so firmly consolidated, that there has been no revolution or internecine strife in Bhutan for the past twenty-four years.

Unlike other Jongs, the present Tashi-cho-jong has been built on the plain; it differs also from other forts in having two large gateways and in being protected on the west and north by a wide fosse filled with water. The bridge across the Tchin-chhu is not connected with the castle, as at Paro and Poonakha. The interior is arranged in a succession of courtyards, as in other castles; the northern portion being set apart for the monks. The main tower was destroyed by the earthquake; the new one was carelessly built on the old and shaken foundations, and already shows signs of serious subsidence. The original castle stood on a spur about a mile away near Dichen-Phodang; but having been damaged by fire, Deb Jidhur, at the end of the eighteenth century, removed the materials to the present site and rebuilt them there. We found the Deb Raja and his court comfortably established for the summer, having completed their annual migration from Poonakha.

After taking formal leave of our hosts, we marched north up the Tchin-chu valley, which for some 3 or 4 miles was open and well cultivated. Turning over a steep bluff, we entered an entirely different country as the valley narrowed considerably, and, being beautifully wooded, was picturesque to a degree. Our destination was Chari, the first monastery founded by the great Shabdung Rimpoche; it is terribly difficult of access, being perched on overhanging rocks, so that to get from the lower to the higher chapel it is necessary to climb up very narrow, rough stone steps, squeeze round the corner of a precipice, and descend other steps to the platform of the temple, which is literally clinging to the cliff. No wonder the Shabdung's enemies attacked it in vain. We now entered the narrow gorge that leads from the middle zone to the upland pastures. At first there was no road along the stream, but our path took us high up the hillside, where we had to round cliff after cliff, all well wooded, until we slightly descended to a small open side valley, in which the fort of Barshong is situated. From this place for some 10 miles the road was close to the stream, which had to be crossed and recrossed about six times before it emerged



POONAKHA: WINTER RESIDENCE OF THE BHUTAN GOVERNMENT.



VILLAGE OF NORBU-GANG.

on to the open uplands below Byaradingka. The gorge was almost filled by the Tchin-chhu, and bordered by stupendous cliffs of most weird shapes. These cliffs appeared to be formed of horizontal strata of sedimentary rocks, consisting of layers of limestone, sandstone, slate, or shale of a dark blue colour, and quartzites, and were cleft in many places from top to bottom, thus leaving narrow slits or fissures, often more than a mile long.

From Byaradingka an hour's gradual ascent led to the Yakleh-la, whence the road descends somewhat sharply to the Pimnakme-chhu, a stream which joins the Mo-chhu below the fortress of Ghassa. A few miles down the valley, Lingzi-jong suddenly appears in sight on a hill that seemingly blocks the valley; we had, however, to round several ridges before reaching our camp some way below the Jong. The fort was totally destroyed by the earthquake, and has not been rebuilt. The road rounds several ridges before making the final ascent to the Phew-la ridge, which separates Bhutan from Tibet. At Gangyul, a little village on the Tsango-chhu, the view of the Chumolhari glaciers is magnificent. A fair bridle-path leads along the left bank of the Tsango-chhu to a small but flourishing side valley, blocked at one end by a gneiss cliff, extending from side to side in a perfect level, over which poured a very fine waterfall. This little valley was well cultivated, and possessed many large juniper trees. The path brought us at an easy gradient to the top of the cliff, which we then discovered was the lower edge of another long level valley. In this way we progressed by a succession of steps, until we came to the last tread of the stairway, which was an almost precipitous slope of stones and rocks, up which our yaks and mules struggled slowly but surely, the zigzag, as far as alignment went, being very good. Above this was a small roundish flat, in the centre of which were the walls, still good, of the fort built by the Tibetans during our late troubles. A short incline leads to the pass, 16,400 feet, whence is obtained a magnificent view of the plains and hills of lower Tibet. The contrast between the fertility of Bhutan and the barrenness of Tibet is startling.

On my third journey along the boundary of Bhutan I traversed a great part of the outer range of hills, and was enabled to judge of the suitability of this ground for Nepalese settlers, of whom large numbers were entering the country, and also of the extent of the forests as well as the amount of damage said to be done by the cultivation of the outer and very wet slopes causing landslips, and consequently raising the river-beds in the plains, and, by altering the old courses, making them overflow the lands on either bank.

These extensive landslips are certainly taking place, and causing very considerable damage to low-lying tea-gardens, but the cause is not cultivation, but the excessive rainfall, which is literally washing away these hills, composed as they are of very soft strata, much shattered and faulted. The worst damage was being caused in most places in the valleys which did not run far into the hills, and in which there were no settlers or cultivation. I also found much excellent land suitable for the cultivation of tea, which would benefit the Bhutan Government to a very large extent were they to allow European capital into the country for the purpose. There are magnificent forests also in this part of Bhutan, but the difficulty of transport would prevent their ever being a source of revenue to the State. I also found a considerable amount of coal in the lower hills, but it was of an indifferent quality and very much crushed.

From Dorunga I travelled with Sir Ugyen, and we went a short way up the Kuru river. Our first day's march took us through a very narrow gorge with perpendicular quartzite rocks on either side, and a hard climb brought us to the top of the pass, where we stayed for the night. The next day we dropped down into the valley, and after two days' march, came to the Dongma-chhu. It is difficult to judge of the relative size of the two rivers, the Dongma and Kuru, without scientific observation, but I am inclined to think that this branch of the Monass, the Dongma, is as large, if not larger, than the Kuru or Lobrak. I saw both rivers on this journey in the cold weather, when the water was at its lowest, and I again saw them on my fourth journey, in the rains, when they were very much swollen, and I was therefore able to judge fairly well. After crossing the Dongma-chhu, the surrounding rocks changed to manganese limestone, and the vegetation lost all its sub-tropical luxuriance, and was chiefly *Pinus longifolium*, of which there were some magnificent forests. On the outer slopes of the hills there is hardly a habitation, but on coming into the Kuru Dongma-chhu river-basin villages became more plentiful, and there was a considerable amount of cultivation. The houses were well built, and the people looked prosperous and contented. My return journey was made by a slightly different route, which brought me out at Dewangiri.

I started on my fourth journey in May, 1907, in the middle of the hot weather, and until I reached Dewangiri the heat was excessive. The track leading from the plains to Dewangiri passes through narrow ravines in the sandstone hills, and a sudden thunderstorm coming on, I was nearly washed away with my baggage. The river rose with extraordinary rapidity. On leaving Dewangiri I followed Pemberton's route *viâ* Tashigong to Naylamdang opposite Lhuntsi Jong, but from thence I turned to the north, following up a tributary of the Kuru river. I was unable to follow the Kuru itself owing to the lateness of the season, for the river was already in flood and had washed away all the temporary bridges thrown across it to make a cold-weather road along its banks.

My route took me past Singhi Jong and over the Bod-la into Tibet. The road is fair all the way to Singhi Jong, and I was able to ride most of it; but soon after leaving Singhi I had to abandon my mules and walk, and transfer my baggage to coolies, as the track crosses some magnificent but almost impassable rocks. The views near the pass were fine, but the weather was very wet for the most part, though in crossing the pass I left the rain behind me and had magnificent weather. The scenery also changed, becoming more rugged and barren, though some of the slopes were still well wooded. On descending the valley I soon realized I had entered Tibet, as the mountains opposite on the other side of the eastern branch of the Lobrak had not a tree or, to all appearance, a blade of grass on them, owing to the monsoon current having been stopped by the southern watershed of the great Himalayan range. I camped at Lhakhang Jong, where the Tibetan officials did all in their power to make me comfortable, and where Sir Ugyen met me. From Lhakhang my journey took me entirely through Tibet, and hence does not come within the scope of this paper, and I will only add that I went as far as the head of the Lobrak Chhu, crossed into the Chomo-Chang-tang lake-basin, and thence into the Neylung valley and on to Gyantsi, from whence I returned by the ordinary route *viâ* Kala Tsho and Phari.

My fifth journey took me practically over the same ground as in my second journey, with the exception that on this occasion I entered Bhutan from Phari *viâ* the Temola, following the route *viâ* Duggye Jong, and returned to the plains from Paro by a hitherto unknown route *viâ* Bite Jong and Dongma Jong, entering the plains at Jaigaon. This journey calls for no special mention, and as my paper is already a very lengthy one, I will pass it over with the remark that on the journey from Paro southwards I passed some magnificent forests of pine of all kinds, and on the outer slopes of fine oaks and chestnuts, which ought in the near future to be of value to the Bhutan Government, and which I have advised them to conserve most carefully, as they are within carrying distance of the large tea districts in the Doars and the prospective tea industry along the Bhutan subhills, where there are most valuable tea lands, regarding which the Bhutan Government is at present negotiating with the British Government.

I hope I have said enough to show what an exceedingly interesting and beautiful country Bhutan is, and hope that under Sir Ugyen's rule it will soon be opened up and become a prosperous and enlightened State.

Geographical Position.—Bhutan is bounded on the south by Assam, on the east by the state of Towang, subject to Tibet, on the north by Tibet, and on the west by Sikkim and the British district of Darjeeling. It lies entirely within the Himalayas, between 26° 30′ and 28° 30′ N. lat. and 88° 45′ and 92° 15′ E. long.

Mountain System.—The mountain system may be most easily described as a series of parallel ranges running, in a more or less southerly direction, from the main ridge of the Himalayas, where they attain an altitude of from 24,000 feet to 25,000 feet.

River System.—The drainage runs from north to south, following the mountain system. The main rivers are—

(1) The Ammo-chhu, known as the Torsa in the plains, which takes its rise in the western slopes of Chomolhari, and drains the Chumbi valley.

(2) The Wang-chhu or Tchin-chhu, known as the Raydak in the plains; its main tributaries are the Ha-chhu and Par-chhu, as well as many small rivers.

(3) The Mo-chhu or Poonakha-chhu, which becomes the Gadadhar in the plains. Its main tributaries are the Tang-chhu, Po-chhu, and Mo-chhu, and it drains a very large area, some of its tributaries taking their rise on the south side of the Wagya-la, at the head of the Neylung valley.

(4) The Karu-chhu or Lobrak-chhu, known in the plains as the Monass. This river, as well as its large tributary the Gongmachhu, takes its rise in Tibet on the northern slopes of Kulu Kangri, and in a snow range to the east of Towang. It has several other large tributaries, amongst them the Pumthang-chhu and the Mati-chhu. The Monass drains the whole of eastern Bhutan, and has cut a deep gorge from its source to its inlet in the plains, passing through the main range at an elevation of 10,000 feet.

General Division of Country.—Bhutan may be roughly described as consisting of three distinct zones rising one above another.

1. The outer hills, which rise abruptly from the plains of Bengal to a height of between 3000 to 4000 feet.
2. The central temperate valleys, running up to a height of 9000 feet.
3. The high grazing-lands and snowy ranges.

1. The first zone is about 30 to 40 miles wide, where the rivers run with great swiftness through deep-cut ravines. The rainfall varies from moderate to excessive, and the vegetation is luxuriant. Owing to the prevalence of fever, habitations are few and far between, tenanted principally by Bhutanese bearing a bad character, and by Paharias, who have migrated from Nepal along the foothills. The climate is indifferent, but on the uplands of Sipchu in the west the Nepalese emigrants have cleared off the forests and are increasing rapidly, in a manner which shows that in their case they find nothing to complain of.

2. The central zone covers from 20 to 25 miles, and is a series of wide valleys parallel to each other, running in the same direction as the mountains. The slopes are not nearly so precipitous as in the outer hills, and, owing to a more moderate rainfall and cooler climate, are clothed with the vegetation of more temperate regions, such as firs, pines, junipers, oaks, etc. These valleys lie at elevations from 4000 feet to 9000 feet, and are sometimes over 2 miles wide, as at Paro and

Byagha. In my opinion, these flats appear to be beds of old moraines which have not yet been scoured out into the deep-cut V-shaped valleys which characterize the lower hills. The rivers, owing to their broader channels and diminished rainfall, are not so swift or so subject to floods, and in consequence the range of fluctuation in their levels does not exceed a few feet.

3. The third or northern and highest zone consists for the most part of narrow gorges opening out into wider valleys, hemmed in by high bare rugged mountains, and as the greater part of it lies above the limit of tree vegetation, it is but sparsely inhabited.

During the summer months, when the higher slopes are covered with luxuriant grass, a limited number of families, with their herds, which are not very numerous, consisting mostly of yaks, migrate to these uplands to take advantage of the splendid grazing. Sheep are conspicuous by their comparative rarity, but game is plentiful, Burhel, *Ovis Hodgsoni*, shau, and takin being found in these parts.

Climate and its Effect on Vegetation and Scenery.—Lying in the position it does, and with such differences in altitude, naturally the climate of Bhutan varies enormously, and with it the vegetation, which graduates from sub-tropical in the deep-cut lower valleys to arctic in the higher regions. Consequently the scenery is very varied and most beautiful. In the lower valleys, with the excessive rainfall and the hot moist atmosphere, the vegetation is luxuriant, palms, ferns, canes, and bamboos growing in wild profusion, changing gradually as one ascends to groves of chestnuts, oaks, alder, fir, magnolia, and birch, the highest of all birch and juniper, close to the snow-line. Between 4000 feet and 15,000 feet, the whole of the higher hills are clothed with most beautiful rhododendrons, of which there are no less than thirty-three known varieties, and which, flowering in masses, make a blaze of colour, while the magnolia blossoms stand out pure white and pink on the huge trees in the midst of dense forest. In the forests themselves, above 7000 feet and up to 10,000 feet, the trees are festooned with trailing masses of moss and grey lichen often 4 feet to 6 feet in length, and have every appearance of a fairy scene, more especially when after rain everything sparkles with dew-drops in the brilliant sunshine. At these high elevations, too, are the enormous pine forests into which the glaciers descend, and still higher, stretches of magnificent grazing-grounds studded with alpine flowers, surrounded by some of the finest snow-peaks in the world.

Every kind of scenery is to be found, from the lower valleys with masses of tropical vegetation growing in the soft damp atmosphere, full of brilliant soft colouring, with their great swift rivers running past, and glimpses of the distant snows, to the higher valleys and mountains with more temperate vegetation, their forests, and craigs, with mountain torrents rushing through narrow gorges and wonderful waterfalls, and wider views of the snowy mountains, still with the peculiar softness due to the damp atmosphere; and, highest of all, magnificent snow-peaks and glaciers standing out sharp against the sky or shrouded in cloud and mist, grim and forbidding. It is impossible to find words to express the beauty of the scenery and its varied character, and I fear my lantern views do but bare justice to their subjects.

History.—To explain some terms in my lecture a very brief history of Bhutan seems necessary. In the eighth century of our era the country was inhabited by people closely connected with India, and governed by small princes, of whom the Sindu Raja was the most powerful. This monarch, with his subjects, was converted to Buddhism by the Indian Saint Padma Sambhava some time prior to the saint's visit to Lhasa. The kingdom, however, was overthrown in the latter part of the ninth century by Lan-darma, the apostate King of Tibet; and again two centuries later the country was overrun by people from the north of the Himalayas; but no one appears to have had any authority, until we find in the thirteenth century a powerful lama, styled Lapha, who in his turn was ousted by Lama Fago Dukgom-Shig-po of Ralong, with whom came five lamas belonging to rival sects. I mention this, because Lama Apha, after his defeat, handed over the Chumbi valley, hitherto Bhutanese, to the ruler of Tibet. In 1557 A.D., another Ralong monk, Dujom Dorji, entered Bhutan, and after continuous warring with the successors of the five lamas mentioned before, made himself master of the whole country; several invasions from Tibet were successfully repulsed, and his kingdom firmly established. He is best known by his title of Shab-dung Nawang-Namgyel-Rimpoche, or the Dharma Raja of Bhutan. He introduced good government, appointed local governors under the titles of Penlops, Jongpens, Zimpens, etc., and established a central council, with a deputy or Deb Raja as president, and to them entrusted the executive or civil administration, while he devoted the latter days of his life to religious duty. He died in 1592, aged fifty-eight.

After his death a triple reincarnation arose. His body reappeared as the Dharma Raja, his voice as the Chole Tulku, and his mind as Thi Rimpoche; and these incarnations have been continuous to the present time. The late Dharma Raja died some four years ago, and his successor has not yet been recognized, the late Deb Raja was the Chole Tulku, while the Thi Rimpoche has committed grievous sin and will not again appear.

The office of Deb Raja was an elective one, and lasted nearly 350 years; but on December 17, 1907, the lamas, officials, and laymen of Bhutan unanimously abolished the office, and proclaimed Sir Ugyen Wangchuk Maharaja or Gyelpo, and declared the office to be hereditary in his family. This was done with the consent and approval of the Deb Raja, who has now retired to a life of seclusion and religious meditation.

BRIDGE AT ANGDUPHODANG.

TONGSA JONG.

The proximity of Bhutan to the route finally adopted for our military expedition to Lhasa in 1904 rendered the attitude of the Bhutanese Government toward us a matter of considerable importance. Fortunately, the Durbar decided to follow the precedent of 1888, and refused to join Tibet. They moreover sent the Tongsa Penlop, Ugyen Wangchuk, as their representative to accompany the mission, to give every assistance in his power. As a recognition of his valuable services, Ugyen Wangchuk was honoured by a Knight Commandership of the Indian Empire, and in March, 1905, I was despatched by the Government of India, at the head of a mission, to convey to Sir Ugyen the Insignia of the Order.

Our knowledge of Bhutan has been chiefly derived from the somewhat restricted reports of previous missions. Bogle in 1774, and Turner in 1783, entered the country from the plains of India at Buxa, Captain Pemberton with Dr. Griffiths at Dewangiri, while Eden crossed from Darjeeling *viâ* Dumsong and Sipchu in 1864. There was also the military expedition in 1864–5, which resulted in our seizure of the eighteen Docars and the Daling Subdivision territory, which has proved of enormous value to the Government of India, and which brings in a large revenue.

Ethnography.—It would be impossible to classify or trace the origin of the many different types of people found in Bhutan, without long and careful study, but I would point out that people from China, Ladakh, and Europe have found their way to Bhutan, as well as Khampas, Duphlas, and other nearer races. We came across two or three men who, in fairness and texture of skin and hair and in feature, were indistinguishable from English or Germans, while others were low animal-looking negroids; but among the better classes there certainly are three distinct types: first, one in which the men, like Sir Ugyen Wangchuk, have broad pleasing faces, somewhat French in character; second, a Semitic type, with features resembling those of Cabulis; and a third type, in which the facial characteristics are oval and refined.

A curious fact differentiates the Bhutanese from all their neighbours, viz. the hair on their faces. It may be noticed that the Dharma Raja is usually depicted with a long pointed beard, and many, like Sir Ugyen, wear moustaches.

Morals.—It is possible that eighteen years' freedom from internecine strife, and a firmer and juster administration, as well as a complete cessation of slavery, when the slaves were recruited from the scum of the plains, may have brought about a change in the moral qualities of the Bhutanese; but my experience in no way bears out Dr. Griffith's strictures that they were "immoral, indecent, dirty, wanting in courage, and given to drink; while the higher classes were utter strangers to truth, greedy beggars, rapacious, and crafty in working evil." I will not finish his remarks, as they are utterly inapplicable at the present time. On the contrary, we were well received and welcomed everywhere. Nothing immoral or indecent ever came to the notice of myself or the members of my missions either time, or in any of my travels. The men are not nearly so dirty or offensive as they have been represented, nor do I consider them idle and drunken. Certainly they do drink much *chang*, but not so much as their Sikkim neighbours. Besides, the strength of *chang*, or *murwa*, is less than half of the mildest of ales, and it is impossible for even a weak-headed person to become at all elevated by drinking it.

On the outer hills bad characters undoubtedly swarm, and so acquire a bad reputation for the bulk of the people; but in so far as personal experience goes, I can hardly speak too highly or gratefully of the friendly reception I met with everywhere, the warmth of their welcome, and the desire of all classes to show me hospitality.

Physically, the Bhutanese are a fine, robust people, who compare very favourably with their neighbours in Sikkim, Tibet, and the plains. They are active and capable of enduring hardships; good walkers, and able to cover immense distances in their own hills. On the other hand, the Bhutanese are rather wanting in energy and initiative, and at the same time are inclined to bluster. Those who live in the intense cold of the higher altitudes, in tiny huts full of smoke, are dirty in person and habits; but we ourselves did not always insist on having a morning tub when at 13,000 feet. All the people who formed the immediate *entourage* of the officials were clean and respectable in their outward appearance, while the officials themselves were always immaculate in their brocades and silks.

It is impossible to estimate the population of Bhutan exactly, or even to decide whether the true Bhutanese race is diminishing; but there can be no question that the outer hills are being overwhelmed by a flood of Nepalese immigrants. The general appearance of the country, the evidences of the abandonment of houses and terraced fields, and the decay of irrigation channels, all show that there were more cultivators formerly, and that there is ample scope for regeneration and immigration. I can safely predict that a little assistance and encouragement from the Government of India, which has benefited so much by the annexation of the Bhutanese Duars, would secure a return of prosperity throughout the country, which at present probably includes a population of at least 300,000.

Religion.—The religion professed by the people of Bhutan is Buddhism or Lamaism, *i.e.* they follow the religion of Lhasa, and though they have their own particular saints, they look up to the Delai Lama as the head of their Church.

Industries.—In handicrafts the Bhutanese used to be exceedingly clever, but the increasing poverty of the state is producing its natural effect, and good workmen are becoming very scarce. Good specimens of metalwork are still made for the monasteries, but the open work, so conspicuous on the older sword-handles and dagger-sheaths, has almost become a lost art, and the same may be said of the work in applique and embroidery. Casting of bells and other articles is still carried on at Paro and Tongsa and other large forts. Weaving is pretty general; the factories are maintained by the wealthier officials, and the weaving-room at Byagha was very noticeable. Cotton, wool, wild and domestic silk are all freely used, but, unfortunately, the introduction of aniline dyes has spoilt many patterns. Matwork is very good, the work in many of their baskets being so fine as to be watertight.

Sword-blades are much valued, and good ones are regarded as heir-looms, and handed down from father to son. These blades, by dint of continual heating in charcoal, have been made into excellent mild steel, and are kept beautifully bright and polished. Their price varies from £2 to £50, though to a casual observer one is just as good as another.

Wood-carving and painting are still in demand for the monasteries, and, though scarcer than formerly, show no signs of deterioration. Clay images and ordinary articles of domestic use are turned out, but the potter's art is at a low ebb.

As architects and builders, the Bhutanese are no mean workmen. The houses are either built of stone set in clay, or clay empese. Under the latter process, clay mixed with small stones is placed in a wooden frame or mould and trodden down until it is consolidated into a block; this, on exposure to air, quickly hardens, and in course of some years acquires nearly the solidity of stone. This preparation is used either in blocks made on the ground and employed like huge bricks, or in layers made on the actual wall. The outer side of the walls has a slight inward slope, but the inner side is perpendicular. The houses consist of three or four stories, with generally a balcony or two, and sliding shutters to let in light or keep out cold. No ironwork is used, the doors turning on wooden pivots. The frames, beams, etc., are all fitted together on the ground, before being set up in the building itself, and kept together with key-pegs. Timber being plentiful, the ceilings are supported on numerous heavy beams, and are well planked, the highest being always covered with a coating of pounded clay to help keep rain out. The roofs are gently inclined, and formed of pine shingles from 4 to 5 feet long, which are kept in place by heavy stones, as in Switzerland. There are no chimneys, and ladders take the place of staircases. In laying out buildings, set-squares and a skirret and line are used. Wedges and heat are employed in splitting the stone slabs (many of which are of great size) used in paving the courtyards.

The cantilever bridges are very strongly made, and some are as much as 170 feet in span. The chains for suspension bridges are made of wrought-iron links, but of late years the construction of this kind of bridge seems to have been abandoned, whilst previously existing ones have been allowed to rust and decay. I did not notice any cane suspension bridges such as are common in Sikkim.

Geology.—I regret to say I know very little of geology, but, speaking generally, the extreme outhills are formed of soft sandstone, which contains veins or strata of coal. This series is the same as the Damuda series, and the coal is of the same formation. Where I have seen the coal, it is much crushed, has often been forced up by enormous pressure into lintel-shaped pockets, and is usually much faulted, and in many places inverted. The sandstone does not extend the whole way along the foothills, and has in several places been denuded.

Above these come mica-schists and quartzites. It is in the former that most of the minerals are found, but with the exception of copper, none have been found of any value. Iron is found in places, and is still worked by the Bhutanese. Above the quartzite magnesian limestone appears in several places, such as the Kuru river at Kenga, on the road to Tongsa from Dewangiri, and at Buxa. Above them comes gneiss, which forms the bulk of the rocks right up to the snows. This, however, is not invariable, as thick beds of limestone and shale are met with—limestone up the Tchinchhu, at Poonakha, Rokhbi, and in the Chumbi valley; and shale in the Tchinchhu and Chumbi valleys. Some of the very highest peaks are composed of granite, as the horn of Chumulhari. Beyond, *i.e.* to the north of the very highest peaks, come shale and limestone containing fossils. This tract is, however, in Tibet. A piece of gypsum was found in the river-bed close to the Dung-ma-chu.

Botany.—We had a professional plant-collector with us, who succeeded in finding some 150 or 160 new species; the collection has not yet been systematically examined, so I cannot give any definite information as to the net result. This, however, is of little consequence in view of the magnificent collection made by Dr. Griffiths; and I can add nothing to Dr. Anderson's short note of 1865.

Zoology.—As regards animals, the habitat of the Takin (*Budorcas taxi color Whitei*) was ascertained. Also news of several herds of shau does in the Chumbi valley was brought in, but none of stags, so they were left severely alone. Burhel were plentiful; in north-east Bhutan, *Ovis Hodgsoni* was common. Elephants were numerous in the outer hills, but most of the tusks we saw were said to have been obtained from elephants that had been dead for years. In the Tongsa Jurisdiction quail were very plentiful.

Among their domestic animals, the cross between the hill cattle and the wild mythun (*Bos frontalis*) is a very fine animal; the plough oxen in the Pumthang valley would earn a high place at our agricultural shows. So highly valued is this breed, that the Nepalese Government constantly send over to Bhutan for pure and half-bred mythun; a yearling calf which was offered to me was said to be worth at least £20 on the spot.

VALLEY ABOVE PASHI-CHO-JONG.

INTERIOR, TONGSA JONG.

Pigs also are good, English and China stock having been imported. Many of the fowls were fine birds, and pigeons swarm everywhere.

The once celebrated Tangun pony, mentioned by Turner and others, had entirely disappeared some twenty or more years ago; a mysterious disease broke out and swept the stock away. Mr. Paul seemed to have possessed one of the last; it was a very powerful skew-bald about 13 hands high at the outside, with a silky coat remarkable in a hill pony. At present the ponies are not equal to the mules, but Sir Ugyen has now imported an Australian stallion. The best mules, however, are brought from Tibet. Altogether horse-breeding is at a low ebb, as railways and cart-roads have put an end to the trade in ponies with the plains.

Revenue.—The second Deb Raja Migyur Tempa made a very good cadastral survey and record of rights, which is the basis of the present revenue system. The rent rolls are issued under the seal of the Deb Raja, and counter-sealed by the local Penlop or Jongpen. The position, size, and nature of each man's holding is carefully entered, and all increases or decreases, and any change of ownership, are noted under seal; the ryots only pay for what they actually possess; in consequence the state revenues vary, and are declining. The old village boundaries are still retained, and consist of natural features, such as rivers, streams, and ridges.

Agriculture.—Griffiths records, "Of the agriculture of Bhutan little is to be said, as so very large a proportion of the supplies is derived from the plains. The stage in which the little agriculture that is carried on is, argues as little in favour of the amount of agricultural skill they possess as the uncultivated state of the Duars does in favour of the numerical extent of their plains subjects." Probably the loss of these Duars has compelled the Bhutanese to pay more attention to agriculture. The Bhutanese cultivator lays out his fields in a series of really beautiful terraces, levelled from the side of the hill and often supported by strong revetments of stone, sometimes of considerable height. The fields are usually carefully protected either by stone walls or by fences of young pine trees and pine staves. In the main valleys further protection to the crops is afforded by planting rows of willows and other trees across the general direction of the violent winds which rush up from the plains.

To the excellence of their irrigation works I have already borne testimony. Both hoe and plough are used; the latter being larger and stronger than that of the plains. The principal crops are rice, wheat, barley, maize, buckwheat, turnips, and peas; as well as mustard and castor-oil seed and sugar-cane in small quantities. Oranges of excellent quality are grown on the outer hills, and very good walnuts are indigenous. Madder and rubber are not properly cultivated, but are found wild. Paper of very tough quality is made from the daphne plant, which also grows wild. No attempt has been made to grow mulberry plants, because the cocoons, from which Endi or Erhi or Tussar silk is made, are collected in their wild state from the jungles inhabited by the insects which produce them.

The PRESIDENT (before the paper): Mr. White, who has kindly consented to lecture here to-night, is an engineer by profession, and, in the course of his professional duties, he has visited a great many parts of India. During the last twenty years he has been chiefly employed in Sikkim and in connection with the Tibetan border, and he has thus had the opportunity of making a number of interesting journeys into Bhutan, a region which is very little known. It is the results of those journeys which he is kindly going to describe to us to-night.

After the paper, Sir JAMES BOURDILLON: I was not aware that any discussion would take place, but I should like to say a few words which occur to me with reference to Mr. White's lecture. I wish first to draw attention to a matter which would certainly never have been mentioned by Mr. White himself, and that is the great debt we all owe to his untiring endeavours, and to his personal qualifications for carrying out the expedition he has described. He was stationed for a long time in the Eastern Himalayas, and gradually acquired a unique influence and authority among the people of those regions. Thus has grown up gradually, and by almost imperceptible degrees, the great power he displayed in carrying through this expedition. Bhutan, for a long time, has been an absolutely closed country to Europeans, and, if we look back to our official relations with that country, the review is one which cannot be regarded with satisfaction. Our envoys have been insulted, and our efforts towards friendship have been frustrated again and again; so that it is a most remarkable achievement on Mr. White's part that he has been able to carry out this expedition, and to turn what was a hostile foreign state into a neighbour closely allied in friendship with the Government of India. Mr. White has not been able, in the short time placed at his disposal this evening, to say much about the manufactures and the beautiful artistic work accomplished by the people. The Bhutanese have long enjoyed a very remarkable civilization. The metal work, the weaving, the embroidery, are all of the highest character, and not only very beautiful, but possessed of very distinct characteristics of their own. In conclusion, I will only ask you to express your satisfaction with the lecture we have heard to-night, and in doing so, never to forget how much is due to the great personal influence of Mr. White himself.

General Sir RONALD MACDONALD: My first acquaintance with Mr. White was just at the start of the Tibet Expedition. I had then the feeling that trusting to a single line was perhaps rather hazardous, and I asked Mr. White whether he could run an alternative line from Sikkim. He at once undertook to do so, and, thanks to his influence in Sikkim, he was able to put on something like 1500 men, who worked all through the winter and assisted our advance. When we got into the Chumbi valley in the winter, we very soon found that Mr. White had a great reputation among the Bhutanese, and when the Tongsa penlop, who is now the Maharajah Bhutan, came to visit us, he was already predisposed in Mr. White's favour; but this rapidly ripened into confidence and friendship, which has enabled Mr. White to achieve the great results of which we have just heard. We have heard how Mr. White was a welcome and honoured visitor in the exclusive country of Bhutan, and I will mention one little incident at Lhasa. When we arrived there, the Tibetan representatives asked us that we should prevent any of our officers or men entering any of their sacred places. After consulting Colonel Younghusband

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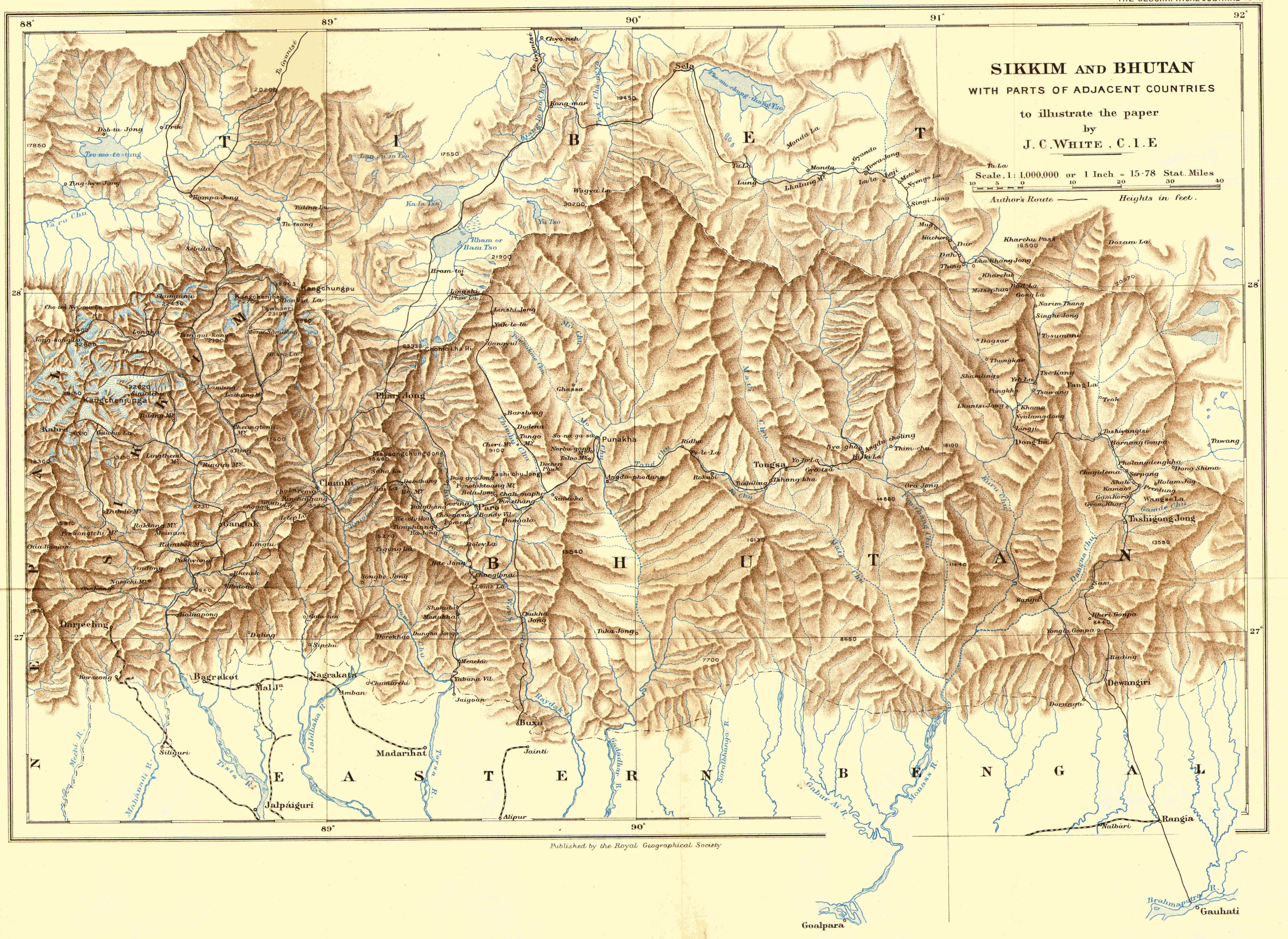

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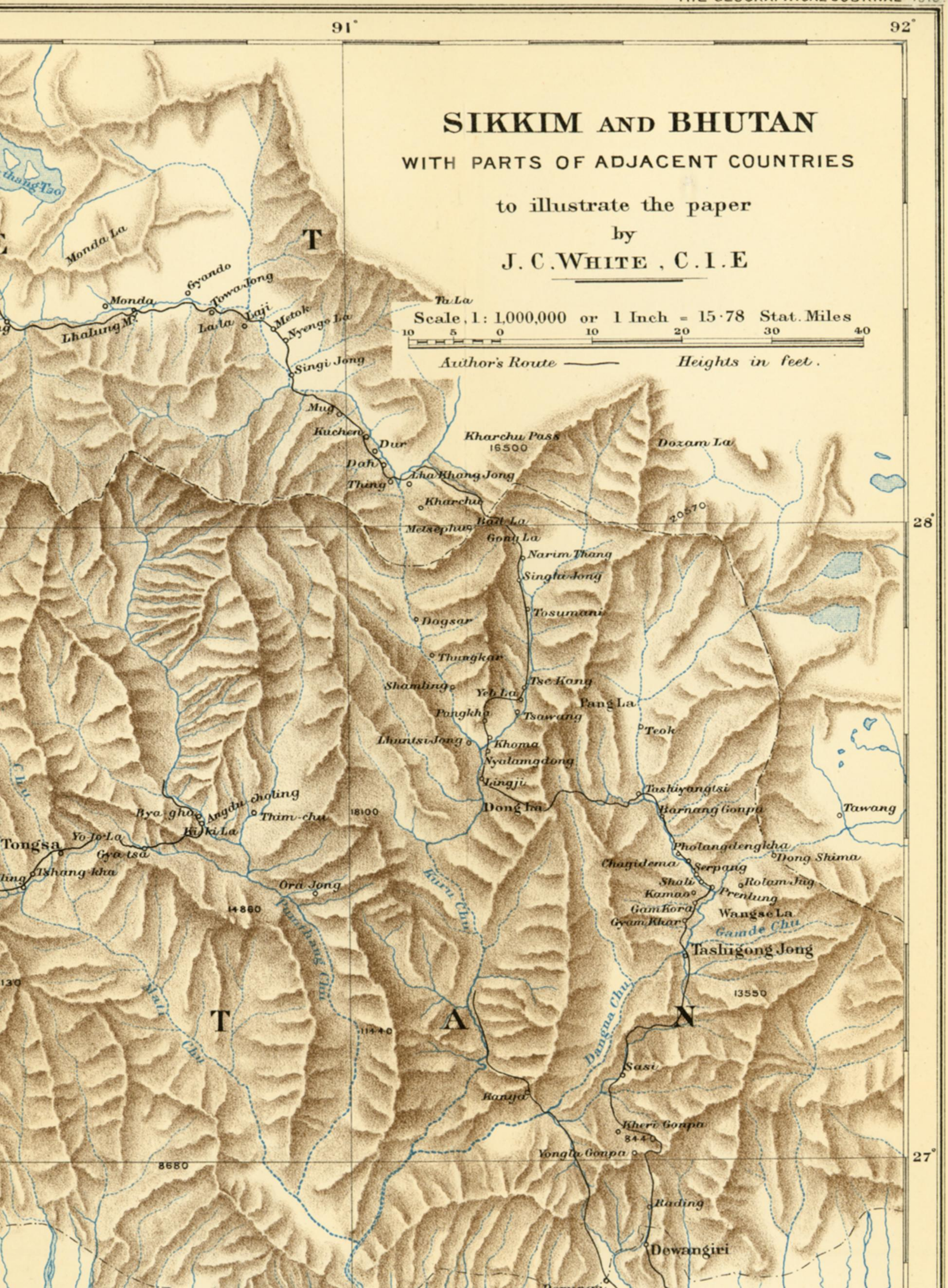
SIKKIM AND BHUTAN
WITH PARTS OF ADJACENT COUNTRIES
to illustrate the paper
by
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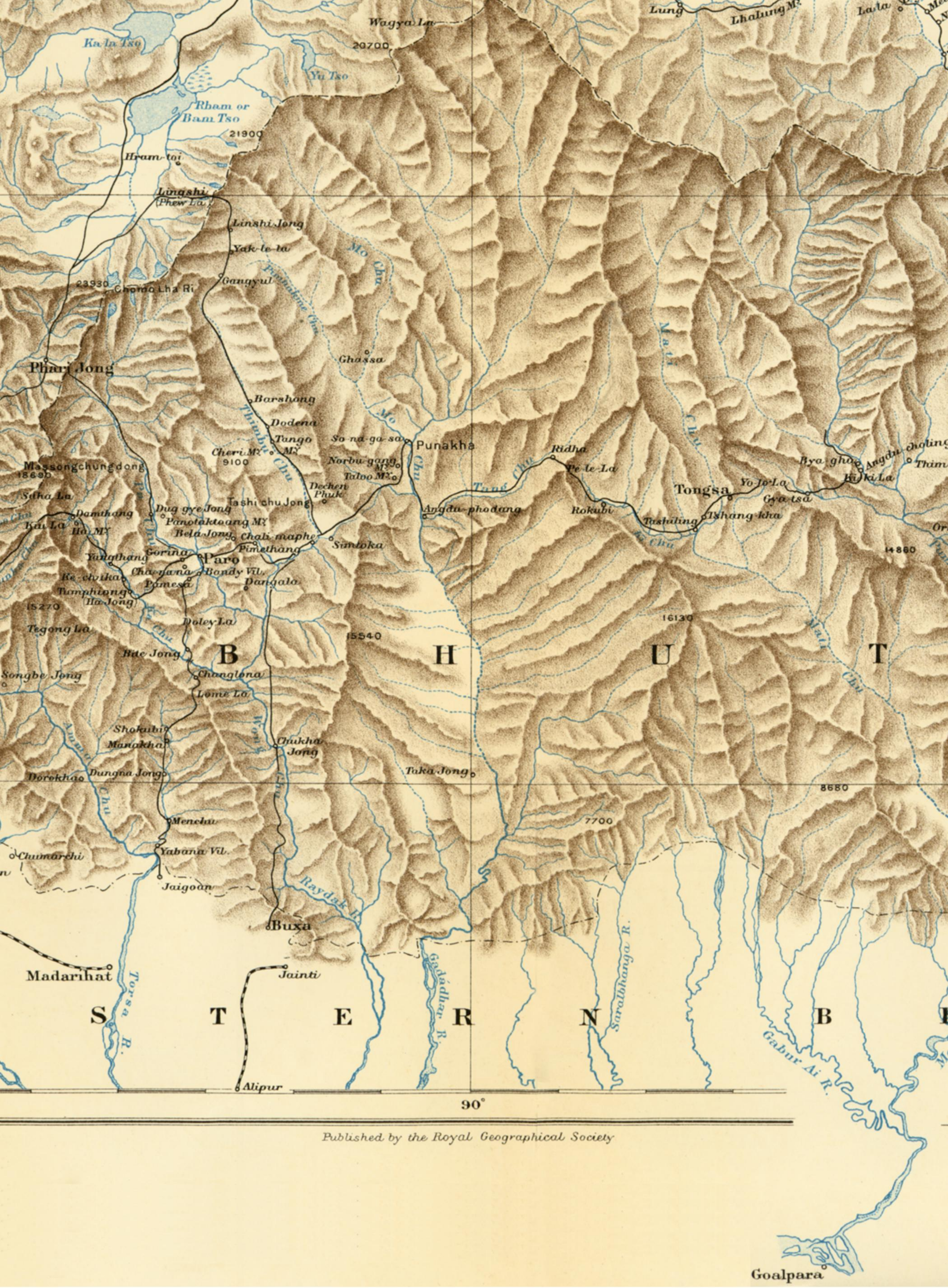

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published in the newspapers give the length of the lava-stream as $3\frac{3}{4}$ miles, and say that it advanced half a mile in twenty-four hours. The fact that it was near Santiago on the 19th shows that it must have flowed rapidly at first, but its progress was arrested or greatly reduced in two or three days, as it is certain that Santiago has not been invaded, and the stream descending towards El Tanque has also come to rest.

The latest reports state that the eruption took place on level ground to the south-east of Mount Bilma, and not far from Chahorra. The craters are situated on a fissure which runs west 15° N. at an elevation of 1525 metres. While the fissure at present active is probably not the same as that from which the lava of 1798 proceeded, it is sufficiently close to it to confirm the opinion expressed by Leopold von Buch in 1829, that this is the principal orifice of the Peak under present conditions. Many parties have visited the scene of the eruption from Orotava and other places, and have found it easy to get within 400 yards of the craters. The wind during the early part of the outburst was persistently from the south, and a cone of ashes, stated to be 400 to 500 feet high, has been built up on the north side of the orifice. Clouds of steam and showers of stones were being projected at intervals from the central crater and from two apertures on the sides of the cone, but the flow of lava seems to have lasted for only a few days, and had nearly ceased on November 26. The distance from Santiago is 3 or 4 miles.

While it is too early to conclude that the eruptions are at an end, there are certain inferences from the facts of which we are in possession that may be safely drawn. As on two previous occasions (1706 and 1798), the north-west quadrant of the volcano has been the seat of activity. Near the base of Chahorra, or to the north-west of it, a fissure has opened and a large amount of lava has been emitted, which has taken its natural course down the valleys towards the sea. The great ring-shaped crater-wall which girdles the base of the Peak is a sufficient protection to the other parts of the island. Probably the lava will continue to creep forward slowly for some time, but the district is not thickly inhabited, and there has been no loss of life. It is interesting to note that the history of the Peak indicates that eruptions tend to recur at intervals of about a century.

John S. Flett.

CENTRAL ASIAN ARCHÆOLOGY.*

These two quarto volumes present us with records of considerable value, dealing with the archæological, zoological, and anthropological aspects of a site at Anau, near Ashkabad, in Turkestan. Russian work in this region has been concerned mainly with geology, and even so is inaccessible to the average Englishman; so that we have here a revelation of prehistoric culture which fills up one of the great gaps in our knowledge of the Orient. The editor is to be complimented on his presentation of the results, which are fully detailed, excellently illustrated, and altogether adequate.

Those who perused the record of the preliminary expedition of 1903 will remember that it was a reconnaissance. Prof. W. Davis, of Harvard, and Mr. Ellsworth Huntington made a rapid survey of the Western Tian Shan mountains, in order to get "a broad view of the region and its development," while Prof.

* Explorations in Turkestan. Expedition of 1904. Prehistoric Civilizations of Anau. Origin, Growth, and Influence of Environment. Edited by B. Pumpelly. 2 vols. Carnegie Institute of Washington. Publication No. 73. 1908. 10$.

Pumpelly and his son examined the region from Sir-darya to the Pamirs, mainly for the choice of a suitable site for excavation.

The various members of the expedition "established independently positive proof of at least three distinct glacial and interglacial epochs of the Glacial period, and obtained abundant evidence of the deep-reaching reaction of these upon the topography of the mountains and plain." The relation of these epochs to the glaciation of Europe, particularly of Russia, was brought out. Prof. Pumpelly further tells us emphatically that Richthofen's theory of the wind-borne origin of loess was duly confirmed, and adds that it is the direct product of deflation and disintegration, and arises from alluviation or dry deltas and dry flood plains.

In the report before us, Mr. R. W. Pumpelly determines the changes and history of geological movement from the Pliocene period, the weathering, glaciation, and alluviation of the mountains, deserts, and oases, and presents a study of deltas and oases in connection with their occupation by man. But the interest of these two volumes centres in the archæological work, the excavation of a site chosen in 1903 at Anau, about a quarter of a mile from the Trans-Caspian railway and a few miles beyond Ashkabad.

Prof. Pumpelly deserves congratulation for his great pluck in undertaking, as he tells us, on the verge of threescore years and ten, such an arduous expedition. As far back as 1863, when travelling in China and Mongolia, he had become interested in the phenomenon of the progressive desiccation of the Trans-Caspian region. It was not, however, until forty years later that the opportunity of testing his surmises presented itself, in the form of a grant from the Carnegie Institute. The object of the expedition cannot be better put than in his own words :—

"It had long seemed to me that a study of Central Asian archæology would probably yield important evidence in the genealogy of the great civilizations, and of several at least of the dominant races; and that a parallel study of the traces of physical changes during Quaternary time might show some coincidence between the phases of social evolution and the changes in environment; further, that it might be possible to correlate the physical and human records, and thus furnish a contribution to the time-scale of racial geology."

Everybody will sympathize with this aim. We are sadly lacking in trustworthy chronology earlier than 3000 or 4000 B.C., and what palæontologist, prehistoric archæologist, or anthropologist has not longed to be able to date, with a fair approximation to the truth, the great landmark of the bridging of the prehistoric European-Asiatic "Mediterranean," and the free ebb and flow of animal migration between Asia and Europe?

Before the end of the 1903 expedition, Prof. Pumpelly realized that the problem was not merely geological, but archæological, and fortunately obtained the aid of the experienced archæologist, Dr. Hubert Schmidt, of Berlin. The site chosen consisted of two mounds, 40 and 50 feet high, and the city settlement of Anau. The northern kurgan had already been trenched twenty years before by General Komorof, and pottery lay on the surface and in the different settlement strata of the trench. The mounds represent, not tombs, but the *débris* of adobe dwellings, etc., of successive settlements of peoples, and these extend to a depth below the level of the plain. As the north and south kurgans and the city mound represent a sequence, with some gaps between, we have a very long period of time, represented by the accumulation of *débris* and sand of at least 170 feet. The earliest inhabitants built dwellings of sun-dried bricks; used flint sickles, but no celts; cultivated wheat and barley; spun; painted their pottery with geometric designs; later possessed domesticated sheep; and towards the end of the First Culture (third millennium B.C., according to Dr. Schmidt) began to use copper implements. This

Anau civilization, beginning with the Neolithic, passed through a lengthy Copper Age, but never a Bronze, and by the Fourth Culture period, *i.e.* at the top of the second or south kurgan, appears the Iron Age.

Dr. Schmidt, in seeking external connections for the culture at Anau, says, "The pottery of Anau and its ornamentation show a non-European character." The design of erect-standing triangles, the foundation of the tent ornament, is in direct opposition to the ancient and long-persisting horizontal and vertical ornament of prehistoric Europe. He finds that while the general culture and the early appearance of painted pottery, giving way to an undecorated ware, agrees with that of the old Tell of Susa excavated by De Morgan, the decoration, motives, and styles are quite different. Two objects help to determine the age of the settlements: a three-sided steatite seal of Cretan form, and a copper sickle with bent tang of Ægean shape. These were found in the lower stratum (Third Culture) of the south kurgan, and were assigned by Dr. Schmidt to a period not later than the first half of the second millennium B.C.

Turning to Dr. Duerst's examination of the bones of sub-fossil and later animals, we have a careful and skilled investigation of the remains of horse, ox, sheep, dog, camel, etc. The contributions to our knowledge of the horse are especially valuable, and one of the species appears to approximate closely to Prjevalsky's horse. He claims to have found a domesticated breed of sheep in the First Culture stratum and the shepherd dog in the Second. It seems a daring thing, in our present state of ignorance, to form an absolute chronology on the base of the differentiation of animal forms and their migrations, as deduced from their appearance in different places, but Dr. Duerst, in agreement with Prof. Pumpelly, does not hesitate to tell us that the shepherd dog appeared at Anau *c.* 5850 B.C., and that the turbary sheep attained its full development 6250 B.C. He adds, "According to Prof. Pumpelly's stratigraphic chronology, which is without doubt the most exact chronological table that we possess, the 20 feet of culture stratum at the base of the north kurgan dates from the latter half of the ninth millennium (8250 B.C.).

Prof. Pumpelly, with youthful confidence, sums up his results as follows: "The evolution of civilization has been traced backward to a time when, before its datings in Babylon and Egypt, man at Anau already lived in cities, cultivated wheat and barley, began the domestication and breeding of the useful animals which are our inheritance, and possessed the fundamental industries and arts, including a certain amount of metallurgical knowledge."

Whence this difference between Prof. Pumpelly's date of the ninth and Dr. Schmidt's of the third millennium B.C. for the beginnings of the civilization at Anau? Prof. Pumpelly says that Dr. Schmidt did not include the zoological testimony of Dr. Duerst, the evidence from the "cyclic" changes, and the accumulation of *débris* on the site. Unfortunately, the cyclic changes recorded by the authors do not help us prior to the beginning of our era. The rates of accumulation of *débris* and sand are such an uncertain factor that no careful scientist would venture to erect a system of chronology upon them. Dr. Duerst appears to owe his dates in the main to Prof. Pumpelly. And the latter, when the expedition became a possibility, suddenly realized, as he admits with praiseworthy candour, that "he had done practically no reading in connection with the subject, and was ignorant of the amount of thought and effort, that during forty years had been devoted to Central Asia." And he allows us to see that he set out to find the "home of the Aryans" and the "cradle of the human race," unaware of the changes that had come over scientists' views in relation to these matters or of the battles that had raged around them. Readers will be disappointed in the failure to correlate physico-geographical changes with phases of social evolution antecedent to our era. To attempt to establish in one season's work an absolute chronology for a newly discovered civilization when half a century's work in Egypt has still left us in considerable uncertainty as to dates prior to 1580 B.C. seems presumptuous, and the evidence presented tallies as well with the view that Babylonian and Egyptian beginnings antedated Anau as with the reverse.

Although this extravagant chronology vitiates many of the conclusions, it does not detract from the value of the mass of records of all kinds and their excellent presentation in these volumes. C. H. H.

DR. LONGSTAFF'S HIMALAYAN EXPEDITION, 1909.

HAVING at length had an opportunity of testing my instruments and compiling my results at the Survey Office at Dehra Dun, I hasten to send my first communication for the *Geographical Journal.*

One of the inducements which decided me to make for the Saltoro pass was the knowledge that the main axis of the Karakoram had never been crossed by any traveller between Younghusband's Muztagh pass and the Karakoram pass itself, a distance of 100 miles in a straight line, and 150 miles as measured along the accepted crest-line. Although the name Saltoro pass has been handed down to us by tradition, there is no record of any one, European or native, having crossed it, and its exact position was uncertain.

When Neve, Slingsby, and I crossed this pass (the Saltoro, 18,200 feet) on June 15 last, we saw before us a huge glacier bounded to the north and east by a lofty range of snow-clad peaks. At first sight we assumed that this glacier flowed northwards as shown on maps; but when, on the following day, we reached the main glacier and were able to examine it, we found that it was flowing to the south. In September, following the independent suggestions both of Colonel Burrard and Sir Francis Younghusband, and with the assistance of Captain D. G. Oliver, British joint commissioner for Ladak, I was able to make my way up the Siachen glacier (Saichar of maps) and establish its identity with the glacier we had visited and surveyed in June. But the Siachen glacier, instead of being some 20 miles in length as has always been supposed, turns out to be more than 44 miles long, and it pierces the range that has hitherto been regarded as the main Karakoram axis.

This discovery has shown that the Siachen is the longest glacier in the Himalayan system, and probably the largest outside the Alaskan and Polar regions, its only competitor being the Inylchek glacier of Merzbacher in the Tian Shan. When we remember that the Siachen glacier drains into the Nubra river, it becomes obvious that the basin of the Indus must extend much farther northwards than has been thought. In short, the Indus-Yarkand water-parting here follows a chain of mountains not shown on any maps, and lying some 20 miles north of the our era. To attempt to establish in one season's work an absolute chronology for a newly discovered civilization when half a century's work in Egypt has still left us in considerable uncertainty as to dates prior to 1580 B.C. seems presumptuous, and the evidence presented tallies as well with the view that Babylonian and Egyptian beginnings antedated Anau as with the reverse.

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To avoid any possible misunderstanding of my views, I must also add that I consider the description in the survey reports of the mapping of the Saltoro and Siachen regions, viz.: "Mr. Ryall made a rapid sketch of the country, but with sufficient precision to give a good general idea of its physical formation," to be a very modest statement of what was done in 1861 and 1862.

Perhaps our most interesting discovery has been the existence of a group of very lofty peaks, crowning this new chain of the Karakoram, and culminating (about long. 77°, lat. 35° 30′) in Teram Kangri, 27,610 feet in altitude. Thus if my measurements can be accepted, this new peak is only overtopped by Everest, K_2, Kinchinjunga, and Makalu. I feel very considerable hesitation in attaching such an immense height to a peak which has escaped the observation of the Survey of India; but this peak is not a satellite of K_2 or of Gusherbrum. It is the culminating point of a totally distinct *massif*, which so far has not been shown on any map. It should be remembered, also, that Colonel Burrard predicted of this region, that it was the most likely of all unexplored areas of High Asia to contain high undiscovered peaks. In any case, the fear lest I may subsequently be shown to be in error should not, I think, deter me from publishing the results of observations which have so far withstood a fairly severe examination by experienced judges.

If, in view of these new facts, we now reconsider our former ideas of the structure of the eastern Karakoram, we must place the main axis of elevation along a line drawn from K_2 to Teram Kangri, and on to the Karakoram pass. Whether the Karakoram is to be considered as consisting of two more or less parallel ranges, or whether it bifurcates, in the neighbourhood of K_2, we are as yet hardly in a position to state with certainty.

I cannot close this note without acknowledging my indebtedness for the assistance given me by Colonel Burrard, F.R.S., and the other officers of the Trigonometrical Survey, and by Dr. Gilbert Walker, F.R.S., and the Meteorological Department. But it must be distinctly understood that the Survey can accept no responsibility for any statements I have made in this communication. I have also to thank Colonel Longe, the Surveyor-General, for his offer of the services of a surveyor—an offer which I did not feel justified in accepting, as his whole time would have been wasted had we been unable to cross the Saltoro pass.

TOM G. LONGSTAFF.

The

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THE HISPAR GLACIER.*

I. ITS TRIBUTARIES AND MOUNTAINS.

By FANNY BULLOCK WORKMAN, F.R.S.G.S., Officier de l'Instruction Publique de France.

When I last had the pleasure of reading a paper before this Society in 1905, I showed a view of J. Petigax, C. Savoye, and myself standing under the reversed cornice, on top of the Alchori col, 17,000 feet, at the source of the Alchori glacier. We made the first ascent of this col with the hope of finding a caravan-passage on the north side to the Hispar glacier. Our disappointment at finding a cornice overtopping a sheer precipice of 2000 feet was mitigated by the wonderful view vouchsafed us of the north Kanibasar tributary of the Hispar, and a galaxy of magnificent peaks at its head. Some scenes spread before the explorer possess a strange allurement which remains fixed in memory, and that picture clung to mine, and I determined, if possible in the future, to visit the Hispar and its branches.

As I stated in my last paper, we had failed to find a caravan-passage to the Hispar on several occasions, both on three cols ascended from the Chogo Lungma branches, which, had they proved feasible, would have led to glaciers accessible to it, and on three points from the Alchori, which would have taken us over its great south wall. I said then I believed the only caravan-pass to it over the south watershed to be the Nushik La. Presently I shall have something more to say of this col as a practicable passage at the present day. Thus, having found we could not reach Hispar by a new, proper, mountaineer's pass, we decided

* Read at a Meeting of the Royal Geographical Society, December 6, 1909. Map, p. 224.

in the summer of 1908 to accept the commonplace, and approach it from the Gilgit road, called eighteen years ago by Knight the Siberia of Kashmir.

Intending to remain six to eight weeks in that region, do some detailed surveying of the main glacier, and particularly of the north tributaries not visited by Sir Martin Conway, it was decided to take a topographer with the expedition. Our friend M. Charles Rabot of Paris consulted Prof. J. Brunhes, of the Fribourg University, who recommended two of his former pupils, Comte Dr. C. Calciati and Dr. M. de Koncza, both of whom had had experience in glacial topography in the Alps. The two being desirous of the opportunity offered to do some Himalayan work, the services of both were accepted. Our old Italian guide of three Himalaya seasons, C. Savoye, and three Courmayeur porters, also accompanied us.

Two or three large caravans a year, only, being allowed to proceed towards the Pamirs, a permit from the Indian Government was necessary. Colonel Sir Francis Younghusband, resident in Kashmir, kindly undertook to arrange this matter, and we have to thank him for varied assistance and instructions given to officials both in Hunza-Nagar and later in Baltistan. Our friend the late Major G. Bruce, then political agent in Gilgit, was most kind in arranging six months in advance with the Mir of Nagar for a supply of grain and the contingent of coolies to accompany us on the glaciers. We were prevented from greeting and thanking him for his valuable aid by the inexorable decree of fate, and in Gilgit had only the mournful satisfaction of placing roses on his newly made grave.

The 240 miles of road separating Srinagar from Gilgit is no longer quite the Siberia depicted by Knight. It is a monotonous, dreary, and, at times, torrid enough stretch of country, but the road is a splendid tribute to the skill and energy of the engineers who built it, and who for years have seen to its constant maintenance, and the traveller has only to give the rein to his pony until he gets there, which is no special hardship to those accustomed to Himalayan travel. Two marches beyond Gilgit, at Chalt, the Hunza-Nagar country is entered, and here we were met by Sher Mohamed Khan, assistant to the political agent, who took charge of all arrangements for the further marches to Nagar. Just beyond Chalt, that famous peak Rakapushi, called by all Hunza-Nagar people Domani, bursts into view, a glorious 18,000 feet of sharp, gashed and séracked snow-slopes, culminating in abrupt ice-glazed pinnacles. To my mind it is a more impressive, grander mountain than Nanga Parbat. The Mir of Nagar was to have met us a few miles before the village, but we arrived six hours earlier than was expected, and were already inspecting the camping-bagh below the palace, when he came hurrying down with a numerous suite to welcome us. He is a slim, fair-skinned, intelligent-looking man, with brown eyes and aquiline nose, and quite

European in his dress. He brought his two bright-eyed little sons to see us.

The afternoon was passed in going over all the previous agreements for grain, sheep, and coolie-supply for the glacier work. He was to arrange for a constant band of sixty to seventy coolies, who every two weeks were to be changed off for a relief-corps.

The next morning, escorted to the outskirts of Nagar by the Mir, Wazir, and Khan, our large caravan in charge of a lambardar and military levy, left for Hispar village, 29 miles distant, whither the European agent and the topographers had preceded us by three weeks. Soon after leaving Nagar, the tongue of the Hopar glacier is crossed, and the narrow valley through which the Hispar river descends followed. It is encased on both sides by steep slopes composed of alternating strata of alluvium, sand, and gravel, interspersed with various-sized boulders, to a height of perhaps 2000 feet above its bed, upon which are superimposed tali of like materials fallen from peaks still higher up, through the whole thickness of which the river has cut its path, leaving the rough walls either vertical or descending to it in abrupt inclines.

These walls are broken at intervals by deep ravines washed out by floods, and avalanches of rock and sand constantly erode them, filling the air with dust. As the valley widens at times, a series of terraces of similar make-up are met with. The whole vale for many miles below Hispar presents a scene of utter desolation. The small path, often quite obliterated, and again barely wide enough for one's feet, winds up and down the barren spurs or over the edge of creepy precipices, to near the alluvial fan upon which Hispar village stands. At Hispar we stayed only long enough to reorganize our loads, interview the topographers who came down to meet us, and visit the Hispar tongue, which descends to 1½ mile above the village.

I would here refer to the Yengutsa glacier, the tongue of which, as well as that of the Hispar, was thoroughly examined by Mr. H. H. Hayden in 1906, on behalf of the Geological Survey of India. The Yengutsa tongue descends at present to within 2952 feet of the Hispar river, and Hispar village lies only about 754 feet east of it. Dr. Calciati made a survey on the scale of 1 : 20,000 with the "règle à eclimètre" of the part, including the tongues of the Yengutsa and Hispar, and so carried further the survey begun by Mr. Hayden.

As points of study for the Yengutsa, he and Dr. Koncza took the same two pyramids marked in black G.S.I., adding in red the initials B.W. and date of our expedition of 1908. Having previously possessed themselves of the facts reported by Mr. Hayden, their examinations show that this glacier remains about as he found it in 1906, manifesting only a small decrease in thickness and length. They report a recession of 98·9 feet, as measured carefully from the line of pyramids on either side of the cañon. This figure has reference to the time of their departure only, the end of August, and they regard such a light retreat as due probably only to the summer contraction. It will be remembered that this is one of the glaciers examined by Mr. Hayden, which five years previous to his visit is said by the natives to have suddenly advanced with great rapidity, a distance which Mr. Hayden, referring to Sir Martin Conway's map, judges to have been about 2 miles. A further advance of this glacier might cause incalculable damage to the meagre wheat-fields of the inhabitants, who, as it is, find hard lines to subsist at all.

In regard to the Hispar, our topographers found the Geological Survey pyramids placed on both sides of the river at the tongue. Near the one on the right bank, they marked the red letters and date of our expedition on a large erratic boulder, repeating this marking on a polished rock near the Geological Survey pyramid of the left bank. They report the shrinkage in the end of the Hispar tongue as not exceeding 30 feet, so that the Hispar may be said to be stationary at present. By the end of August they noticed, however, that the depth of the tongue was much reduced, many large blocks of ice having fallen down and been carried away by the sub-glacial stream.

On July 4 we left Hispar. The weather having turned very fine, it was decided to ascend on the orographical left bank to the Haigatum glacier, and visit it and the Nushik La. This col—for I cannot to-day call it a pass—had a special interest for us, as in 1903 we had wished to cross it from Baltistan, but had been baulked in so doing by the Basha coolies, who had refused to ascend to it from the Kero Lungma. For many years it was spoken and written about as a passage for natives and even animals between Baltistan and Nagar, but when such reports as exist are sifted, there appears to be no history of any authentic crossing until 1892, when four members of Sir Martin Conway's party traversed it to the Basha valley. In 1861, Colonel Godwin Austen ascended from the Kero Lungma to its top, but did not descend it on the Haigatum side. Likewise, Major Cunningham followed later, reaching the summit, but, finding a cornice and steep ice-wall beneath it, retraced his steps. In 1896 Dr. A. Neve tried to cross from the Kero Lungma, but was obliged to turn back.

After camping beyond the entrance on the left bank of the Haigatum glacier, we ascended 600 feet on the arête above to examine the col. From here it was apparent that the sharp wall leading to the Nushik La was so difficult from its gradient and the kind of snow covering it, and so exposed to avalanches, which constantly fell from the overhanging snow-cornice running from end to end of its apex, that it would be tempting providence to attempt its ascent. More to the east, the slopes of a snow mountain, while in places steeper, schrund-cut, and overhung by great stratified cornices, led to a large white mamelon high above

FIG. 1.—PEAKS COVERED WITH HANGING GLACIERS ABOVE JUTMARU GLACIER.

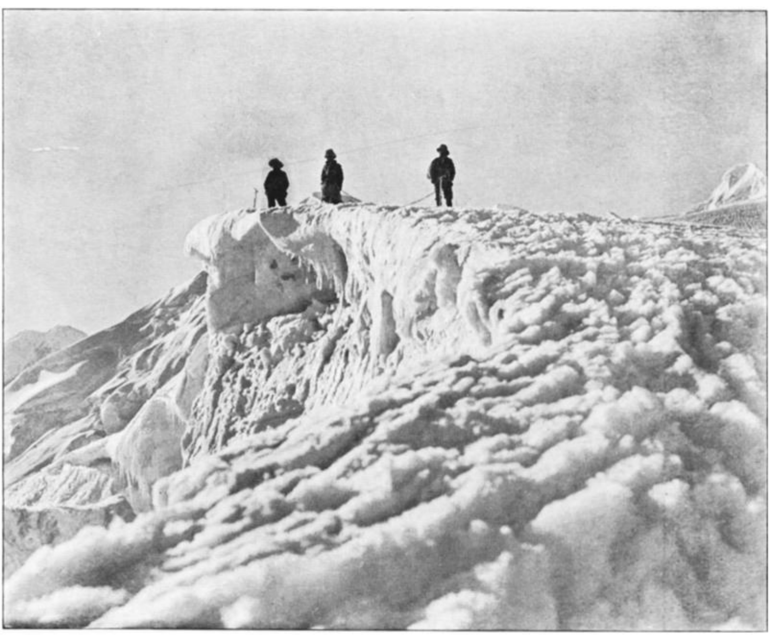


FIG. 2.—WHITE MAMELON COVERED WITH NIEVES PENITENTES, 18,000 FEET, AT TOP OF ICE-WALL ABOVE HAIGATUM GLACIER, EAST OF THE NUSHIK COL.

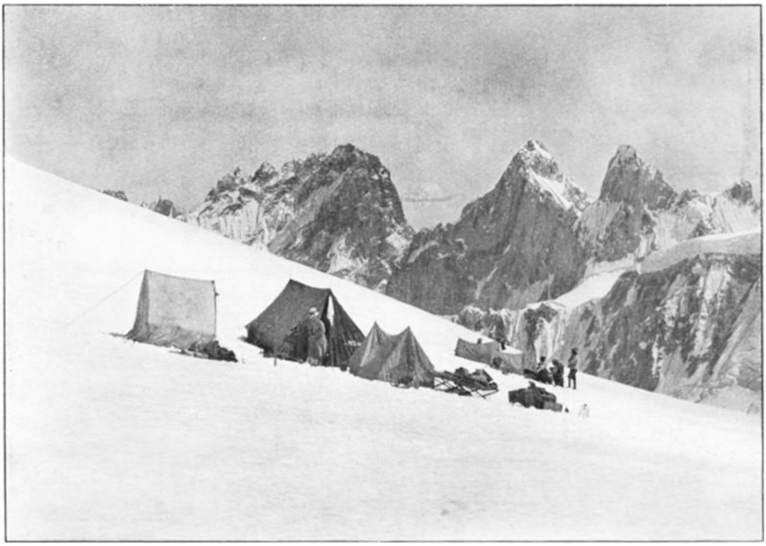


FIG. 3.—CAMP AT 19,100 FEET ON FLANK OF BIAFO HISPAR WATERSHED PEAK, FROM WHICH ASCENT WAS MADE.

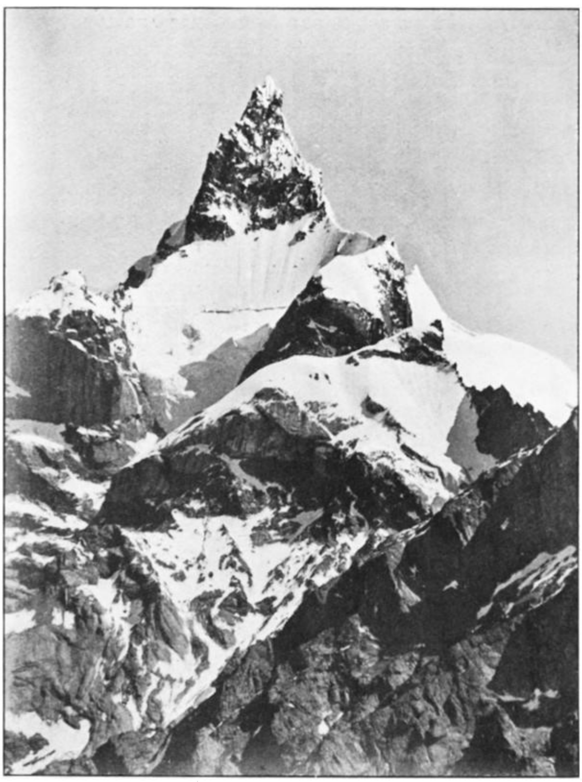


FIG. 4.—TELEPHOTO OF HIGH PEAK OVERHANGING THE JUNCTION OF LAK GLACIER WITH THE HISPAR.

the Nushik La, and this route we decided to try, with the guide and porters only. We should here reach an elevated brow in the depression, and overlook the region on both sides.

The levy and coolies, when asked what they knew of a pass from this glacier, replied that they had heard there was one, but had no personal knowledge of it. To ensure any reasonable surety to life, it would be necessary to start very early, in order to be down on the glacier again by noon, at which time the daily and continuous avalanche-cannonade started in from all slopes at the head of and above the east side of the glacier.

As there are other things to speak of to-night, I will not give a detailed account of the climb carried out from the camp, here seen near the source of the glacier. The dangerous ascent and descent was made between 2 a.m. and 12 noon. An hour or two spent on such scarps as seen in the view was a feature of the climb. Several times, whenever we dared to halt, the clinometer was used, and in each case, the angle of graduation of 60° being exceeded, failed to register. The slopes here and at other points were probably at an angle of 70°. Mr. O. Eckenstein, using Sir Martin Conway's clinometer, graduated to 46°, estimated an angle of $52\frac{1}{20}°$ on his ascent—obviously, as Sir Martin says, an error. The slants we ascended surpassed any such angle. At a point above the snow scarps we found again the interesting *nieves penitentes* first observed by us in Himalaya in 1906 in the Nun Kun. While not very high, from 18 to 24 inches, they were perfect specimens of this curious snow-phenomenon.

Next the white mamelon, height 18,000 feet, which overlooks the Nushik col by 1200 feet, is seen. Its north face presents a nearly perpendicular ice-wall, below which spreads a huge starfish-like bergschrund of unknown depth.

The route we took to the mamelon, the only one feasible at present, is strenuous enough for mountaineers, and cannot be regarded as practicable in any way for a loaded caravan. It would not have been possible to induce our Nagar coolies to follow us loaded up the appallingly steep and dangerous face we ascended. A descent can be made from the mamelon to the Kero Lungma, the ascent to the Nushik from Baltistan being quite possible for loaded coolies. The guide Zurbriggen appears, in 1892, to have ascended to a point well below the mamelon, but also east above the Nushik col, and thence crossed to the other side. In all respects the route, as he then found it, was, apparently, much easier than we found it in 1908, but that may be accounted for in the changed ice and snow-conditions in the last sixteen years. Such changes are known to occur in Himalayan passes, several instances of which might be cited. When one reflects on the mighty natural forces always at work in great mountain regions, particularly in the higher Himalaya, where wind, snow, and water are building up, tearing down, and washing out, with a rapidity unknown in the Alps, this is not surprising. In our own experience of the last ten years in Asia, on revisiting certain places, distinct differences in the obstacles met with have been observed.

Above the mamelon east a fine snow-peak rose about 1000 feet in a series of slants separated by snow-terraces. This peak we climbed to within 20 feet of its apex, where from a small ice-ledge three ice-cornices rose straight above us, like the monster teeth of some petrified Himalayan mammoth of bygone ages. Savoye used his ice-axe for twenty minutes on the first one, and then reported that, owing to hard ice, it would take two hours to cut through them to the top. It was 10 a.m., and, in view of the dangerous avalanche-swept descent to the glacier, we decided to leave out the last 20 feet of cornices, for the mountain was really a *fait accompli*. We named the mountain (height, 19,000 feet) Triple Cornice peak.

I would here mention that our heights of peaks, passes, and camps, as on previous expeditions, were taken by boiling-point readings compared with simultaneous ones taken at a lower Government station—in this case at Gilgit—three times daily for us during the summer.

This view of the mamelon was taken on the descent. Scarcely stopping to breathe, the dangerous downward climb was made amid the boom of avalanches, which fortunately spared our party, and camp was reached by 12.30. To quote the opinion of a mountain-expert, Savoye remarked, *en route* to the lower camp, that he should not care to repeat that climb, as he had not felt easy in his mind from two in the morning until after noon.

The chief northern tributaries of the Hispar are the Lak, the Pumarikich, the Jutmaru, and the Kanibasar, and on the south the Haigatum and the Makorum. A survey with theodolite by Dr. Koncza, and with the "règle à eclimètre" of the Gaulier type employed in the French Army Topographical Service by Dr. Calciati, was made for us of these glaciers, and, in addition, many stereoscopic and panoramic views taken in connection with this work. I believe I am correct in saying that this is the first time that detailed glacial surveying by the methods employed of recent years in the Alps, America, and elsewhere, has been carried out in the Himalaya. They found the above glaciers join the Hispar by a regular slope without the intervention of a terrace, with the exception of the Pumarikish, which is connected by terraces. They report, as do we, no practicable passage between any two of the branch-basins.

Of our first exploration of the fine north tributaries, the Jutmaru and Kanibasar, respectively 9·3 and 5·6 miles long, I would say a few words as to their general character. In view of generally accepted ideas on nomenclature, that names known best to natives should be taken for glaciers and mountains, we have been forced to substitute on our map the name Jutmaru for the glacier marked Kanibasar on Sir Martin Conway's, transferring the name Kanibasar to the higher branch, of which Sir Martin said in 1892 "there appeared to be no name." The Hispar natives accompanying the topographers, and Nagar coolies with us, whenever asked, distinctly stated that they knew these glaciers only by the names referred to, and in the order placed on our map.

As my province to-night is to mention mountain-forms rather than glacial features, I would say that both these branches are surrounded by high, picturesque but inaccessible snow and rock-peaks, often decked by hanging glaciers ending in such abrupt, savage ice-falls that it seemed as if the slightest earth-tremor would precipitate them in shattered ice-blocks to the main stream. The apices of these extraordinary peaks are in many instances festooned with fantastic double and triple cornices, perpetuating here on the frontier in snow-sculpture the weird figures, such as yalis and three-hooded cobras, of South Indian temple-architecture. Both glaciers widen near their sources into snow-basins, and we found, as did the topographers, the reservoir of the Jutmaru to be the more extensive. From that of the Jutmaru two steep tributaries branch east and west about 2 miles in length. These again end in rock-walls several thousand feet high, connecting more high peaks garlanded with furrowed and riven ice-falls, from which avalanches constantly fall.

The long longitudinal moraine-ridges on this glacier in places reach a height of 100 feet, while between them the white ice ascends gently, crevassed, presenting picturesque undulating bands. We found on this and on the Kanibasar many surface-streams, some difficult to ford, one on the Jutmaru being, when we crossed it, quite 50 feet wide. Our tallest man sank into it above the waist. It was coated with frozen slush, presenting a firm enough surface to enable us, by throwing ourselves flat, to crawl across by aid of our ice-axes placed in front.

Our duty as mountain-students was to climb cols for observation-points, but neither on the main glaciers nor on their branches could feasible slopes or ridges be discovered. The only one accessible to human feet was on the right bank of the Jutmaru, and this col overlooked a limited region of no geographical importance. This is the first branch on the left of the Kanibasar, the only one of any account.

To return to the Hispar. The only trees growing there at present are dwarf-willows. Cedars evidently formerly grew, as in a few places their dead trunks were found, but no living cedars were seen. The wood-growth limit is at about 14,500 feet, somewhat higher than on the Chogo Lungma glacier. The snow-line, on the contrary, is lower than we found it on the Chogo. After many observations we placed it on south slopes at not over 16,500 feet, while on northern ones it is, of course, considerably lower.

Passing by the still higher, equally interesting north branches of the Hispar, I must ask you to follow me on an ascent made from the highest base, called "Coolies' Paradise Camp," 15,900 feet, situated on the last moraine-ridge below the Hispar pass on the right bank. We have explored three out of four of the longest Himalayan glaciers, and on the Hispar found the greatest number of inaccessible peaks. I do not recall one on the north boundary high enough to afford a view of importance which is climbable, and certainly not one crowning the south snow-wall for 20 miles is even approachable.

To the north of the Hispar pass, and separated from it by 3 or 4 miles of ascending snow-fields and gashed ice-falls, rises a very sharp triangular pyramid-peak. The snows of its east side feed the Biafo and Snow lake; those of the south-west and west flanks contribute to the Hispar reservoir, hence the name, Biafo Hispar Watershed peak, which was given it. It is seen for 20 miles on the Biafo glacier, overtopping Snow lake to the west. From the Haigatum branch onward, always fore-shortened, it is visible from the left of the Hispar. The mountain had a singular attraction for me, for I knew that from its summit not only a grand view could be had, but one of much topographical interest. Three arêtes diverged from its pointed top, sweeping down precipitously 2000 to 3000 feet, of which the west and south ones looked impracticable of ascent, but the east had yet to be studied.

On August 1, with eighteen coolies under the lambardar, we left camp early, climbing the long, frozen slopes to the south of the pass. A day or two previous a new relay of Nagar coolies had taken the place of a bad lot who had returned, and we feared the new set would handicap the possible ascent of the mountain. After three hours' climbing, the peak came into full view, and we saw that the long ridge must be contoured, then a sharp ascent made to a high basin between the south and east shoulders. The caravan was still behind. We continued on to the base of a steep 800-feet wall, which, if surmounted, would bring us to the scoop between the arêtes, and render the peak probably within reach the next day. Making a solid zigzag path, we had climbed about 500 feet when the caravan arrived at the base.

The bearer called up that the coolies would not attempt the wall. We replied that they must. Then the lambardar harangued them, but in vain. Finally, Savoye went down to see what he could do. After he had talked a while, to our surprise, three of the loudest Nagaris attacked him with their spiked sticks. In self-defence he struck one of them over the back with his ice-axe, felling him to the snow. That settled the matter. They all subsided, and began to file slowly upward. This was the first time they had attacked the guide, and the first and only time a coolie was struck by our Europeans. The lambardar often used his stick on coolies; but that was the Mir's affair, not ours. Later, some of them reached the small snow-flat where we waited, while others

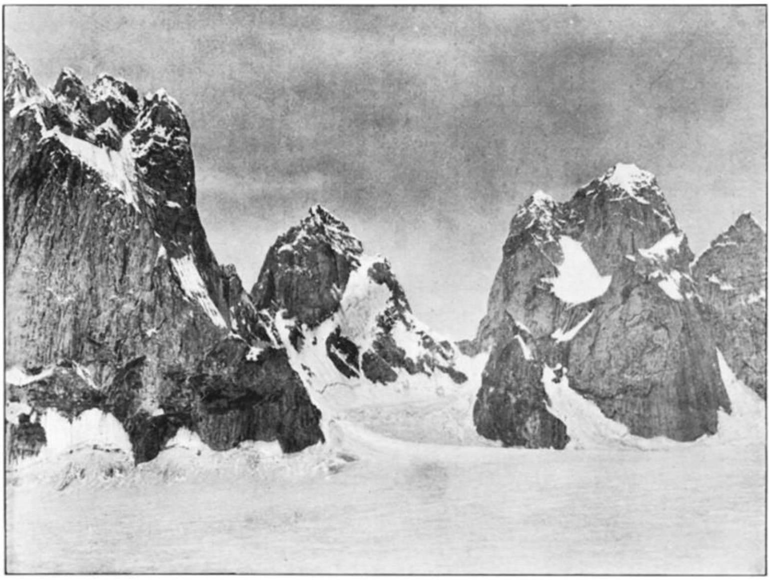


FIG. 5.—MOUNTAINS FORMING WEST WALL OF BIAFO GLACIER JUST BELOW THE POINT WHERE THE GREAT HISPAR-BIAFO WALL CHANGES ITS COURSE SUDDENLY FROM EAST TO SOUTH, ON WEST SIDE OF THE SO-CALLED SNOW LAKE.

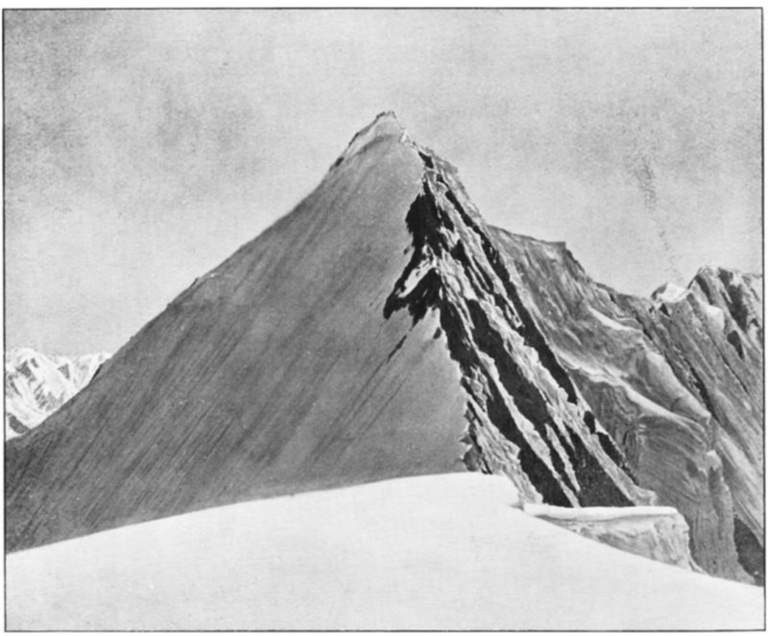


FIG. 6.—HISPAR-BIAFO WATERSHED PEAK, 21,350 FEET, MRS. BULLOCK WORKMAN AND TWO GUIDES SEEN ON SUMMIT. PHOTOGRAPHED BY DR. WORKMAN FROM A NEIGHBOURING PEAK.

stopped short of it, allowing the porters to return and bring up their loads. We were, however, very glad to reach this spot, the height of which, later computed, was 19,100 feet. Savoye and one porter went off to examine the east shoulder, which was found impossible because of a fluting of cornices. The only solution was the south, much sharper arête facing the Hispar pass.

While still clear the next morning, the sky had a filmy look, indicating a storm before night, so all haste was made to secure the peak before a change came. With the guide and two porters, I left for this mountain; while later Dr. Workman and the third porter started for a lower peak east, overlooking Snow lake.

Crossing the intervening slopes, we ascended a steep snow-wall leading directly to the arête. This arête was ice-glazed, and at most 18 inches wide, ascending at an angle beyond 60° for some distance. To the right of it sank the wall just ascended, and sheer to the left a deeper seemingly endless abyss, filled with the gloom and mountain intangibility of early morning. Cutting each step, we climbed steadily for an hour to some gendarmes, which gave us a little rock-work. Beyond these a gentler gradient brought us to the base of a blue ice-wall about 15 feet high. Here we had some food. It was still fairly clear toward the Biafo, but toward the Hispar mist floated in, so Savoye at once began step-cutting on the wall, which we took sideways, each foot only half in a step. Below lay two-thirds of the mountain, a tortuous, precipitous mass, inviting to instant death should head or feet fail. The long, glistening arête was hailed again, rising sharper than ever, making every movement more arduous. Finally, this came to a climax, and the top was seen just ahead, a small cone turning over to the north in a cornice. Crossing an easier slope, then climbing a short narrow ridge, we arrived at a group of spiked rocks. From here, in five minutes, the cone was ascended, and, with the others holding the rope, I stood on the cornice, and saw one of the most remarkable and comprehensive panoramas I have beheld in Himalaya.

This single pyramid stands alone, with no near higher peak to mar the view on any side. Eastward, 5000 to 6000 feet beneath, lay Snow lake, its glacial branches spread like white fans, clearly defined, framed each by its border ranges. Beyond this swept, still further east, a great glacier fully 15 miles, behind the B 15 range, to the base of a high snow-wall which joins the east perpendicular slopes of the peak, 23,900 feet, which ten years ago we named Kailasa No. 2. Miles beyond, the Baltoro giants, K_2, the Mustagh Tower, Gusherbrum, and the Golden Throne caught the eye. Following south-east, the Biafo sank downward many miles, until lost behind dark mountain-flanks. Straight across, beyond the south ridge of the Hispar, I saw the wide void, beneath which, 2000 feet below, lies Cornice glacier, first discovered by us from the Col des Aiguilles at the head of the Hoh Lumba in 1903. The wall and mass of peaks cutting it off absolutely from the Biafo on the east, and the great avalanched walls separating it from the Hoh and Sosbon glaciers on the south, were clearly seen, as were the cols we had climbed on these glaciers.

The western boundary formed by the Alchori mountains we followed up in 1903, and found no opening. I was thus able from this peak to obtain evidence confirming our observations made in 1903, that Cornice glacier lies in a deep hollow with no observable outlet at any point. We have examined its barriers on every side—and I believe it to be an example of what Sir M. Conway says cannot exist, an enclosed glacier. West, though clouds were rushing in, 20 miles of the Hispar were visible; and beyond it, partly snow-swathed, I recognized Pyramid peak on the Chogo Lungma and the sublime form of Domani. North of west stretched range after range of wild, unmapped mountains, beyond the frontier, and in the foreground of these rose what, from its charted position, appeared certainly to be the highest Kunjit peak No. 1, 25,492 feet. For a minute it was a glorious vision, but I recall it only as a stage phantom, for a dark purdah of mist fell between it and me.

I had seen wonders not of earth, the memory of which will cling while life lasts. Knight aptly called his book, 'Where Three Empires meet.' My eyes beheld at a glance on that day the whole magnificent mountain-landscape encompassing the meeting-places of three of Asia's greatest glaciers.

The other party was seen on their peak 1800 feet below, and from there Dr. Workman photographed us on the summit. A band of mist entwined itself about our cornice, and one-half the mountain world was lost in a sea of cloud. The others told later of the striking picture we presented: three black figures encircled by a cloud-wreath, not standing on a peak at all, but hung high in a heaven of incoming mist and storm.

We retreated to the rocks below, where instruments were noted and the record of the ascent left in a box, and, having hastily eaten something, began the descent, as an icy wind chased the mist backward, leaving a few steps of our path clear. It was a slow and dangerous descent through fog and cloud-billows, down the unending precipitous arête. But camp was safely reached, where the others greeted us with bravos of approval.

The height of the peak, since carefully computed, is placed at 21,350 feet. Savoye hoped it would be nearer our highest Nun Kun climb of over 23,000 feet, but, as I told him, we did not come to the Hispar to break records. This and the other climb are the first ascents to date of high peaks overlooking Snow lake, the Hispar pass, and the Biafo, and I am satisfied with all, except the storm that suddenly interfered with many photographs I wished to take.

Ten days later we crossed the Hispar pass to the head of Snow lake. I would here refer to Sir M. Conway's review of our book 'Ice-bound Heights of the Mustagh,' in the July, 1908, *Geographical Journal,* in which he says of Cornice glacier, just mentioned, "This glacier is a tributary of the Biafo." On his map he makes a large tributary enter Snow lake through its western wall at the point shown in this photograph. No break occurs in the wall here, and no glacier enters either here or for many miles further down, through the western Biafo wall. Our observations of the wall on its western side from Col des Aiguilles and mine from the Watershed peak, show conclusively that Cornice glacier is not a tributary of, and has no connection whatever with, the Biafo.

We wished to cross the Biafo and ascend the glacier east of B 15 to see if a caravan passage could be discovered to the Punmah glacier, but not a coolie could be persuaded to enter on the journey. Savoye and a porter went alone to the end of the east glacier, which they found closed. They then took a north branch, and ascended a steep col at its head, from which they saw a glacier flowing in the direction of the Punmah, as placed on existing maps, but the sharp col, heavily covered with new snow, was found quite impossible for coolies. By using snow-shoes on the glacier, and marching from 6 a.m. till midnight, they were able to make these observations. We ended our summer's exploration by descending the Biafo, reaching Askole August 27.

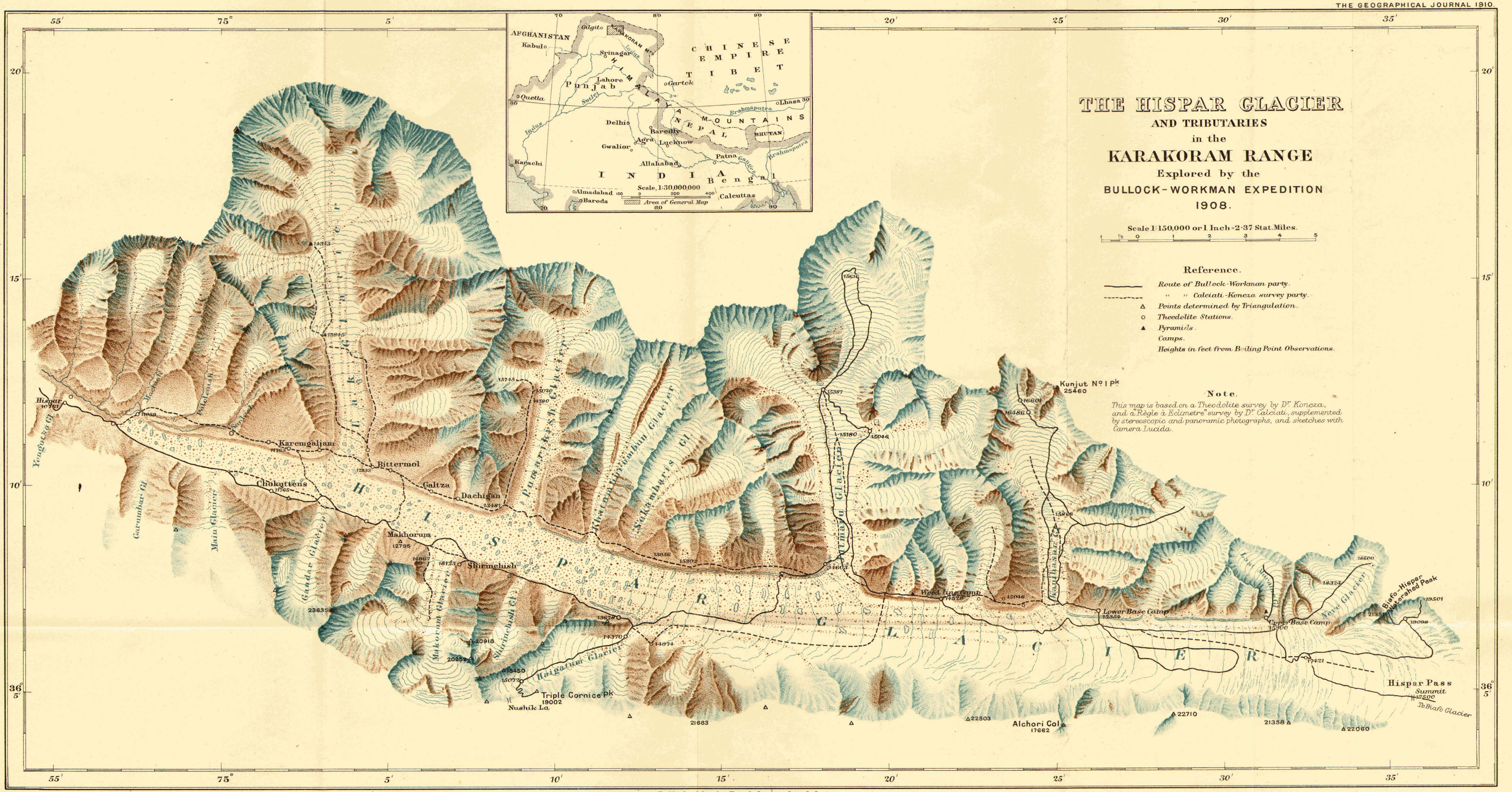
II. PROMINENT FEATURES OF ITS STRUCTURE.

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

Among the ice-bound heights of the Karakoram, in one of the most snowy of Asiatic mountain-regions, in a parallelogram bounded by 35° 40′ and 36° 20′ lat. N. and 74° 50′ and 76° 40′ long. E., lies a group of four of the world's greatest mountain-glaciers, three of which, the Biafo, the Chogo Lungma, and the Hispar, with many of their branches, have been explored from end to end by Mrs. F. Bullock Workman and myself.

Born amid the howlings of the tempest and the roar of the avalanche, in inaccessible fastnesses far above the habitations of man or animals, and fed by large tributaries themselves glaciers of the first order, these vast rivers of ice force their way downward through the intervals between precipitous mountains for many miles into the deep valleys below, where, succumbing to the heat there encountered, they gradually die out and disappear. The waters into which all of them are finally resolved find their way into that remarkable river, the Indus.

These great glaciers are not mere bands of snow and ice running smoothly from their sources to their tongues, but they are most



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55'
75°
5'
20'
15'
10'
36°
5'
Kabul
Quetta
30
Indus
Karachi
70
Hispar
10761
Yengutsa Gl.
11059
Karemgaljam
11765
Bittermol
12533
Chokuttens
11765
Galtza
Dachigan
13487
Makhorum
12795
14967
13123
Shirinchish
14343
13845
15745
15020
14780
Garumbar Gl.
Main Glacier
Gandar Glacier
Makorum Glacier
Shirinchish Gl.
23635
20918
20252
18450
15072
19002
Nushik La

20'
70
80
90
AFGHANISTAN
Gilgit
KARAKORAM MTS
Kabul
Indus
Srinagar
CHINESE EMPIRE
TIBET
HIMALAYA
Lahore
Punjab
Gartok
Quetta
Sutlej
30
Lhasa 30
Brahmaputra
MOUNTAINS
NEPAL
BHUTAN
Delhi
Bareilly
Agra
Lucknow
Gwalior
Brahmaputra
Karachi
Patna
Ganges
Allahabad
INDIA
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Almadabad
Baroda
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80
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15387
15180
15046
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14780
Pumarikish Glacier
Khatamburumbun Glacier
Sekambaris Gl.
Dachigan
13481
13956
15302
14603
16601
16486
Wood line Camp
14528
15046
Shirinchish
SPARGLACIER
13678
14370
14974
20918
Shirinchish Gl.
Haigatum Glacier
18450
15072
Triple Cornice Pk
19002
Nushik La
21683
22503
Alchori
17662


THE HISPAR GLACIER
AND TRIBUTARIES
in the
KARAKORAM RANGE
Explored by the
BULLOCK-WORKMAN EXPEDITION
1908.
Scale 1:150,000 or 1 Inch = 2·37 Stat. Miles.
Reference.
Route of Bullock-Workman party.
" " Calciati-Koncza survey party.
Points determined by Triangulation.
Theodolite Stations.
Pyramids.
Camps.
Heights in feet from Boiling Point Observations.
Note.
This map is based on a Theodolite survey by Dr. Koncza, and a "Règle à Eclimetre" survey by Dr. Calciati, supplemented by stereoscopic and panoramic photographs, and sketches with Camera Lucida.
25′
30′
35′
20′
15′
10′
36°
5′
Kunjut No. 1 Pk
25460
16601
16486
15866
Kanibasar Gl.
15046
Lower Base Camp
15354
Last Moraine Gl.
Upper Base Camp
15900
18600
18324
Neve Glacier
Biafo-Hispar Watershed Peak
19501
19098
17421
A
C
I
E
R
Hispar Pass
Summit
17500
To Biafo Glacier
22503
Alchori Col
17662
22710
21358
22060


Kabul
Quetta
Indus
Karachi
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Hispar
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Yengutsa Gl.
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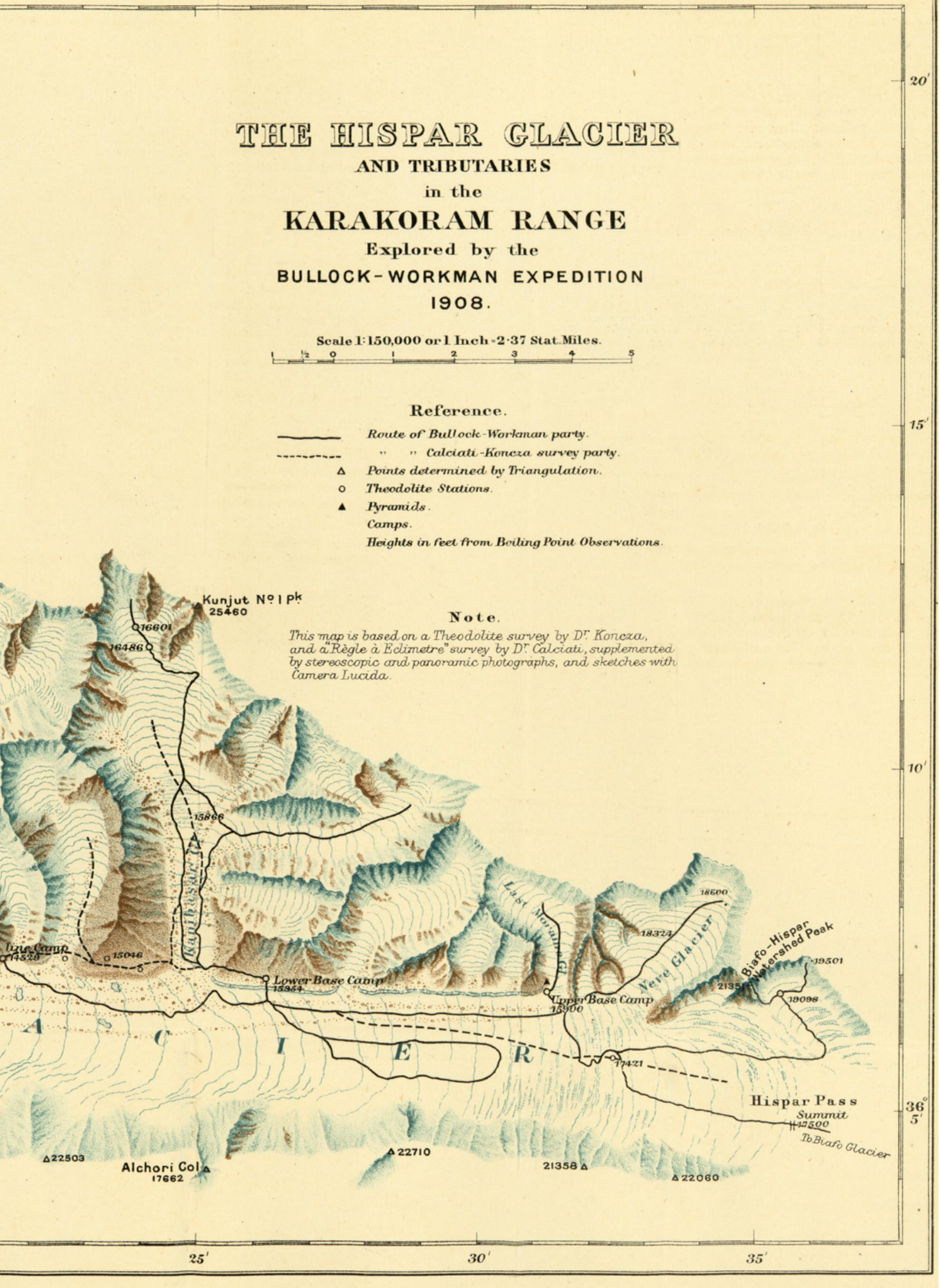
THE HISPAR GLACIER
AND TRIBUTARIES
in the
KARAKORAM RANGE
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BULLOCK-WORKMAN EXPEDITION
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Scale 1:150,000 or 1 Inch = 2·37 Stat. Miles.
1 ½ 0 1 2 3 4 5
Reference.
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Kunjut No. 1 Pk. 25460
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Lower Base Camp 15354
Last Moraine Gl.
Upper Base Camp 15900
18600
18324
Neve Glacier
Biafo-Hispar Watershed Peak
19501
21351
19098
17421
Hispar Pass
Summit 17500
To Biafo Glacier
A C I E R
22503
Alchori Col 17662
22710
21358
22060
20'
15'
10'
36° 5'
25'
30'
35'

complicated structures descending in steep, broken ice-falls covered with splintered séracs or thrown up into huge undulations, ridges, and high hillocks, seamed by unfathomable crevasses, and bearing on their surface or within their substance an incredible amount of *débris* from the decaying mountains, whose crests they fringe with fluted snow-ruffles and whose flanks they rasp away and sculpture out in their downward progress.

From the similarity of their environing conditions these glaciers have many features in common, but each has also distinctive features sufficiently marked to render a comparative study of them all of engrossing interest.

We are considering this evening the Hispar glacier, the most northerly of the group. The tongue of this glacier is first encountered 2·1 kilometres (1·5 mile) east of Hispar village, at an altitude of about 3354 metres (11,000 feet). It is a broad, *débris*-covered, discoloured mass of ice, with irregular surface sloping down to the detritus-strewn valley-bed where it ends. A large torrent, issuing from an ice-cave on its southern side, has cut a passage for itself through the rock-*débris* to the valley below. This is joined at the extremity of the tongue by a smaller stream descending in a sulcus between the north side of the tongue and the ragged edge of a large alluvial fan radiating from a gorge in the mountains opposite.

From here the glacier ascends with a gentle gradient in a direction somewhat south of east for 59 kilometres (36·63 miles),* to the highest point of the Hispar pass lying at an altitude of 5335 metres (17,500 feet), where it meets the upper extremity of the Biafo glacier. Its average width above the tongue is about 3 kilometres, 1·95 mile. In the lowest 25 kilometres (15·53 miles) of its course it receives on its south, or orographical left side, six branches, three of them large, the highest being the Haigatum; but from here to its culmination in the Hispar pass no branch enters it on that side. On the north side, nine branches, six of which are large, enter it at various points along its course. Most of these branches, but particularly the northern ones, are laden to an unusual degree with *débris*, the effect of which is manifested on the main trunk.

The mountains enclosing the Hispar, especially its upper half, as well as its branches, are high, greatly broken, very steep, and heavily covered with ice and snow. Their crests and summits are largely crowned with huge, overhanging cornices, many of them of great thickness and stratified in numerous layers. These, when they break

* Drs. Calciati and Koncza consider the length of the Hispar glacier to be 56·6 kilometres, which, as measured on their map, corresponds to the point where their route-line ends. By repeated altitude observations while crossing it, I found the highest part, or summit, of the Hispar pass to be 2·4 kilometres beyond or east of this point, viz. at 59 kilometres.—W. H. W.

away, give rise to avalanches of immense size, on account of which it is dangerous to approach the bases of the mountains, where avalanche-beds cover the edge of the glacier.

The southern barrier of the Hispar extends from the Haigatum glacier to the summit of the Hispar pass, a distance of 34 kilometres (21·1 miles), without a break. It consists of a high, continuous wall, rising at intervals into sharp peaks, the whole covered with snow, masses of ice, glaciers, and hanging glaciers, and surmounted by cornices, which frequently break loose and shower down avalanches on the glacier below. These avalanches score and chisel out its icy flanks into deep furrows, sharp ridges, battlements, and spires, which, combined with the frozen cataracts and flutings of the hanging glaciers, present a most weird and bizarre effect in the changing shadows which chase one another across the face of the wall, as the sun marks the hours in its westerly course. In our six expeditions in Himalaya, we have seen no ice-expanse that approaches it in extent, complexity, and grandeur. On account of the size and frequency of the avalanches falling from it, its base cannot, at any point, be approached with safety.*

For a distance of 24 kilometres (14·9 miles) above the tongue, the whole of the Hispar surface is broken into ice-hillocks separated by deep depressions and heavily coated with *débris* of every size from mud and sand to granite blocks 6 to 15 metres (20 to 50 feet) in diameter. Many of the hillocks have the form of symmetrical cones and pyramids, but many more have a perpendicular ice-wall on the one side and on the other slant back to the glacier at an angle of 45° or less. This formation is more pronounced and extends up the glacier to a greater distance than the similar formation on the Chogo Lungma, which has a length of 14·5 kilometres (9 miles), or that on the Biafo, which only reaches to a point about 5 kilometres (3·1 miles) above the end of the tongue.

A short distance below the entrance of the Haigatum branch a narrow band of smooth, white ice appears among the *débris*-covered hillocks, which stretches upward, becoming ever broader, till it merges in the white ice pressing down along the left or southern side of the glacier. On the north side the hillocks persist for 18 kilometres (11·5 miles) farther to the entrance of the Kanibasar branch. Above the Haigatum many of them are oblong in shape and are arranged in lines, their long diameter being coincident with the lines; but below the Haigatum such arrangement is less apparent. They vary in height from 15 to 70 metres (48·9 to 229·6 feet), but some, as will later be

* About 5 kilometres (3 miles) beyond the Hispar pass, the wall makes a sharp turn to the south and continues on, also unbroken, as the west wall of the Biafo glacier, for 24 kilometres (15 miles) farther. It thus forms a continuous barrier 64 kilometres (40 miles) in length, unpierced by a single glacier though extending through a region of snow and ice.

stated, exceed the latter height. Throughout the hillock-area, although the glacier carries such a vast amount of detritus, no well-marked median moraines are observable, the continuity of the moraine-material being destroyed by the broken condition of the surface.

From the edge of the hillock-area to the ice-falls below the highest part of the glacier the surface consists of fairly smooth, somewhat rolling, white ice, bearing only a moderate amount of *débris*. On the north side this section is only a few kilometres in length, reaching from the Kanibasar glacier upward; but on the south side it extends well downward toward the Haigatum branch.

The last and highest portion of the glacier forms the Hispar pass. This is a plateau of *névé* 5 kilometres (3·11 miles) long and about the same in width, covered with driven snow, unbroken by crevasses, and gently rising to a snow-ridge crossing its eastern end from north to south. The highest part of this ridge, near its termination in an ice-shoulder descending from the last snow-peak above the Hispar on the south, was measured by boiling-point readings, compared with simultaneous ones at the Government Station at Gilgit, at 5335 metres (17,500 feet). This ridge is the summit of the pass, and from it, on the east, one steps down upon the most westerly of the three heads of the Biafo glacier, between which and the Hispar it forms the line of demarcation. The gradient of descent of the Biafo from the ridge is much sharper than that of the Hispar.

North of the pass and east of Last Moraine branch of the Hispar lies a large snow-clad region, extending back 5 to 8 kilometres (3 to 5 miles), and sloping upward some 760 metres (2500 feet) above the Hispar pass. This is bounded and intersected by peaks and ridges, the highest of the former of which reaches an altitude of 6509 metres (21,350 feet), and forms a part of the watershed between the Biafo and Hispar glaciers. We entered this region at two points, and explored it to its northern enclosing walls. It sends down to the Hispar its highest northern branch, a large snow and *névé*-covered glacier, named by us the Névé branch. This region is one of the largest contributors to the Hispar stream, and the ice and snow from it break down into the latter in a chain of tumultuous ice-falls.

The reservoir of a glacier consists of a basin or basins usually enclosed by mountains and the highest portion of its own structure, which collect the snows that contribute to its formation. The dissipator is the lower portion, of varying extent, where melting exceeds the ice and snow-supply, and where, therefore, the glacier wastes away. The Hispar reservoir comprises the greater part of the region just mentioned, the whole of the Hispar pass to the highest summit-snow-arête, and the whole northern slope of the great southern Hispar mountain-barrier for a distance downward of 33·5 kilometres (20·8 miles) to the opening of the Haigatum branch.

FIG. 1.—THE FACE OF THE SNOW-REGION DIRECTLY NORTH OF THE HISPAR PASS AS VIEWED FROM A POINT ON SOUTH SIDE OF PASS OPPOSITE CENTRAL PEAK. THE PEAK IN CENTRE IS THE BIAFO HISPAR WATERSHED PEAK, 21,360 FEET (6509 METRES). SNOWS ON THE RIGHT (EAST) OF THE CENTRAL MASSIF DESCEND TO THE EAST INTO THE BIAFO GLACIER. THOSE IN FRONT AND TO THE LEFT (WEST) OF IT INTO THE HISPAR. WEST HEAD OF BIAFO DESCENDS BETWEEN THE SNOW-RIDGE AND ROCK-FACE AT EXTREME RIGHT. THE NORTHERN HEAD OF BIAFO PASSES NORTH BEHIND THE ROCK-FACE AND SNOWY RIDGE LEADING BACK FROM IT.

FIG. 2.—THE UPPER 19·3 KMS. (12 MILES) OF THE GREAT ICE-COVERED WALL FORMING THE SOUTHERN BARRIER OF THE HISPAR GLACIER. IT EXTENDS FROM THE HAIGATUM BRANCH TO THE HISPAR PASS, A DISTANCE OF 34 KMS. (21·1 MILES) WITHOUT A BREAK; THENCE 4·83 KMS. (3 MILES) BEYOND AS THE SOUTH WALL OF THE WESTERN HEAD OF THE BIAFO GLACIER TO A POINT, WHERE IT MAKES A SHARP BEND TO THE SOUTH, AND CONTINUES ON, STILL UNBROKEN, FORMING THE WESTERN BARRIER OF THE BIAFO GLACIER FOR 24 KMS. (15 MILES) FURTHER, WHEN IT IS PIERCED FOR THE FIRST TIME BY A LARGE BRANCH ENTERING THE BIAFO FROM THE WEST. THE TOTAL LENGTH OF UNBROKEN WALL IS ABOUT 64 KMS. (40 MILES).

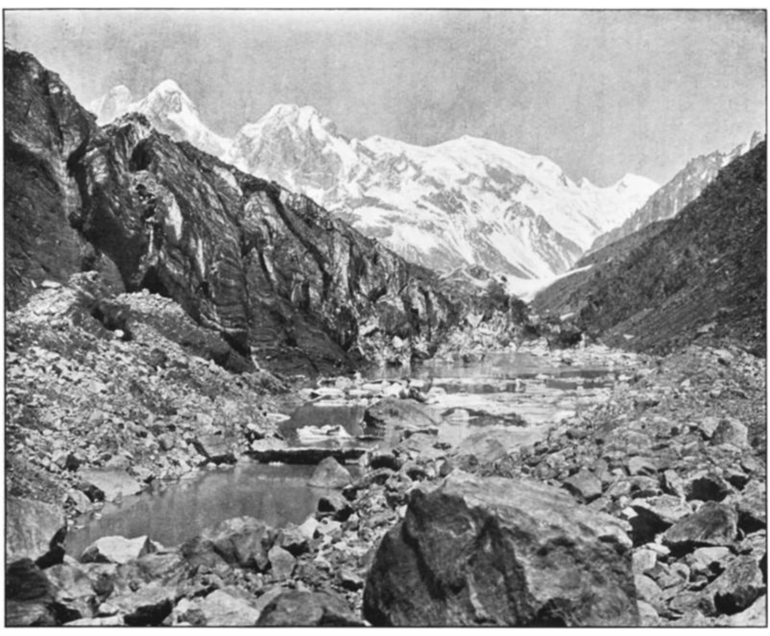

FIG. 3.—A BORDER-LAKE NEAR THE JUNCTION OF THE JUTMARU WITH THE HISPAR GLACIER, IT IS ENCLOSED BY A LATERAL MORAINE AND THE MOUNTAIN-WALL ON THE RIGHT, AND THE HIGH SIDE OF THE JUTMARU GLACIER ON THE LEFT, FROM WHICH THE ICE-FRAGMENTS FLOATING ON THE WATER ARE DERIVED. THE STRATIFICATION OF THE BLACKENED GLACIAL ICE IS WELL SEEN. BEHIND ARE THE HIGH SNOW-PEAKS WALLING IN THE JUTMARU.

The powerful pressure from the north exercised by Névé branch, aided by that of Last Moraine and the large Kanibasar and Jutmaru branches, forces the glacier over bodily hard against its southern wall, which pours down a constant succession of glaciers, ice-falls, and avalanches over the line of contact, covering it so completely that the glacial surface, sloping upward into that of the wall, forms as intimate a connection with it as does that of any glacier with that of its initial reservoir. At no point in this long distance can any interval be seen between the edge of the glacier and the wall.

A remarkable circumstance connected with this is, that for 26 kilometres (14 miles) above the Haigatum branch the main part of the glacier opposite this ice-wall, excluding a comparatively narrow section adjoining the wall, serves as a dissipator, all loose snow, and, indeed over much of it, all *névé* being melted away in late summer. Also the northern edge of the glacier throughout this section, in complete contrast with the southern edge, has so melted away that it lies at a considerable distance from the mountain-slopes, which themselves are at that season free from snow.

A peculiar feature of the Hispar, not observed on the Biafo or Chogo Lungma, is the great number of lakelets scattered over its surface, especially in the hillock-area. From any point somewhat raised above the glacier a dozen or twenty in the immediate vicinity may readily be counted. With their transparent water, of beautiful green or reflecting the deep blue of the sky, they flash in the sunlight like emeralds and sapphires from their setting of brown and grey. The great majority of them are merely collections or pools of water occupying the depressions between the hillocks; but some of the larger are highly picturesque, their cleft, scarred, and banded ice-barriers, in places thickly covered with rock-*débris*, enclosing beautifully curved bays, between which graceful crystal promontories project, and their surfaces dotted with islets of ice or partly submerged boulders. These lakelets are seen even in the *névé*-area to as high an altitude as 4878 metres (16,000 feet). They are formed by the settling of the water resulting from surface-melting into the depressions. Very few of those observed were fed by streams even of small size, and few had outlets. There was a notable absence on the glacier of streams of running water, the greater part of the surface-water apparently finding its way into the lakelets. Few large streams, such as exist on the Biafo, were seen.

Besides these surface-lakes, many border-lakes and a few subglacial ones were found at the lateral edges of the Hispar and its branches, resulting from the damming of water by ice or moraine-barriers. Some of these, their surfaces flecked with miniature icebergs interspersed among projecting boulders, in their setting of mountain and glacier, formed pictures of great beauty. These lakes were more interesting to observe than to negotiate. On several occasions we were obliged to cross the beds of border-lakes recently drained, when we had the pleasure of wading through soft, sticky mud, ankle-deep, that cleaved to our boots in great, unwieldy balls.

The existence over the lower two-thirds of the glacier of such a large number of surface-lakes implies an absence of crevasses, or, at least, the presence of very few, for, did any considerable number exist, the lakes either would not form at all or would be quickly emptied. This inference was shown by observation to be correct in fact. Notwithstanding the extreme irregularity of the surface, few crevasses of any size were seen in this area.

Crevasses are usually caused by steepness or irregularity of the glacier-bed, and are intimately associated with ice-falls. Only one series of ice-falls occurs on the Hispar, viz. in the section near its head, where it descends sharply from the Hispar pass to the level of Last Moraine glacier, into which section the northern portion of its reservoir tumbles, also in ice-falls. Here large crevasses occur, though many of them are not deep. From Last Moraine glacier to its tongue the Hispar descends in an even, regular stream with a gentle gradient. In the 20·5 kilometres (12·7 miles) from the upper edge of the Kanibasar junction to the lower edge of the Haigatum junction it falls about 305 metres (1000 feet) or 1 : 67 metres or feet. This, together with the absence of crevasses, points to the conclusion that the glacial bed is practically smooth.

Now, in the case of a simple glacier without affluents, with a smooth bed of uniform breadth and gentle gradient, we should expect to find its surface smooth, even if bearing moraine. How, then, does it happen that the surface of the Hispar, where both the last two conditions obtain, is so universally broken up, over the detritus-covered portions, into high hillocks separated by deep depressions? The answer to this question can only be found in the effect on the glacier of its branches.

The four moraine-bearing branches on the north side above the Hiagatum, coming from high mountains, exert a tremendous pressure on the main stream, forcing it over bodily, as has been stated, against the ice-covered mountain-wall on the south side. Being prevented by the wall from yielding any more, and being compressed into the smallest possible space, the main stream resists further encroachment on the part of the branches.

Under such circumstances, what next happens depends on the resisting power of the ice to compression as compared with the pressure brought to bear upon it. If the former be greater than the latter, the branch simply turns in a curve into the space from which it has pushed the main glacier, and moves downward side by side with the latter with a smooth surface, as is the case with the large Haramosh branch after its junction with the Chogo Lungma. If, however, as is the case here, the pressure is greater than the resisting power of the ice, the ice is obliged to yield still farther, which it does in the direction of least resistance, *i.e.* toward its free surface, and is folded up into ridges and protuberances having a size and height proportioned to the excess of pressure over resistance, till an equilibrium is established.

Owing to the conditions existing at the lines of impact of the branches upon the main stream, the direction of pressure varies at different points, and in consequence ice-hillocks, many of them of great size, are formed instead of long ridges. While some of these, as already stated, take the forms of symmetrical or oblong cones and pyramids, their contours probably rounded somewhat by the heat of sun and air, the shapes of others in the hillock area indicate that, under the severity of the pressure, the ice composing them bursts asunder and forms a fault, one portion being crowded high above the other as a perpendicular ice-cliff shelving back to the glacial surface on the farther side. This process occurs most markedly in the upper layers of the ice, the lower ones, so far as can be seen, remaining in solid contact without the development of deep crevasses.

The hillock-formation first appears at the line of junction of the Kanibasar branch with the main stream, developing in the Kanibasar area as it moves downward. At the entrance of the Jutmaru it becomes more accentuated, the pressure here being evidently increased, and the broken surface extends upward into the Jutmaru itself for some 3 kilometres, nearly 2 miles, while it also spreads out laterally farther over the Hispar, encroaching still more on the area occupied by the white ice. The pressure is augmented at the junction of each succeeding lower northern branch.

The entrance of the Haigatum and the five lower branches on the south side now introduces a new factor of active counterpressure, thereby enormously increasing the compressing force to which the ice is subjected. The effect of this manifests itself immediately. The white ice, which after the junction of the Jutmaru branch narrows rapidly, and opposite the Haigatum is reduced to a slender tongue, just below this point is completely overwhelmed and disappears from view. From here to the end of the Hispar, a distance of 24 kilometres (14·9 miles) only a chaos of detritus-covered hillocks is seen. These, which higher up were more or less arranged in lines, are here thrown into disorder by the variety of opposing forces. They are also crowded up to a greater height, and, opposite the Makoram branch, their apices rise 85 metres (278·8 feet) above their bases.

The similar, though much less pronounced, formation existing at the lower ends of the Chogo Lungma and Biafo glaciers appears only after the lateral pressure on their streams has been increased by the junction of large branches and narrowing of their beds. A reach of typical hillocks was found at the middle third of the Biafo, in the area of a large western branch entering at that place, but it disappeared lower down. At and below the junction of the Alchori glacier with the Kero Lungma, the former descending rather sharply on the latter, a similar crowding up of the surface was observed in 1903, the elevations presenting some of the largest, highest, and most impressive, ice-slants I have anywhere seen on a glacier. The hillocks here were composed of ice bearing but little moraine-material.

A notable instance of this formation exactly paralleling the Hispar hillocks, and by no means yielding the palm to them in size or height, as it was larger than any of those observed on the Hispar, was mentioned by me, in a paper before this Society in November, 1907, as met with in the Nun Kun.* This was only a single hillock, but its genesis by pressure was all the more apparent on that account. It occurred at the line of impact on the Shafat glacier of a short branch falling some 2750 metres (about 9000 feet) directly from two high peaks. It was covered thickly from bottom to top with black detritus, while the side of the Shafat, which was opposing its advance, was clothed with red granite detritus, so that the area occupied by each was clearly marked. This instance and the hillock-area of the Hispar were particularly favourable to the study of this process, as it was not complicated by the presence of ice-falls or séracs in either case.

The pressure of most of the branches at the line of their first contact with the Hispar acts upon the latter in a direction nearly or quite perpendicular to its axis. As the branches, under the pressure from behind and the resistance of the main glacier in front, turn in great curves toward the west and align themselves with the main trunk, the pressure is transmitted around the curves so as to act, finally, at right angles with its former direction, or parallel with the glacial axis. Hence it follows that the lateral displacing power of the branches on the glacial trunk is greatest at or shortly below the line of their impact upon it, diminishing as the angle of contact, in their passage around the curve, becomes more acute, and becoming practically nil, when they have fully aligned themselves with the glacial axis and become constituent columns of the main trunk.

An interesting circumstance connected with the pressure of the branches, especially of those above the Haigatum which have no opposing branches on the south side, is, that, when an equilibrium has been established by the yielding of the main stream, the compression and folding of the ice, and the pushing up and faulting of its upper layers into irregular projections, and the branch has turned into and occupied the space from which it has displaced the main glacier, the compound glacier thus formed moves downward, until joined by the next lower branch, without exercising any perceptible return lateral pressure toward the side from which the branch entered. This is seen in the fact that,

* *Vide* the *Geographical Journal*, January, 1908, p. 17, illustration.

after the branches have turned downward in the direction of the glacial axis, their free edges, though broken and greatly serrated, rising perpendicularly high above their beds run in straight lines at considerable distances from the former lateral moraines or from adjoining mountain-walls to the junction of the next lower branch. The same was observed to as marked a degree on the Biafo.

Besides the absence of typical median-moraines in the hillock-area, where moraine-material is most largely found, such moraines are rather feebly marked over the remainder of the glacier. A few small ones extend out from the south ice-wall just above the entrance of the Haigatum and from the junctions of the Kanibasar and Last Moraine glaciers, but otherwise the remarkable, highly developed moraine-formation existing on the Chogo Lungma is wanting.

Not so, however, with lateral moraines. On the south bank of the glacier below the Haigatum and along the whole of the north bank as far as Last Moraine branch, gigantic, ancient, primary moraines overgrown with vegetation and dwarf-willows exist. The highest of these are found on the north bank between the Lak glacier and the end of the Hispar, where the ridges of some of them, as measured by Drs. Calciati and Koncza, stand 120 metres (393·6 feet) above the present surface of the ice.

Between these and the glacier more recent secondary moraines, some of them of large size, are seen at various places. On the west bank of the Haigatum, just above its entrance into the Hispar, where we camped, five lateral moraines were found, one below another, the fifth, by no means a small one, being still in the process of formation. The highest recently formed lateral moraine adjoining the ice is situated on the north side of the Hispar, just below the junction of the Lak glacier. Its height was measured at 40 metres (131·2 feet).

The Hispar and its larger branches, and also the Biafo at certain points, are, at present, actively engaged in building lateral moraines. At the edges of these glaciers great, ragged, perpendicular ice-walls rise high above the glacier-bed, their summits as well as their substance heavily loaded with *débris*, which is constantly showered down, often in cart-loads, upon the moraines at their bases. At some points the moraines can be seen to grow day by day, and even hour by hour. As these walls move downward in straight lines, they apparently exert no lateral pressure on their moraines, so that there is no question as to their forming moraines by pushing or ploughing up ground-moraine-material, and I saw no evidence that such was pressed out on their sides by their weight. The moraines appeared to be wholly built up by the deposition of the *débris* borne on the glacial surface, as well as in the crevasses and substance of the ice-walls.

Some fine examples of intraglacial moraines cropped out in places on the glacier-edges, composed of detritus which had fallen into and filled large crevasses. The capacity of the Hispar as a moraine-builder appeared to be exhausted before its ice reached the extremity of its tongue. In contrast to the large lateral moraines higher up, the terminal moraine-formation was not marked, only a small moraine existing in front of one section of the tongue.

Névé and glacier-ice are composed of strata or bands, which represent the snow-accumulation of successive seasons in the reservoir. At the sources of a glacier these are of considerable thickness, and overlie one another in horizontal or gently curving layers corresponding with the conformation of the terrain on which they rest. In a glacial trunk they are compressed, often into thin ribbons, and their edges may be tilted to any angle with the horizontal. They may also be curled and twisted into serpentine folds.

A great glacier is not the best place to study the relation of banding in the trunk to *névé*-stratification in the reservoir. In the complexity of currents, the breaking up into ice-falls and seracs, the displacements, the regelation, the conditions of pressure, folding, and torsion, and other accidents to which the ice of a glacier is subjected, the difficulty of tracing the relation of the final structure of a given mass of ice to that of the *névé* in which it originated, after the great distance it may have travelled from its source of origin to the place where it is observed, is obvious. Indeed, it is marvellous that, considering the vicissitudes it has undergone, the ice near the tongue of a 50-kilometre (31-mile) long glacier should retain such perfect stratification as it often exhibits. This subject is more advantageously studied on short uncomplicated glaciers.

On all exposed surfaces of the Hispar ice-falls, as on similar surfaces elsewhere, the *névé*-stratification was well marked, the strata being horizontal or somewhat curved. So on exposed ice-surfaces at all points of the glacier, even to the extremity of the tongue, stratification was visible; but the strata ran in every direction according to the conditions to which the ice had been subjected on its downward journey. Perpendicular strata were common. In many instances they were curled and twisted into curious patterns, while in one large ice-ledge projecting from the extremity of the tongue they were as horizontal as could be found in the level *névé*. Over the greater part of the end of the tongue stratification could not be observed owing to the discoloured and detritus-covered condition of the ice.

Not one of the grassy, flower-sprinkled maidans described in connection with the Chogo Lungma and Alchori glaciers was met with on the Hispar.* The mountains rise too abruptly from the glacier to afford any space for these. One such maidan was found at the junction

* *Vide* 'Ice-bound Heights of the Mustagh,' pp. 179, 352, 361; and the *Geographical Journal*, March, 1905, pp. 252, 253.

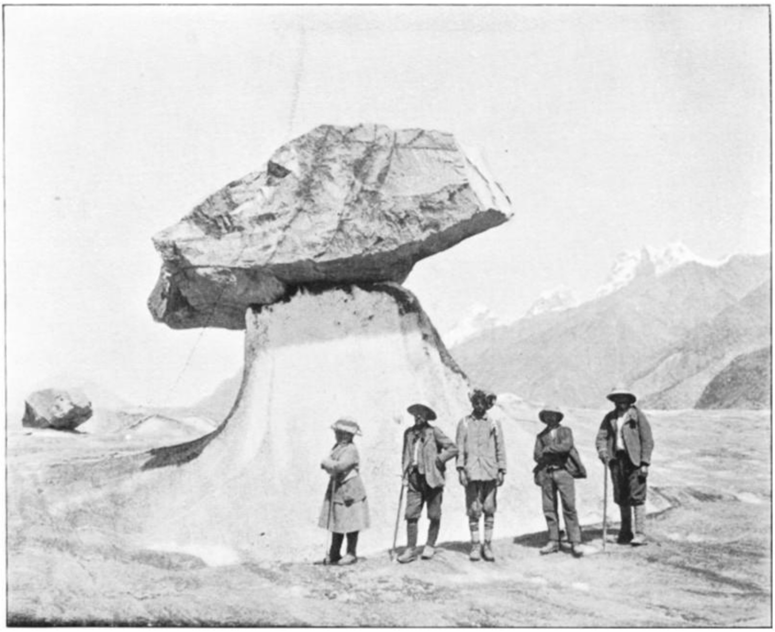

FIG. 4.—A GLACIER-TABLE OF UNUSUAL SIZE MET WITH ON THE LOWEST THIRD OF THE BIAFO GLACIER AT AN ALTITUDE OF ABOUT 3660 METRES (12,000 FEET). THE ROCK-BOULDER WAS 5 METRES (16·4 FEET) LONG, THE ICE-PEDESTAL 3·8 METRES (12·46 FEET) HIGH, AND THE HEIGHT OF THE WHOLE 5·5 METRES (18 FEET). A TABLE WITH MUCH LOWER PEDESTAL SEEN IN DISTANCE AT LEFT.

FIG. 5.—MUD-COVERED NIEVES PENITENTES, THICK DÉBRIS, VARIETY VI., IN CENTRE OF BIAFO GLACIER; COATING THICKEST AT APICES. PYRAMIDS ARRANGED IN TWO LINES. LARGEST 70 CENTIMETRES HIGH. HIGH MEDIAN MORAINE SHORT DISTANCE BEHIND THEM.

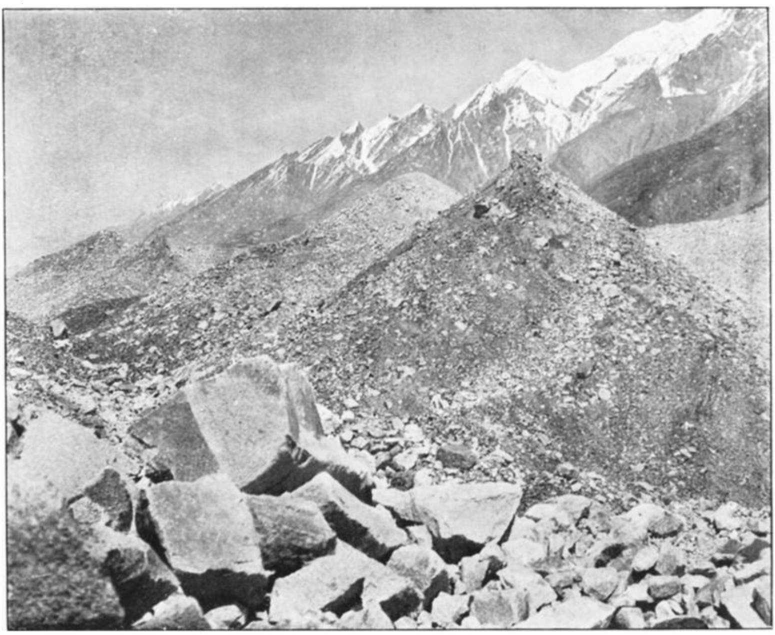

FIG. 6.—FOUR OF THE DÉBRIS-COVERED HILLOCKS OF THE LARGER VARIETY STANDING IN A LINE IN THE CENTRE OF THE HISPAR GLACIER AT A DISTANCE OF 29 KM. (18 MILES) ABOVE THE EXTREMITY OF ITS TONGUE. THE HEIGHT OF HILLOCKS LIKE THESE VARIED FROM 15 TO 85 METRES (48·9 TO 278·8 FEET). THE ONES HERE SHOWN ARE AMONG THE LARGEST.

of a branch of the Jutmaru with that glacier, and utilized for a camp. This was of alluvial formation, and had, in the not distant past, been the bed of a border-lake, which had mostly silted up through the deposit of mud poured into it by the streams from the glacier above.

Nieves penitentes were met with, widely distributed, on the Hispar and its branches, on the mountain-slopes enclosing them, and on the Biafo and Skoro glaciers, occurring under a variety of conditions. Careful observation of the material presented, many times repeated, afforded confirmatory evidence of the truth of the views relative to the development of this formation expressed by me before this Society in November, 1907,* and also added new facts regarding it, which throw definite light on this hitherto obscure and little-understood question, in regard to which opinions have differed so materially.

The *nieves penitentes* studied by myself in the Nun Kun in 1906, though scattered over a wide area, appeared to be everywhere of the same kind, and due to the action of one and the same set of causes. The diversity of opinion, however, regarding the mode of development of *nieves penitentes* expressed by various observers, many of whom are men trained in glaciological science, induced me at that time to suspect that more than one set of conditions were concerned in the production of this phenomenon, and that different observers had met with *penitentes* that were determined by different causes, the formation of which they endeavoured to explain upon a common principle, upon which they, naturally, were unable to agree. This view has since been borne out by the various forms of *nieves penitentes* met with in the Hispar region in 1908.

Among the variety of views that have been advanced, observers have practically agreed that one factor essential to the production of *penitentes*, and according to some the only one, is the unequal melting of *névé* under the application of heat in some form, principally that of the sun. Having become convinced by my observations in the Nun Kun, that the action of heat is simply to melt the softer and less resisting faster than the denser and more resisting parts, this action being identical in all cases; and that, for the development of *nieves penitentes* under the application of heat, an antecedent or concomitant differentiation of *névé* or ice into alternate areas or centres of unequal density is also necessary, with the profusion and variety of *penitentes* spread before my eyes in the Hispar region, I endeavoured to solve the problem by directing my attention to the study of the circumstances that might produce such differentiation, with the result that I was able to recognize eight distinct varieties of *nieves penitentes*, the first including three sub-varieties, classified according to observed antecedent causes other than

* *Vide* the *Geographical Journal*, January, 1908, pp. 17–22; also the *Alpine Journal*, May, 1908, pp. 139–148.

melting. This being, so far as I know, the first attempt at classification of *penitentes* that has been made, and based only on what was actually seen, it is quite possible that further observation may disclose additional varieties.

The varieties observed were (I.) The avalanche variety with three subdivisions. (*a*) It was found that in the case of avalanches composed originally of hardened *névé* falling from heights above upon sloping surfaces, over which they travelled for considerable distances, the coarser constituents or blocks showed a tendency to arrange themselves in lines, while the more finely divided and pulverized portions took the form of ridges, both lines and ridges being parallel to one another, with a direction coincident with the incline of the slope and the course of the avalanche. These ridges contained at short intervals centres denser than the rest of their substance, formed between pressure of moving snow behind and resistance of that in front. The action of sun and heat on these avalanche-beds, thus differentiated, had developed *penitente*-pinnacles of various forms and sizes by shaping the *névé*-blocks and melting away the softer portions of the ridges.

(*b*) Where snow-avalanches without a primary, perpendicular drop had slid down over *névé*-slopes, parallel ridges containing centres of denser *névé* were formed, which centres under heat developed into *penitente*-pinnacles of pyramidal type and moderate size, both ridges and pyramids orienting with the slopes and courses of the avalanches.

(*c*) Where new, soft snow at high altitudes of upwards of 5800 metres (19,000 feet) had slid down very steep slopes, and lodged without travelling forward after striking, *nieve*-pinnacles with serrated, feathery apices were developed by melting. These stood in rows largely transverse or diagonal to the direction of fall of the avalanches, though often coincident with it. Although their material was softer than is usual with other *nieve*-forms, denser centres constituting the bodies of the pinnacles were demonstrable. The nature of the avalanche itself thus seems to condition the type of *penitentes* developed on its bed.

II. Subsidence variety. On beds of old, consolidated *névé* covering sloping surfaces not sufficiently steep for production of avalanches, subsidence of their component snow gave rise to straight-edged, longitudinal ridges with denser foci, which had developed into pyramidal *nieve* of medium size, both pyramids and ridges orienting with the inclines of the slopes.

III. Wind - conditioned *penitentes*. Extensive *névé*-surfaces with gentle inclines, both on glaciers and mountains, were covered with parallel ridges running in every direction according to the incline of the slopes, with which their course always coincided. The tops of these ridges bore *penitente*-pyramids of medium size denser in structure than the *névé* between them. These ridges and pyramids, like those on the Shafat glacier, occupied surfaces swept by wind and not exposed to avalanches. The *névé* composing them was not so old or dense as that of the subsidence-variety, and the ridges were more wavy in outline.

The next four varieties, each presenting distinctive features of its own, depend for their formation on the deposition of detritus of various kinds on a glacier, the detritus, according to its nature, causing the ice beneath it to melt by absorbing and transmitting the sun's heat, or protecting the ice beneath it from the action of heat while the glacial surface around melts away, thus giving rise to *nieves penitentes*.

IV. Thin detritus variety. Over large areas of the Hispar and Jutmaru glaciers *penitentes* were met with varying from a few centimetres to 2 metres (6·5 feet) in height, the intervals between which were occupied by oblong pools with perpendicular walls often a metre or more in depth, the bottoms of which were covered with thin layers of finely divided earthy material, sand, gravel, or thin pieces of shale. These pools were arranged with great regularity, their long axes orienting mostly east and west, as did those of the *penitentes* between them.

Here the *penitentes* owed their existence to an antecedent deposit of detritus, probably mostly through æolian agency, in parallel wavelets upon smooth surfaces of the glaciers. These wavelets, absorbing and transmitting the sun's heat in virtue of their dark colour, caused the rapid melting of the ice beneath them, thus forming the pools at the bottom of which they lay. The pinnacles of ice left standing white and clean between them were moulded by heat into *nieves penitentes* of typical shape.

V. Glacier-table-variety. This was seen in abundance on the Hispar and branches, and on the Biafo and Skoro glaciers, below the limit of *névé* along the courses of moraines, where multitudes of boulders and glacier-tables covered the surface. Glacier-tables are formed by the melting of a glacial surface around the resting-places of large boulders, leaving the latter supported on pedestals composed of ice, which, protected from the sun's rays by the boulders, has remained unmelted. As the upper extremities of the pedestals become bevelled by melting, the boulders no longer sit level upon them but begin to tilt, and, as the bevelling becomes more accentuated, they finally slide off on to the glacier, leaving the pedestals standing as ice-shafts 1 to over 2 metres (6·5 feet) high, which are further sharpened off into *nieve*-pinnacles by heat. In some cases the shaft is developed into a fully formed pyramid before the top slides off. In other cases it is sharpened off after this event. These *penitentes* were found single, in groups, and in lines, in the two latter cases being developed from pedestals of several glacier-tables standing together, or from several hardened columns formed beneath very large boulders. Their orientation was determined by the shape and character of the boulders to which they owed their existence.

VI. Thick detritus-variety. This was seen mostly on ice below the *névé*-line also along the courses of moraines, orienting in every direction irrespective of inclines. The pinnacles were met with, a few in a place or in large numbers, arranged in great part in lines, covering plain ice-surfaces, slants, crests, depressions, and even the exterior of séracs. They were invariably coated with mud, sand, or gravel, most thickly over their apices and the ridges running out from them. They consisted of dense, crystalline ice destitute of air-bubbles, and much harder than the melting aërated ice around. They owed their origin to the deposition on the glacier of patches of mud, sand, or gravel, which, like the boulders of the glacier-table variety, protected the ice beneath them from the heat of sun and air, that melted away the surrounding ice, leaving them as *penitente*-pinnacles, always of pyramidal type, and often 2 to 3 metres (6·5 to 9·75 feet) high, one of 10 metres (32·8 feet) being found.

VII. Lacustrine or composite variety. This was found on old beds of consolidated *névé* adjoining glacier-lakes, in the mud-laden waters of which they had been submerged. The pinnacles were triangular and quadrilateral pyramids, 30 to 40 centimetres (12 to 16 inches) high. They were arranged in regular rows, were connected with one another by ridges, and oriented with the slopes they stood on. They were coated with mud, most heavily over apices and ridges. In this case the differentiation into pyramids and depressions probably occurred through the agency of wind or subsidence and sun antecedently to their immersion in the lake; but the action of water may have accentuated the process, and it deposited the mud in consequence of which their further development, after subsidence of the water, would proceed on the lines of that of variety VI. Similar *nieve* was seen on beds of hardened *névé*, which had been submerged by muddy torrents resulting from the bursting of glacier-dams.

VIII. Sérac variety. Many tall, slender séracs were seen on ice-falls modelled by heat into cones and pyramids of giant size displaying all the features of ordinary *nieves penitentes*, even to hoods, and evidently fashioned in the same manner. Also on their surfaces small projections and irregularities were sculptured into *penitentes* of usual size and shapes.

The extended observations, which have made the above classification possible, lead me to the conclusion that *nieves penitentes* are developed by the action of heat, from whatever source derived, upon *névé* in which ridges containing centres or foci of hardened snow, and sometimes such centres independent of ridges, have been formed by avalanches, subsidence or wind, the size and shape of the centres determining the size and shape of the resulting pinnacles; and also upon *névé*, but more notably upon ice on which detritus has been deposited under circumstances described, or which has been disrupted into comparatively slender fragments or séracs. In all cases heat melts away the softer and less protected portions more rapidly than the harder and better protected ones, leaving the latter standing as *nieves penitentes*. The sculpturing process may, in rare instances, be assisted by the action of water as in variety VII.

NOTE.—For a detailed consideration of this subject, which is only indicated in a very condensed form here, *vide* a paper entitled "A study of *Nieves Penitentes* in Himalaya," Paper No. 2, by William Hunter Workman, M.A., M.D., in the *Zeitschrift für Gletscherkunde*, Band III., Heft. IV., May, 1909. Also for a somewhat less detailed description *vide* "Peaks and Glaciers of Nun Kun," by Fanny Bullock Workman and William Hunter Workman, pp. 163–199.

Sir MARTIN CONWAY: Before making one or two remarks on this interesting paper, I should like to return my very cordial thanks to Dr. and Mrs. Workman for the delightful pleasure they have enabled me to enjoy to-night, in revisiting, by aid of their beautiful photographs, this perfectly glorious region, second to none of the mountain regions of the world, for beauty and interest. Mrs. Bullock Workman referred to the nomenclature of the glaciers of the Hispar basin. Of course, travelling very rapidly through a country, as a first pioneer must do, it is not possible to do more than collect such names as the natives present give. My experience is that it is very difficult indeed to place much reliance upon those names. Certainly the glacier which was called Kanibasar on my map appears to be next to the one called Kanibasar on Dr. and Mrs. Workman's map. I have no doubt they may have obtained a more correct location for the name; but when I was there, only a few of the oldest coolies had been up the Hispar glacier before, and none of them were quite sure of where some names should be located. Names float about in those very remote places, and, as a matter of fact, they may not become firmly fixed until the map-maker comes and fastens them down. I found a similar uncertainty as to the names of some of the tributaries of the Baltoro glacier.

The second point I would refer to, is the question of the Cornice glacier. Dr. and Mrs. Workman have proved clearly, by their photographs, that the place where I put the exit of the Cornice glacier is barred across by a rock wall. When I was on the spot, that rock wall was hidden under clouds. By some peculiar divination, for which I give myself great credit, I must have discovered that there was a glacier behind that wall, for my only reason for marking the glacier on the spot where I did, and where the Cornice glacier is actually situated, was because on that foggy day I thought I saw it. Now it appears I did not, and therefore, frankly, I know nothing at all about the Cornice glacier. I wish, however, to call attention to the very remarkable fact, which Dr. and Mrs. Workman have put on record. They have looked down into the Cornice glacier basin from various points. This glacier basin lies at a level approximately 17,000 or 16,500 feet above sea-level, and the wall on the side where they showed us the photographs cannot be above 1000 feet above glacier-level. So that you have a glacial basin entirely surrounded by mountains, at one place only 1000 feet high, and this glacier basin has no exit whatsoever. There it is, and there it has been, I suppose, for thousands of years; and into that basin there must have been pouring snow all that time, and yet it is not full up: 1000 feet of snow would fill it, and to make a thickness of 1000 feet of snow would certainly not take above two hundred years of snowfall, and it has had a great deal longer than that. Now if there is no exit anywhere, how does the snow get away? Why has it not filled up and overflowed the low gap that opens to the Biafo glacier? My conclusion is that there must be an exit somewhere; and I think that after Dr. and Mrs. Workman's repeated journeys of exploration, they have got to go back again once more. They have got to climb into this glacier and find its outlet.

Finally, I would refer to Dr. Workman's most interesting remarks and observations about the surface forms of snow and ice, which he has grouped under a number of different heads. I would only quarrel with him about the name under which he unites them, that of *nieves penitentes.* In my opinion all the variety of forms he has identified and grouped under different headings include no *nieves penitentes* amongst them. It is, perhaps, a mere question of name. You can call them all *nieves penitentes* if you like; only that is not what *nieves penitentes* really are. *Nieves penitentes* is a name given in the southern part of the Andes to a particular snow formation, not just the snow pinnacles, but to a particular kind of snow pinnacle. It is a snow pinnacle of a quite definite kind. It is different in appearance from anything that was shown in those beautiful slides of Dr. Workman's. They all show you phenomena connected with the surface forms of snow—how it may be moulded into pinnacle shapes and ridges of several kinds, and produced by different processes; but the *nieves penitentes* of South America are different from all of them. We have seen actual *nieves penitentes* on that screen on many occasions. The characteristic of the *nieves penitentes* is that they are moulded out of a bed of snow by the peculiar action of the sun. They are all of them roughly pyramidal in form, of an oval-pyramid form, the major axis of the oval running approximately east and west, and all the pyramids dip towards the north in the southern hemisphere—towards the sun. Then those of one group are almost always of approximately the same height, and they look (and that is why they are so called) like a crowd of *penitentes* clad in white sheets on the hill-side, and the Spaniards in South America call them *nieves penitentes.* As the season advances, the hollows enlarge and deepen between them. The sun looks down into the hollows; the reflection concentrates heat at the bottom, and the hollows are melted deeper and deeper right down to the ground. The pinnacles of snow are finally left standing on the ground, each one separate from the other, very often in hundreds. Those are what in South America they call *nieves penitentes.* You may take the name, and by analogy apply it to various pinnacular forms of snow, only you would not be understood in South America if you did. I have never seen, either actually or in photographs, anything like them in the Himalayas, or the Alps, or in Spitsbergen, or in any other part of the world, and I should be very glad to know that, after Dr. and Mrs. Workman next year have made an expedition to Cornice glacier, they will make another expedition to the Andes of Chile and the Argentine, where they will find these *nieves penitentes*, and where Dr. Workman might continue to enlarge his observations on the various forms of sculptured snow surfaces, which he has already so carefully studied. I am not now criticizing his classification; I am merely suggesting that it would be better to keep the term *nieves penitentes* for the particular form for which the name was invented. I should like once more to thank Dr. and Mrs. Workman for their delightful paper, to congratulate them on the continued success of their great achievements, and to express the hope that we have not heard them here for the last time.

The PRESIDENT (after the paper): Any one travelling in such a region as this must often be tempted merely to focus their interest on feats of mountaineering. I believe I am right in saying that the feats accomplished by Mrs. Bullock Workman are more remarkable in the way of mountaineering than those which have been performed ever before by any one of her sex. Whether I ought to make that limitation or not, I am rather doubtful, but at all events, with that limitation, it will not be denied. But in spite of all the difficulties, our travellers have throughout the whole of their journeys kept their eyes steadily fixed on geographical work, and have therefore brought back with them ample stores of new information, both with regard to the topography of the districts visited, and concerning those interesting snow columns, whether they be called *nieves penitentes* or not. Therefore, I am sure in the name of every one here present, we not only thank them for their extremely interesting papers, but wish them good luck the next time they go to these regions —good luck in conquering new peaks and traversing new icy fastnesses.

Dr. WORKMAN: I am greatly surprised at the assertion of Sir Martin Conway, that the formations I have shown on the screen to-night are not *nieves penitentes* at all. If they are not *nieves penitentes*, I would ask him, What are they? His conception of *nieves penitentes*, as he gives it, is too restricted to be up to date. In the light of the careful observations made during the last fifteen years in the Andes, in the Sierra of North America, in equatorial Africa, in Himalaya, and even in Iceland, it cannot be said to-day that this formation occurs only in the Andes, or only on one variety of basis, or that the pinnacles have any exclusive shape or size, or that their long axis or the lines in which they may stand orient only east and west.

Among others who have studied them elsewhere than in the Andes, Prof. Hans Meyer, than whom there is no higher authority on *nieves penitentes*, who has seen them in great quantity in various localities in the Andes, and who, therefore, according to Sir Martin Conway's standard, if any one, should be able to recognize them, asserts that he found typical *nieves penitentes* on Mount Kilimanjaro and in the crater of Kibo in Central Africa.

Sir Martin's argument to support his contention that an enclosed glacier cannot exist because the basin in which it lies would fill up with snow is not convincing. It is true that Nature furnishes a new supply of snow to feed a glacier each winter, but it is also true that, during the succeeding summer, it removes a large amount of such snow by melting and evaporation, even above the snow-line, and below it the waste exceeds the supply, till the glacier finally dies out.

There is no reason why an enclosed glacier should not die out within its own basin without having an outlet on another glacier, provided its basin falls to an altitude sufficiently below the snow-line. The question of the life of a glacier is simply one of supply as compared with waste, irrespective of its connection with any other glacier or of its basin with any other basin.

Cornice glacier in question, from its origin on the west Biafo wall, occupies the bottom of a deep narrow valley, or nala, with precipitous sides. Its reservoir is therefore small, and the amount of snow which collects to feed it limited. From its head it descends speedily to a level of 15,000 feet, and then considerably lower than that, *i.e.* to a level much below the snow-line of the region. Further, the valley and glacier run from east to west, and the sun pours its rays into the former upon the latter for many hours during the long summer days with a heat of from 180° to 210° Fahr., the melting effect of which is increased by the confining of the heat by the perpendicular enclosing walls, which exclude all wind. The singeing heat experienced in such valleys is well known to those who have travelled through them in Himalaya during the warm hours of the day. Under these circumstances the wastage from melting and evaporation equals at least the increment from the winter snow-supply, and in fine-weather seasons must exceed it, and is sufficient to keep the glacier, as we saw it, at the very bottom of its nala.

When we looked down from the col at the head of the Hoh Lumba (overhanging Cornice glacier not a great distance below its origin) upon Cornice glacier beneath us in the middle of June, its surface even at that point and at that early season consisted of fully formed glacier-ice, cut up by crevasses, entirely denuded of winter snow and *nieve*, which had already melted away. This was six to eight weeks before the maximum of melting takes place in that region, and, with the sun exerting its destructive effect upon that narrow surface of ice for another eight weeks, it is easy to judge what the chances are of that glacier filling up the chasm 2000 to 3000 feet deep, at the bottom of which it lies.

The noteworthy facts, that this glacier lies at a much lower level than the corresponding portions of other glaciers around it, that it is composed of fully formed ice, while they are deeply covered with snow and *névé*, and that it is enclosed on all sides by high mountain walls, in which the direct observation of those who have been entirely around it has disclosed no opening, as well as the indications afforded by the condition and size of the glacier itself, supply more conclusive evidence that it is enclosed only by and ends only in its own basin, than the disbelief of Sir Martin Conway, who has never seen the glacier nor any of its barriers, except the south Hispar wall, which, according to his own testimony, has no opening at this part.

A NATURALIST'S TRAVELS ON THE CONGO-ZAMBEZI WATERSHED.*

By S. A. NEAVE, M.A., B.Sc. Oxon.

THE following notes are the result of more than four years' wanderings in Northern Rhodesia and the Katanga region of the Congo Free State. Some of the country here discussed has already been dealt with by Mr. L. A. Wallace, the present administrator of North-West Rhodesia, in the *Journal* of this Society for 1907, pp. 369 *sqq.* He has there described the main geographical and geological features of the country very fully. It may, however, be of some interest to supplement his excellent account with some notes on the faunistic features of this part of Africa—more especially as I was fortunate enough to travel some considerable distance through a contiguous area in the Congo Free State, a region which does not come within the scope of Mr. Wallace's paper.

Before dealing with the local conditions, it is necessary to shortly review the general distribution of the fauna of Africa south of the equator. The South African subregion has usually been considered to be bounded to the north by the Zambezi river, on the east, and by the Cunene river on the west, and this is, no doubt, roughly correct. It is, however, of great interest to observe that whilst the tropical species of the equatorial zone (I am here more particularly referring to butterflies and other insects) have spread down the east coast as far as Durban, they do not on the west extend much below the Kwanza river in Angola, a difference of 20° of latitude. This is no doubt mainly due to the high central plateaus on the eastern side of the African continent in this latitude being remote from the sea-coast, whilst on the west, in Angola, the lowlying coast-belt is vastly narrower. On the west side the advance of a tropical fauna to the south is also much checked by the very dry climate which obtains on the coast-belt in southern Angola and to the south of it. This great central plateau is often hundreds of miles wide, and in this latitude its long

* Read at the Royal Geographical Society, November 22, 1909. Map, p. 224.

something of this region, a great deal of our own ignorance. I must confess, as one who has been in a portion of that region, that I have learned much that has been new to me, and I have been specially interested in the allusion which Mr. Neave made to-night to the character of the native inhabitants of those regions. It is one of the most difficult problems that people in a new country have to deal with, how to make their work fit in, if I may say so, with the native habits, so as not to dislocate the order of ideas to which natives are accustomed too rapidly. We have to develop those territories in the best way possible, so as to make the best use of the material at our disposal. We have to displace the primitive methods of agriculture with something that is better, and to teach methods that will enable natives to satisfy their wants with less effort and better results than is possible at present. That great work, I hope, is being done gradually and effectively by the posts which the Administration of the British South Africa Company is establishing throughout these vast territories, of which you have got an illustration to-night in the admirable photograph which Mr. Neave has shown us of the post which was being established in the extreme north at the time of his visit.

Dr. Arthur Haydon : There is one point we have just heard a little about, and that is of the progress which is being made in the treatment of sleeping-sickness. We have seen various models of houses, and some example of the inoculation treatment. I should like to know what progress is being made in the control of the disease under the present conditions.

Mr. Neave : I think I might say very stringent regulations are being made in Northern Rhodesia to prevent the spreading of it, but I think it is more a question to be answered by the Administration of the country than by myself.

The President (after the paper): Mr. Neave has shown us how the highlands separate the country into three districts; how they prevent migration of animals from one part to another; and how they have created districts where the process of evolution has run different courses. To-night's paper is, in fact, the account of a Boundary Commission dealing with the boundaries between various animal kingdoms, and I am sure you will wish me in your name to thank Mr. Neave for the charming description he has given of his labours in this direction. All the speakers have joined in wishing good luck to Mr. Neave on his coming mission to Africa, and have expressed their sincere hope, in which we all join, that these labours will be successful.

THE CYCLE OF MOUNTAIN GLACIATION.*

By Prof. WILLIAM HERBERT HOBBS, University of Michigan.

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* Read before the Section of Geography of the British Association for the Advancement of Science at the Winnipeg meeting, August 27, 1909. When not otherwise credited, the views reproduced in this paper are from photographs taken by the author, mainly during the summers of 1908 and 1909.

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THE CIRQUE AND ITS RECESSION.

Introduction.—With the advance of knowledge concerning the sequence of conditions affecting glaciers, it has come to be generally recognized that for any given district the factor of supreme importance is temperature, a very moderate change in the average annual temperature being sufficient to profoundly transform a district, the aspect of which is temperate, and to furnish it with snow-fields and mountain glaciers. These slight variations in average annual temperature involve less important geological changes than must be invoked in order to greatly modify the annual precipitation. Thus it has been recently estimated that a fall of but 3° (Fahr.) in the average annual temperature would result in the formation of small glaciers within the area of the Scottish Highlands, while a like fall of 12° within the Laurentian Lake district of North America would suffice to bring on a period of glaciation.

With the probability that such climatic changes would be initiated slowly, the first visual evidence of the changing condition within all districts of accentuated relief would probably be a longer persistence of winter snows in the more elevated tracts; which accumulations of snow would eventually contribute a remnant to those of the succeeding winter, and so bring on a cycle of glaciation. From this beginning the cycle is an advancing one until a culmination is reached corresponding to the most rigorous of the climatic conditions. A resumption of a more genial climate would result in a reverse series of changes, terminating so soon as the winter's fall of snow is insufficient to produce permanent snow-drifts even in the higher areas. It is therefore proper to speak of the *advancing* and the *receding hemicycles of glaciation.*

Mountain versus *Continental Glaciers.*—The land-forms which result from glaciation within districts of strong relief when not entirely submerged beneath snow and ice, are totally different from those which are sculptured beneath a glacier of continental dimensions. Examination of university text-books and experience with students have alike convinced the writer that this difference has not been sufficiently accented. In part, this may be explained by a rather general tendency to treat the subject of erosion by glaciers in mountains from studies made especially in the lower altitudes.* A quite general neglect of those special conditions of denudation which are operative in high-level areas of glaciers is, it is believed, responsible for an over-emphasis laid upon the U-shaped trunk valley and the hanging tributary valley, important as these features are.† This over-emphasis can, perhaps, be best illustrated by reference to a series of three successive idealistic sketches, executed with great skill by an eminent American geographer, and intended to develop especially the erosion forms which result from mountain glaciers.‡ The low-level sculpturing expressed by these sketches is, in the opinion of the writer, admirable, and a true rendering of nature. It is the failure to recognize any additional process of erosion operative in higher altitudes which destroys the value of the high-level sculpturing displayed.

So far as low-level mountain glaciation is concerned, the erosive processes are pretty well understood to be identical with those of continental glaciers, namely, abrasion and plucking. The larger proportion of projecting rock-masses in the case of mountain glaciers will, however, presume a greater emphasis upon lateral undercutting from the operation of both of these processes acting conjointly. It is the operation of an additional denuding process of the first importance, head-wall erosion, that differentiates all types of mountain glaciers from continental ones. This distinguishing process is responsible for the development of the *cirque* (Ger. *cirkus*), which is known by a variety of names in different glacier districts. In Scotland it has been generally referred to as the *corrie*, in Wales as the *cwm*, and in Scandinavia as the *botn* or *kjedel* (*kessel*). In the scientific literature of the subject, the Bavarian-Austrian word *kahr* has been used with increasing frequency for the same topographic feature. In view of this diversity in resultant topography, and despite their close genetic relationships, we would do well to sharply separate in our discussions continental glaciers from all other types, which latter we may include under the broad term of mountain glaciers.

The Glacial Amphitheatre in Literature.—It is safe to say that no topographic feature is more characteristic of the mountains which have

* "The visitor replied that he was a valley climber, not a mountain climber. He found sufficient pleasure at the mountain base, and such was my case also. Mountain-tops are indeed worthy objects of a climber's ambition, but if one wishes to get at the bottom facts, let him examine the valleys" (W. M. Davis, "Glacier Erosion in the Valley of the Ticino," 'Appalachia,' vol. 9, 1901, p. 137).

† On hanging valleys, see especially W. M. Davis, *Proc. Boston Soc. Nat. Hist.*, vol. 29, 1901, pp. 273–322; and G. K. Gilbert, 'Harriman Alaska Expedition,' vol. 3, "Glaciers."

‡ W. M. Davis, "The Sculpture of Mountains by Glaciers," *Scot. Geogr. Mag.*, vol. 22, 1906, figs. 1–3.

been occupied by glaciers than is the cirque. Approaching a range from a considerable distance, there is certainly no form which so quickly forces itself upon the attention. The U-shaped valley and the hanging side valley, important as these are, are here decidedly less impressive. Yet the great majority of works upon the subject, by ignoring the significance of the cirque, allow the reader to assume that the glaciers discovered the cirques ready formed to gather in the snows for their nourishment. Even the standard work of Chamberlin and Salisbury is open to this objection.*

Despite the attitude of the general texts, which so largely determine what might be called the accepted body of doctrine of a science, there are a number of papers dealing with the origin of the cirque. One of the first to recognize the cirque as a product of glacial erosion was Tyndall, whose keen mind has so illumined the page of mountain glaciation.† In opposition to his view, Bonney published in 1871 a somewhat elaborate article, in which the line of argument was: (1) that the Alpine cirques must have been produced by the same agency which shaped the valleys below them; (2) that the valleys were not moulded by glaciers; and hence, (3) the cirques must have been retained from the pre-glacial land surface.‡ The published discussion of this paper developed no opposition to the view, though Doctor, now Sir Archibald, Geikie stated that he could not see his way to account for the vertical walls surrounding the cirque. On the other hand, the Italian Professor Gastaldi recognized the work of the ice in the shaping of cirques in the Italian Alps, § as Helland did in those of Norway. The latter believed that excessive weathering in the rock above the *névé* played an important *rôle*, though abrasion by the ice upon the floor was the larger factor.‖ Later, Russell in America,¶ Wallace in England,** and de Martonne on the continent, †† further advocated the glacial origin of cirques. Penck has explained the development of cirques as the

* 'Geology,' vol. 1: "Processes and their Results," 1904, pp. 272-276, and especially fig. 250. See also 'College Geology,' by the same authors, 1909, p. 256.

† John Tyndall, "On the Conformation of the Alps," *Phil. Mag.*, Ser. 4, vol. **24**, 1862, pp. 169-173.

‡ T. G. Bonney, "On the Formation of 'Cirques,' with their Bearing upon Theories attributing the Excavation of Mountain Valleys mainly to the Action of Glaciers," *Quart. Jour. Geol. Soc.*, vol. **27**, 1871, pp. 312-324.

§ B. Gastaldi, "On the Effects of Glacier-erosion in Alpine Valleys," *ibid.*, vol. **29**, 1873, pp. 396-401.

‖ Amund. Helland, "Ueber die Vergletscherung der Färöer, sowie der Shetland und Orkney Inseln," *Zeitsch. d. Deutsch. Geol. Gesellsch.*, vol. **31**, 1878, pp. 716-755, especially pp. 731-733.

¶ I. C. Russell, "Quarternary History of Mono Valley, California," '8th Ann. Rept. U.S. Geol. Surv.,' 1889, pp. 352-355.

** A. R. Wallace, "The Ice Age and its Work," *Fortnightly Review*, vol. **60**, 1893, especially p. 757.

†† E. de Martonne, "Sur la période glaciaire dans les Karpates méridionales," *C. R. Acad. Sci. Paris*, vol. **129**, 1899, pp. 894-897; *ibid.*, vol. **132**, 1901, p. 362.

result of sub-glacial weathering—alternate thawing and freezing—beneath glaciers during the incipient stage particularly ("hanging glaciers").* This eroding process, he considered, would be greatest toward the middle of the glacier, so that the original concavity of the slope beneath it would be more and more deepened. It must be evident that this explanation does not properly account for the steepness of the cirque walls, which it will be remembered could not be accounted for by Geikie.

Attention was again directed to the process of cirque shaping by an important paper of Richter's published in 1896.† His studies having been made in Norway, where a country rounded and polished by the continental glacier had been only partly invested by mountain glaciers, the cirques from the latter formed individual "niches" in the uplands. Following Gastaldi, the form of these niches was happily likened to that of an armchair (see Fig. 1).‡ Richter observed that the steep

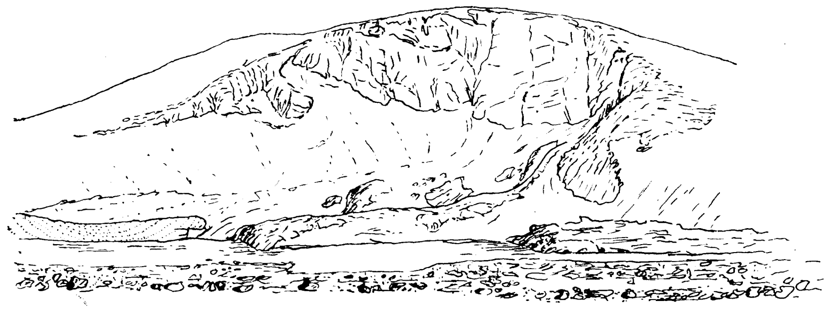

FIG. 1.—A GLACIAL CIRQUE EXCAVATED FROM THE PLEISTOCENE GLACIATED SURFACE OF NORWAY. THE NORTHERN KJEDEL ON GALDHÖPIG. (AFTER E. RICHTER.)

walls of the cirque were the only surfaces unglaciated, and hence he concluded that they were not to be ascribed to ice-abrasion, but to weathering. The moulding of the cirque floor he ascribed to abrasion, and, referring to the cirque walls, said—

"The material loosened by weathering is removed by the glacier or slides off over the *névé* to form either actual moraines, or, at least, *névé* moraines. These walls do not bury themselves in their own *débris*, and in consequence continually offer fresh surfaces for attack. Finally, the wearing away of the cirque floor by the glacier co-operates to keep the cirque walls on a steep angle and facilitates avalanching."

* Albrecht Penck, 'Morphologie der Erdoberfläche,' vol. **2**, 1894, pp. 307–308, figs. 17–20.

† E. Richter, "Geomorphologische Beobachtungen aus Norwegen," *Sitzungsber. Wiener Akad., Math.-Naturw.-Kl.*, vol. **105**, 1896, Abt. I., pp. 152–164, 2 pls. and 2 figs.

‡ See topographic definition of the cirque by De Martonne ("La periode glaciaire dans les Karpates meridionales," *C.R.*, 9^e Cong. Geol. Intern., Vienna, 1903, pp. 694, 695).

In a more extended and later paper,* treating especially the formation of cirques, Richter has explained that his view differs from that of Helland only in ascribing greater importance to weathering upon the cirque walls and less to abrasion upon the cirque floor. Inasmuch as the excessive weathering of cirque walls, as maintained by Richter, is above the surface of the *névé*, a horizontal plane of denudation should develop at that level. No evidence of this plane being discovered, its absence is explained by Richter through abrasion from the snowbank which would collect upon it so soon as formed. This is the fatal weakness of the Richter hypothesis.

Relation of Cirque to Bergschrund.—Up to the beginning of the twentieth century, as we have seen, few geologists had greatly concerned themselves with the erosion conditions at high levels, the work of Richter being on the whole the most comprehensive. The whole subject of cirque erosion was rather generally ignored, as it is indeed to-day. Sir Archibald Geikie, referring to the corries of the Scottish Highlands,† wrote—

"The process of excavation seems to have been mainly carried on by small convergent torrents, aided of course by the powerful co-operation of the frosts that are so frequent and so potent at these altitudes. Snow and glacier ice may possibly have had also a share in the task."

Writing in the same year, Reusch ascribed the Norwegian cirques to the action of surface water descending through the crevasses over falls in the continental glacier which, in Pleistocene times, overrode the country; ‡ and the following year, Bonney reiterated his view that cirques were the product of water-erosion.§ Only a few years before, Gannett had curiously explained the origin of cirques through the wear of avalanched snow and ice upon the cirque floor, likening the erosive process to that which takes place beneath a waterfall. ||

The discovery of the method by which the glacier excavates its amphitheatre must be credited to a keen American topographer-geologist, Mr. Willard D. Johnson of the United States Geological Survey.¶ In

* E. Richter, "Geomorphologische Untersuchungen in den Hochalpen," *Pet. Mitt.*, Ergänz. Heft 132, 1900, pp. 1–103, pls. 1-6.

† 'Scenery of Scotland,' p. 183 (revised in 1901).

‡ H. Reusch, 'Norges Geologiske Undersögelse,' No. 32, Aarbog for 1900, 1901, pp. 259, 260.

§ "Alpine Valleys in Relation to Glaciers," *Quart. Jour. Geol. Soc.*, vol. **58**, 1902, p. 699.

|| "The effect is precisely like a waterfall. The falling snow and ice dig a hollow depression at the foot of the steep descent just as water does" (*Nat. Geogr. Mag.*, vol. **9**, 1898, p. 419).

¶ W. D. Johnson, "An Unrecognized Process in Glacial Erosion" (read before the Eleventh Annual Meeting of the Geological Society of America), *Science*, N.S., vol. **9**, 1899, p. 106; also "The Work of Glaciers in High Mountains" (lecture before the National Geographic Society), *ibid.*, pp. 112, 113. The first public formulation of the doctrine by Mr. Johnson was in an address before the Geological Section of the Science Association of the University of California, delivered September 27, 1892.

fact, to him and to another American topographer, Mr. François E. Matthes, we owe the most of what is known from observation concerning the initiation and the development of the glacier cirque. Reasoning that abrasion was incompetent to shape the amphitheatre, Johnson early surmised that the great gaping crevasse which so generally parallels the cirque wall and is termed the *Bergschrund*, went down to the rock beneath the *névé*, and that it was no accident that glaciated mountains alone "abound in forms peculiarly favourable to snowdrift accumulation." These observations were made as early as 1883, and in order to test his theory, Johnson allowed himself to be lowered at the end of a rope 150 feet into the Bergschrund of the Mount Lyell glacier uutil he reached the bottom. He found a rock floor to stand upon, and rock extended up for 20 feet upon the cliff-side. We may here quote his terse sentences, since too little attention has been accorded this important observation.*

"The glacier side of the crevasse presented the more clearly defined wall. The rock face, though hard and undecayed, was much riven, the fracture planes outlining sharply angular masses in all stages of displacement and dislodgment. Several blocks were tipped forward and rested against the opposite wall of ice; others quite removed across the gap were incorporated in the glacier mass at its base."

Everywhere in the crevasse there was melting, and thin scales of ice could be removed from the seams in the rock. The bed of the glacier, elsewhere protected from frost-work, was here subjected to exceptionally rapid weathering. By maintaining the rock wall continually wet, and by admitting the warm air from the surface during the day, diurnal changes of temperature here resulted in very appreciable mechanical effects, whereas above the *névé* only the seasonal effects were important.

This observation of Johnson is, it will be observed, in contrast with the suppositions of Richter, who believed that the maximum sapping upon the cirque wall occurred above the surface of the *névé*. The function of the Bergschrund, which separates the stationary from the moving snow and ice within the *névé*, is thus found to be of paramount importance in the shaping of the amphitheatre.

The Schrundline.—That a sharp line is observable in abandoned cirques separating the accessible from the non-scalable portions of the wall, has been pointed out by Gilbert, who has given his support to the view of Johnson, and confirmed it by observations of his own.† Penck, on the other hand, the following year revived the view of Richter that excessive sapping occurs upon the cirque walls *above* the *névé* surface,

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* W. D. Johnson, "Maturity in Alpine Glacial Erosion," *Jour. Geol.*, vol. **12**, 1904, pp. 569-578 (read at Intern. Congr. Arts and Sciences, St. Louis, 1904).

† G. K. Gilbert, 'Systematic Asymmetry of Crest-lines in the High Sierras of California," *Jour. Geol.*, vol. **12**, 1904, pp. 579-588. See also E. C. Andrews, *ibid.*, vol. **14**, 1906, p. 44.

though he calls in the Bergschrund in order to gather in and remove the rock fragments which fall from the cliff.*

Initiation of the Cirque—Nivation.—Johnson's studies upon the processes of cirque shaping, had shown how a nearly perpendicular cirque wall is steadily cut backward through basal sapping at the bottom of the Bergschrund. The problem of how the snowbank, which was the inevitable forerunner of the glacier, had transformed the relatively shallow depression which it presumably discovered into the steep-walled amphitheatre, he did not attempt to solve. Yet the nourishing catchment basin is a prerequisite to the existence of the normal glacier. The solution of this problem has been suggested by another American topographer, Mr. F. E. Matthes.† In the Bighorn mountains of Wyoming he has found exceptional opportunities for this study. Owing to the low precipitation within the region and the consequently inadequate nourishment of

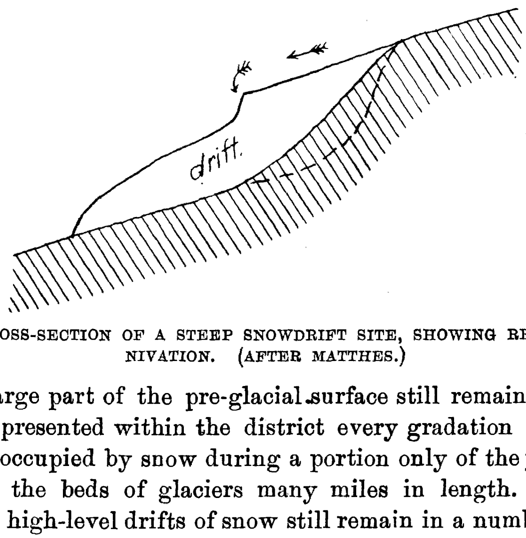

FIG. 2.—CROSS-SECTION OF A STEEP SNOWDRIFT SITE, SHOWING RECESSION BY NIVATION. (AFTER MATTHES.)

glaciers, a large part of the pre-glacial surface still remains. There is, therefore, represented within the district every gradation from valleys which were occupied by snow during a portion only of the year to those which were the beds of glaciers many miles in length. Both small glaciers and high-level drifts of snow still remain in a number of places.

Mr. Matthes has demonstrated that the snowbanks without movement steadily deepen the often slight depressions within which they lie by a process which he has called *nivation*—excessive frost-work about the receding margins of the drifts during the summer season. The ground being continually moist in this belt due to the melting of the snow, the water penetrates into every crevice of the underlying rock, so that it is rent during the nightly freezing. Rock material thus broken up and eventually comminuted is removed by the rills of water from the melting snow.‡ By this process the original depression is deepened, and, if upon a steep slope, its wall becomes recessed (see Fig. 2).

* Albrecht Penck, "Glacial Features in the Surface of the Alps," *Jour. Geol.*, vol. **13**, 1905, pp. 15–17.

† François E. Matthes, "Glacial Sculpture of the Bighorn Mountains, Wyoming," '21st Ann. Rept. U.S. Geol. Surv.,' 1899–1900, pp. 167–190.

‡ Mainly in later seasons.

The occupation of a V-shaped valley by snow, as Matthes has further shown, tends through the operation of this process to transform it into one of U-section, since the weathered rock material upon the slopes is transported by the rills and deposited upon the floor. All gradations from nivated to glaciated forms are to be found in the Bighorn range.

During the past field season the writer has taken the opportunity to examine *névé* regions and high-level snowbanks in a number of districts, with the result of confirming the importance of the nivation process as outlined by Matthes. In Figs. 3 and 4 are shown two snowbanks which were photographed on July 25 near the summit of Quadrant mountain, in the Gallatin range of the Yellowstone National Park. The gently sloping surface of this mountain represents the pre-Glacial upland unmodified by Pleistocene glaciation. Though between 9000 and 10,000 feet in height, it supports a rich herbage, and is a favourite grazing-ground of the elk. In Fig. 3 the snowbank is seen surrounded by a wide zone within which no grass is growing, but where a finely comminuted brown soil is becoming a prey to the moving water. Fig. 4 exhibits another bank lying in the depression which it has largely hollowed. At its lower end (at the left) is seen an apron of fine brown mud deposited by the over-burdened stream as it issues from beneath the drift.

An interesting question is at what point the snow-field or *névé* will, by taking on a motion of translation, assume the functions of a glacier. At this stage of transition the Bergschrund should first make its appearance. Comparison of nivated and glaciated slopes in the Bighorn mountains led Matthes to think that upon a 12 per cent. grade the *névé* must attain a thickness of at least 125 feet before motion is possible. Another possible method of approaching this problem has suggested itself to the writer. In mountains like the Selkirks, with steep slopes terraced by the flatly dipping layers in the rock, a peculiar type of small cliff glacier is nourished high above the larger snow-fields of the range and avalanched upon the lower shelves so as to leave vertical sections open to study (see Fig. 5). Perhaps because of their small size these cliff glaciers have not developed cirques, though a Bergschrund parallels the generally straight head-wall. Examined through a powerful glass, the snow in the lower layers can be seen to have lost its brilliant whiteness, though it does not yet appear as ice. A number were examined with a view to determine the approximate minimum thickness of the glacier, but all exceed the minimum estimate of Matthes by at least 100 feet. This is not regarded as in any way discrediting his figure, but rather as suggesting the possibility of more thorough examination along the same line.

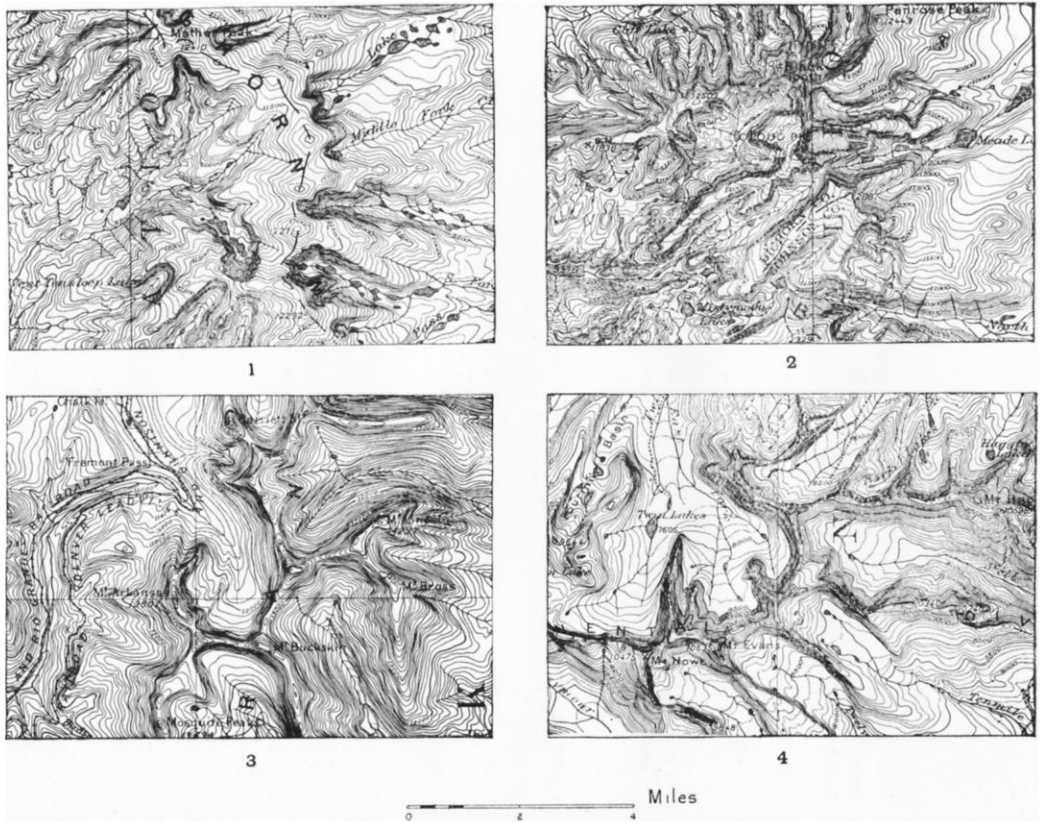

PLATE I.—SERIES OF FOUR MAPS TO ILLUSTRATE THE PROGRESSIVE DISSECTION OF AN UPLAND BY MOUNTAIN GLACIERS.

Fig. 1.—Early stage of glaciation (Cloud Peak Quadrangle, Wyoming).
Fig. 2.—Further investment of the upland, producing a *grooved upland* (Cloud Peak Quadrangle, Wyoming).
Fig. 3.—Early maturity (Leadville Quadrangle, Colorado).
Fig. 4.—Complete dissection at maturity, producing a *fretted upland* (Philipsburg Quadrangle, Montana).

FIG. 3.—SUMMER SNOWBANK SURROUNDED BY BROWN BORDER OF FINELY COMMINUTED ROCK. QUADRANT MOUNTAIN, Y.N.P.

FIG. 4.—SNOWBANK LYING IN A DEPRESSION LARGELY OF ITS OWN CONSTRUCTION. NOTE STREAM OUTWASH OF FINE MUD AT THE LEFT. QUADRANT MOUNTAIN, Y.N.P.

Sculpturing of the Upland.

The Upland dissected.—Having obtained a clear conception of the process of head-wall erosion through basal sapping, Johnson was in a position to account for the topography which he encountered in the High Sierras of California. This topography is best described in his own words *—

"In ground plan the canyon heads crowded upon the summit upland, frequently intersecting. They scalloped its borders, producing remnantal table effects. In plan as in profile, the inset arcs of the amphitheatres were vigorously suggestive of basal sapping and recession. The summit upland—the pre-Glacial upland beyond a doubt—was recognizable only in patches, long and narrow and irregular in plan, detached and variously disposed as to orientation, but always in sharp tabular relief and always scalloped. I likened it then, and by way of illustration I can best do so now, to the irregular remnants of a sheet of dough on the biscuit board after the biscuit tin has done its work."

In a portion of the region where Johnson's studies were made, his views have received verification by Lawson in a beautifully illustrated paper.† Davis has furnished an excellent example from the Tian Shan mountains of the operation of the same cirque-cutting process, recording his adhesion to the Johnson doctrine,‡ though his later papers would indicate that he does not ascribe large importance to the discovery.§

With little doubt the failure to generally recognize the importance of this process of cirque recession, clearly here a more effective agent than abrasion, is to be explained by the fact that in Europe generally, and in the Alps in particular, one looks in vain for evidences of the earlier and more significant stages of the process. Glaciation was here so vigorous as to cause the removal of all summit upland. Within the arid regions of the western United States, a more fruitful field for study is to be found. Here the work of Johnson has been supplemented by that of Gilbert ‖ and Matthes.¶ Perhaps nowhere are the early stages of the process so clearly revealed as in the Bighorn mountains of Wyoming (see Fig. 6).

A somewhat more advanced stage of the same process is to be found in the Uinta mountains of Wyoming, recently described in a valuable monograph by Atwood, though here without consideration of the

* W. D. Johnson, *Jour. Geol.*, *loc. cit.*

† A. C. Lawson, "The Geomorphogeny of the Upper Kern Basin," *Bull. Dept. Geol. Univ. Calif.*, vol. **3**, No. 15, especially pp. 357–362 and pls. 32 and 45.

‡ W. M. Davis, "A Flat-topped Range in the Tian Shan," 'Appalachia,' vol. **10**, 1904, pp. 279–280.

§ *E.g.*, cf. *Scot. Geogr. Mag.*, vol. **22**, 1906, pp. 76–89.

‖ *Jour. Geol.*, *loc. cit.*

¶ *Ibid.*, *loc. cit.*

cirque-cutting process in accounting for the present topography.* Yet nowhere, so far as the present writer is aware, has a view been reproduced which so well illustrates the remnantal tableland and the "biscuit-cutting" process of cirque recession (see Fig. 7).† The present writer has photographed other examples of the same type in the Yellowstone National Park (see Figs. 8 and 14). Remnants of the pre-Glacial surface will, in any given district, be large or small according as nourishment of the glaciers has been insufficient or the reverse. The Uinta range, which extends in an east-west direction, and, like

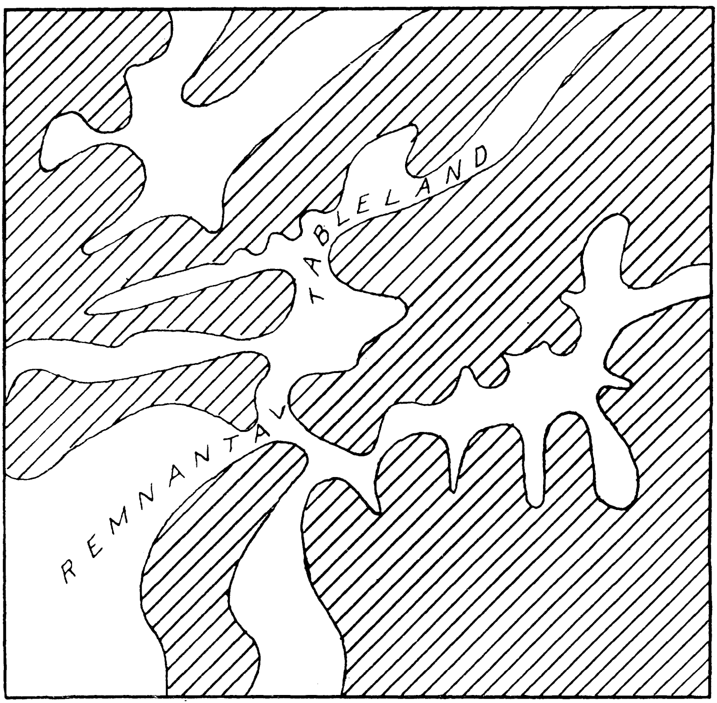

FIG. 6.—PRE-GLACIAL UPLAND INVADED BY CIRQUES, "BISCUIT CUTTING" EFFECT, BIGHORN MOUNTAINS, WYOMING.

the Bighorn mountains, has a core of homogeneous granitic rock, displays this fact. An examination of Atwood's map ‡ shows that to the eastward, where the precipitation has been least, the remnants of the original upland are more considerable. This qualifying condition

* Wallace W. Atwood, 'Glaciation of the Uinta and Wasatch Mountains,' Prof. Paper, U.S. Geol. Surv., No. 61, 1909, pp. 1-96, pls. 1-15.

† Other apt illustrations have been furnished by Lawson in a photograph taken the Upper Kern region of the California Sierras (*loc. cit.*, pl. 32 B), and by Davis in sketch made in the Tian Shan mountains ('Appalachia,' vol. **10**, 1904, p. 279).

‡ *Loc. cit.*, pl. iv.

FIG. 5.—VIEW OF THE YOHO GLACIER AT THE HEAD OF THE YOHO VALLEY, SHOWING TO THE RIGHT A SERIES OF THREE SMALL CLIFF GLACIERS. CANADIAN ROCKIES.

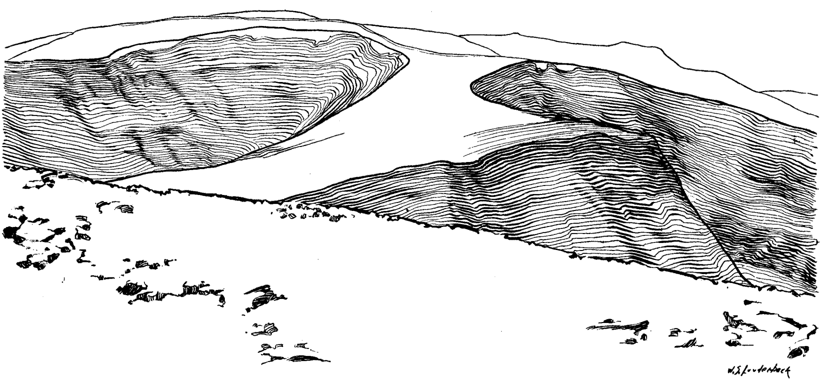

FIG. 7.—VIEW OF THE SCALLOPED TABLELAND WITHIN THE UINTA RANGE, AND NEAR THE HEAD OF THE WEST FORK OF SHEEP CREEK. (AFTER ATWOOD.)

FIG. 8.—PRE-GLACIAL UPLAND ON QUADRANT MOUNTAIN, Y.N.P., INVADED BY THE CIRQUE KNOWN AS THE "POCKET."

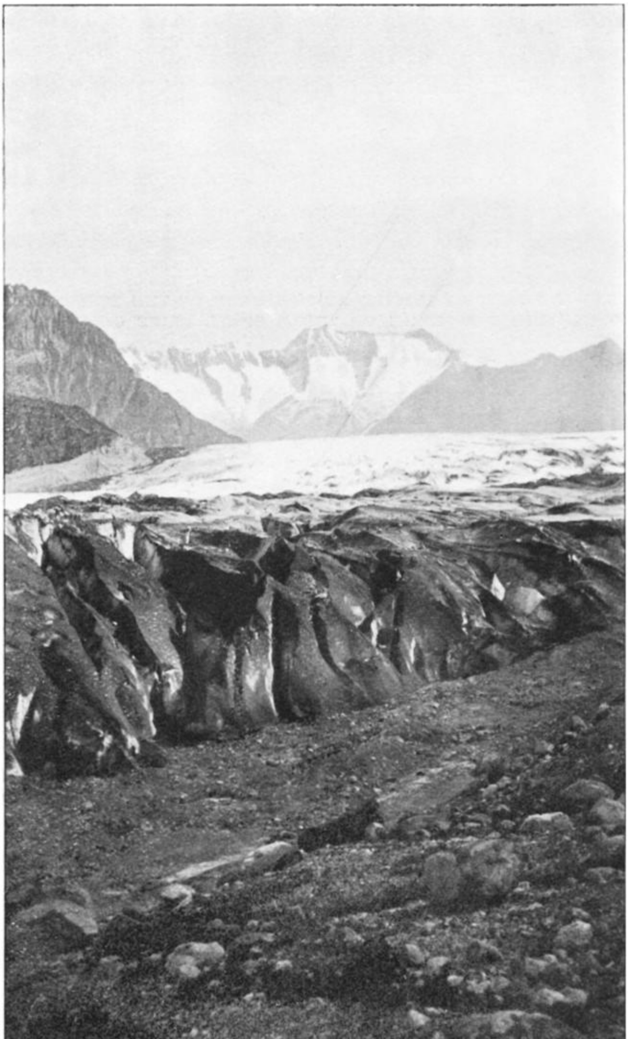

FIG. 11.—MULTIPLE SECONDARY CIRQUE ON THE WEST FACE OF THE WANNEHORN SEEN ACROSS THE GREAT ALETSCH GLACIER, TO WHICH IT IS TRIBUTARY.

of glacier nourishment will be subject to some modification because of peculiarities in snow-distribution. As shown by Gilbert, the first glaciers within any mountain district will probably appear upon that side of the divide which is in the lee of the prevailing winds. This fact is particularly well brought out in Fig. 9.

Modification in the Plan of the Cirque as Maturity is approached.—Owing to the fact that the sapping process within the cirque operates on all sides, its early plan, when the upland surface is supplying snow from all directions, will approach the circle (see Figs. 6 and 8). Moreover, in this stage the cirque will be but little, if any, wider than

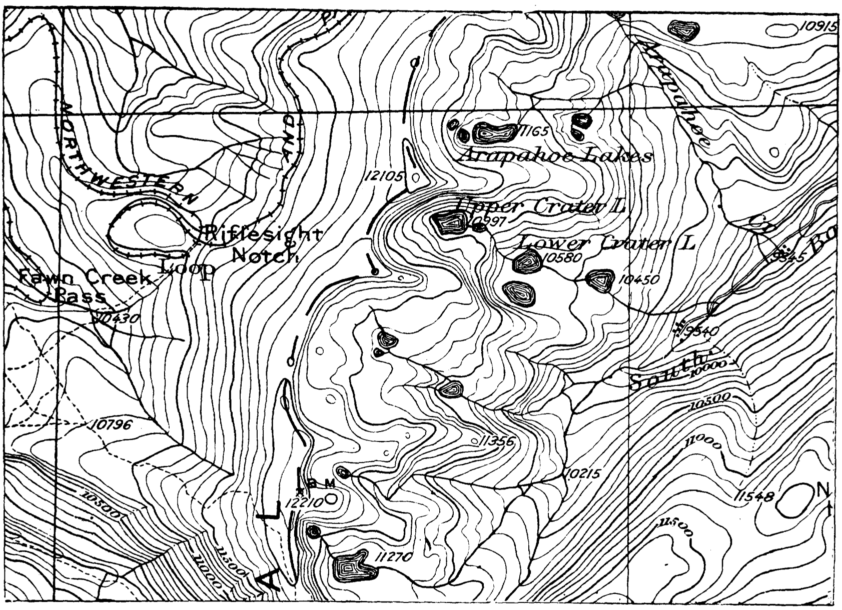

FIG. 9.—SERIES OF SEMICIRCULAR GLACIAL AMPHITHEATRES, WHOSE SCALLOPED CREST FORMS PART OF THE DIVIDE OF THE NORTH AMERICAN CONTINENT. CENTRAL CITY SHEET, TOPOGRAPHICAL ATLAS, U.S. GEOLOGICAL SURVEY.

the deepened and widened valley below (see Plate I., Figs. 1 and 2). Later, with the continuation of the sapping process, the cirque becomes enlarged to such an extent that its sides form recesses in the walls of the valley. Thus, in the plan, the glacial valley of this stage bears some resemblance to that of a nail with a large rounded head.

As the upland is still further dissected, the cirque becomes more irregular in outline and widens into a roughly elliptical form, not infrequently allowing it to be seen that it is in reality composite or made up of several cirques of a lower order of magnitude (Figs. 10–12).

Grooved and Fretted Uplands.—The new emphasis put upon topographic expression of character in the maps issued by Government bureaus during the past few years, has furnished physiographers a tool of which they are hardly yet fully aware. Before, the aim of topographers seemed to be to suppress all character through a rounding off of angles and an averaging of the data. Perhaps nowhere has the change been more noteworthy than in the maps issued by the United States Geological Survey,* and the later sheets particularly, when relating to glaciated mountain districts, afford us the opportunity of tracing the successive steps in the dissection of such upland districts by the cirques of mountain glaciers. For Plate I. four areas have been selected to represent successive stages in such a progressive dissection.

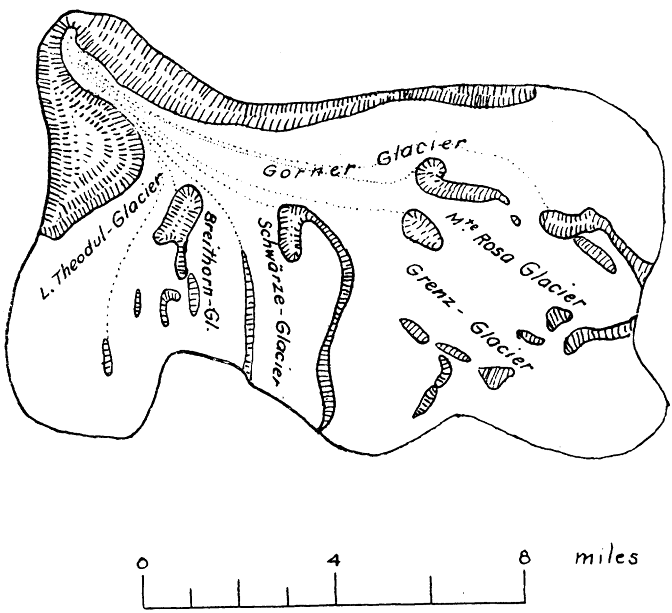

FIG. 10.—OUTLINE PLAN OF ONE OF THE ELLIPTICAL MINOR CIRQUES AT THE HEAD OF THE NICOLAI VALLEY, SWITZERLAND.

An early product in which large remnants of the upland surface still remain, may well be designated a *grooved* or *channelled* surface (see Fig. 13 (*a*)).

As the hemicycle advances, it will be observed that on the flanks of the range are found the largest remnants of the original upland surface (see Fig. 14),† owing to the tendency of the cirque to push

* See D. W. Johnson and F. E. Matthes, 'The Relation of Geology to Topography.' Reprint from Breed and Hosmer's 'Principles and Practice of Surveying,' chap. vii. Wiley & Co., N.Y., 1908.

† Other quadrangles of the U.S. Geological Survey which display the upland surface more or less completely dissected by mountain glaciers are the following: *Early stage*: Younts peak (Wyoming), Marsh peak (Utah-Wyoming), and Georgetown

FIG. 12.—MULTIPLE CIRQUE OF THE DAWSON GLACIER, HAVING A MAJOR SUBDIVISION INTO HALVES, WHICH ENCLOSE RESPECTIVELY THE DAWSON AND THE DONKIN NÉVÉS. THE VIEW IS FROM THE ASULKAN PASS, SELKIRK MOUNTAINS.

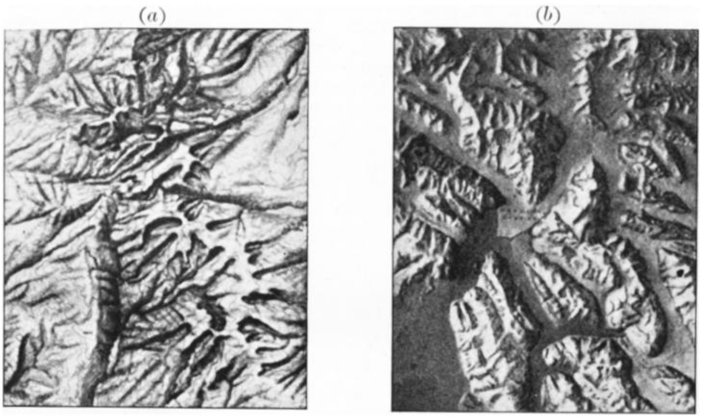

FIG. 13.—(*a*) A GROOVED UPLAND IN THE BIGHORN MOUNTAINS, WYOMING. (*b*) A FRETTED UPLAND, ALASKA.

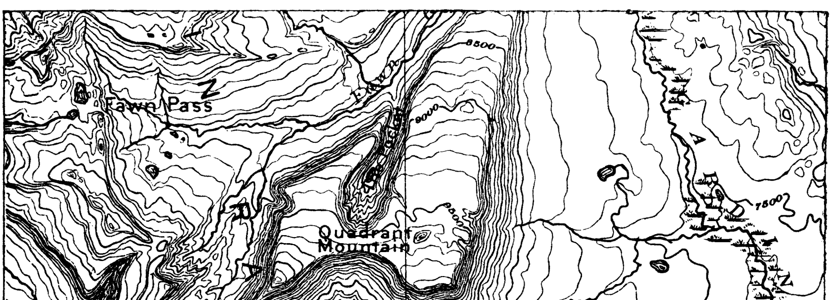

FIG. 14.—MAP OF QUADRANT MOUNTAIN, A REMNANT OF THE PRE-GLACIAL UPLAND ON THE FLANKS OF THE GALLATIN RANGE, YELLOWSTONE NATIONAL PARK.

FIG. 15.—FRETTED UPLAND OF THE ALPS AS SEEN LOOKING NORTH-EASTWARD FROM THE SUMMIT OF MONT BLANC, JULY 25, 1908. THE CIRQUE TO THE LEFT IS THAT OF THE GLACIER DE TALÈFRE, WITH THE JARDIN IN ITS CENTRE, AND DISTANT ABOUT 10 MILES. BOUNDING THIS TO THE LEFT ARE THE ALGUILLE DU MOINE AND THE AIG. VERTE ; AT THE REAR ARE THE AIG. LES DROITES AND LES COURTES ; AT THE RIGHT IS THE AIG. DE TRIOLET ; AND TO THE FRONT THE AIG. DE TALÈFRE, AIG. DE L'EBOULEMENT, AND AIG. DE LESCHAUX.

FIG. 16.—MAP OF A PORTION OF ONE OF THE LOFOTEN ISLANDS, SHOWING A FRETTED SURFACE PARTIALLY SUBMERGED AND EMPHASIZING THE APPROXIMATE ACCORDANCE OF SUMMIT LEVELS.

its side walls out beyond the limits of the U-shaped valley below. With complete dissection of the plateau no tabular remnants are to be discovered. The general level of the district has now been lowered, but above this irregular surface project one or more narrow pinnacle ridges, which at fairly regular intervals throw off lateral palisades having crests which fall away in altitude as they recede from the trunk ridge. In general terms, and describing the major features only, we have here to do with a gently domed surface, on which is a fretwork of comb-like ridges projecting above it. This surface may be designated a *fretted upland* (see Fig. 13 (*b*)). Such a condition is realized in the Alps, and is seen to special advantage from the summit of Mont Blanc (see Fig. 15).

The transition from the grooved to the fretted upland is well brought out in two views taken by Lawson in the High Sierras of California (*loc. cit.*, Plate 45, A and B). The fretted upland differs from the grooved upland of an earlier stage of the cycle in the complete dissection of the surface. The character of the fretted surface is well brought out by the topography of the Lofoten Islands off the arctic coast of Norway, where the effect is somewhat heightened through the submergence and consequent obliteration of the irregularities in the floor (see Fig. 16).

At this stage there is undoubtedly a general accordance of level in the crests of the frets upon the domed surface, as Daly, taking due account of the cirque-cutting process, has claimed.* Moreover, the existence of such a series of frets as are to be found in the Alps, forces us to conclude that such an accordance of summits persists for a considerable time. Were this not the case, we should find a larger number of low cols and a longer persistence of the semicircular form of the cirque. It seems probable, therefore, that a very definite relationship obtains between the plan of the cirque and that of the near-lying upland remnants that contribute snow to its basin. So soon as cirques approach from opposite sides of a divide, the portions of their basins which are more nearly adjacent receive less snow, and, in consequence, accomplish less sapping than the walls on either side where snow is lodged in a quantity but slightly diminished. This self-regulating process will tend to broaden the cirque and eventually give it irregularities of outline dependent primarily upon the initial positions and the individual nourishments of its near-lying neighbours.

Characteristic Relief Forms of the Fretted Upland.—In the earlier stages of mountain glaciation the upland is channelled by valleys U-shaped in

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(Colorado); *partial dissection*: Mount Lyell and Mount Whitney (California), Grand Teton (Wyoming), Gilbert peak and Hayden peak (Utah-Wyoming), and Silverton and Anthracite (Colorado); *complete maturity:* Kintla Lakes (Montana).

* R. A. Daly, "The Accordance of Summit Levels among Alpine Mountains: the Fact and its Significance," *Jour. Geol.*, vol. 13, 1905, pp. 117–120.

their upper stretches, and somewhat broadened into steep-walled amphitheatres at their heads. With the complete dissection of the upland, the coalescence of the many cirques at last cuts away every remnant of the original surface and yields relief-forms which are dependent mainly, as already stated, upon the initial positions of the cirques.*

If there be a highest area within the upland, the snow will be carried farthest from it by the wind, and this will be in consequence the last to succumb to the cirque-cutting process. The dome of Mont Blanc in the midst of a forest of pinnacles, no doubt owes its peculiar form to the fact that it dominated the pre-Glacial upland. Elsewhere

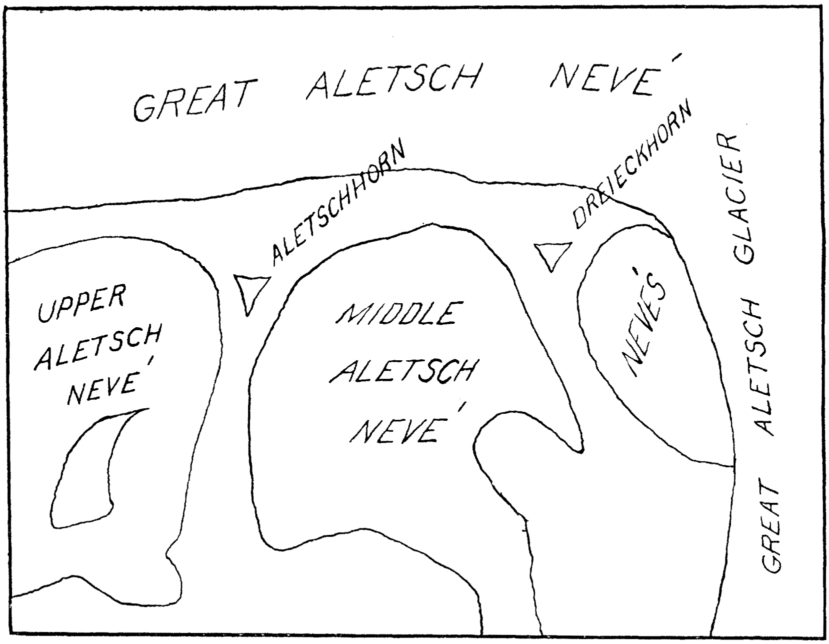

FIG. 17.—POSITION OF THE ALETSCH- AND DREIECKHORNS BETWEEN THE UPPER, MIDDLE, AND GREAT ALETSCH NÉVÉS.

within the upland the coalescence of cirques has produced comb-like palisades of sharp rock-needles which have long constituted the *aiguille*

* The analogy with the forms produced by etching upon crystal faces is so striking that it may be helpful to note it in comparison. The first effect of a reagent in its attack upon the plane of a crystal face is the excavation of deep pits which have a similar and wholly characteristic form, though the surface in other places remains unchanged. These pittings later increase in number, as they do in size, and eventually they mutually coalesce, destroying utterly the original plane surface, and leaving in relief a series of hills and ridges (etch-hills) projecting above a somewhat irregular floor, whose average level is a measure of the average depth of the excavations made by the process. The noteworthy difference between this process and that of cirque recession in glaciated uplands is that the glacial etch-figures are relatively longer and narrower.

type of mountain ridge. In the literature of physiography, such ridges have perhaps most frequently been designated by the term *arête* (fish-bone), though in the Alps the term *grat* * (edge) has been applied especially to the smaller and lateral ridges of this type. I propose to use for all such palisades of needles derived by this process the name comb-ridge † as the best English term available. The frequent occurrence of lateral arms joined to the main palisade of needles suggests a differentiation into main and lateral comb-ridges.

In every mountain district maturely dissected by glaciers, are to be found sharp horns of larger base and especially of higher altitude than the individual minaret-like teeth of the comb-ridges. They are further in contrast with the latter by having an approximately pyramidal form, and a base most frequently a triangle with flatly incurving sides. They appear most frequently at the junction points of the comb-ridges between three or more important snow-fields (see Fig. 17). Such forms are generally termed *horns* in the Alps, and the word being of the same form in English, it may well be retained as a technical expression. The Matterhorn in Switzerland is the type *par excellence* (see Fig. 18), though similar and almost equally striking examples are numerous, as, for example, the Weisshorn and Gross Glockner in the Alps, Mount Assiniboine in the Canadian Rockies, or Mount Sir Donald in the Selkirks. The triangular base and pyramidal form are so common to this feature that they have found expression in the local names, as Dreieckhorn, Deltaform peak, etc.

The Col and its Significance.—The prominent horns of any glaciated mountain district no doubt occupy positions corresponding in the main to the more elevated areas in the original upland surface, since such positions would be earliest cleared of snow, and hence latest attacked by the cirques. After complete dissection of the upland the comb-ridges which fret its surface will be attacked from opposite sides, and their crests will be first lowered at the points of tangency of the adjacent cirques—generally near the middle points of their curving outlines. The sky-line of the ridge will thus be lowered in a beautiful curve forming a pass or *col*. Inasmuch as the cirque approaches in its form an inverted and truncated cone of acuminated type, the curve to which the rim of the col approximates will be furnished by the intersection of two cones of revolution with the same apical angle and having parallel axes (see Figs. 19 and 20). This curve is approximately a hyperbola, the

* Very likely originally from *gräte*, fish-bone.

† The use of *combe* in the Jura and the Cote d'Or for different types of valley, or of *coombe* in the Southern Uplands of Scotland for a glacial valley, being each essentially local and having further no relation to the toothed article which suggests the name comb-ridge, does not constitute a serious objection to this choice. Mr. Matthes (and possibly others) have already used the expression comb-ridge in the above described sense ('Appalachia,' vol. **10**, 1904, p. 260).

eccentricity of which will be largely dependent upon the relative sizes of the two cirques in question.

The corries of the Scottish Highlands, being generally of small size, have coalesced to produce a very characteristic scalloping of the horizon line seen to advantage in Ben Nevis, or, better still, in the sculptured gabbro of the Cuchulin hills in Skye.* To judge from views, also, such forms are found in North Wales, features which in many respects are different from those found in the Alps or in the North American mountains.†

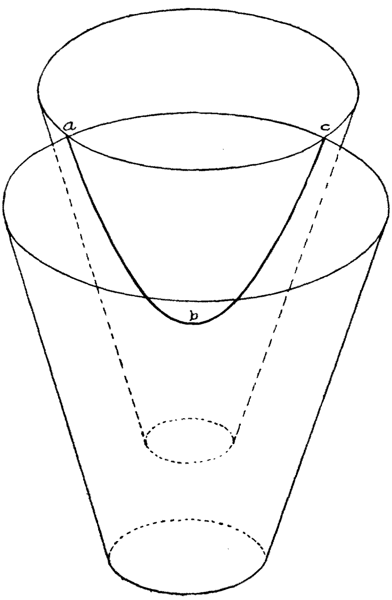

FIG. 19.—ILLUSTRATION OF THE FORMATION OF COLS THROUGH THE INTERSECTION OF CIRQUES.

It must be regarded as of deep significance that mountain passes in areas which have supported glaciers are so generally at high levels. Deep glacier-cut valleys available as highways and transecting high ranges are extremely rare; so far as the writer is aware, being known only from the Southern Andes ‡ and Alaska.§ This fact must have its explanation, it is believed, in a notable and abrupt retardation in the rate of cirque-wall recession, following close upon the dissection of the upland. Whether this is due to the reduced snow accumulation immediately beneath the cirque wall owing to the lack of a near-lying collecting ground, it is as yet too early to say; but a comparison of the acclivities in the marginal snow-slopes on *névés* of the Bighorn and Alaskan districts might yield an answer to the question.

Though the sapping process at the base of cirque walls up to maturity is doubtless far more potent than abrasion and plucking upon the floor of the amphitheatre, it seems likely that in the subsequent stage the reverse is the case. This would at least explain the tendency

* See Harker, "Glaciated Valley of the Cuchulins, Skye," *Geol. Mag.* (Fig. 4), vol. **6**, 1899, p. 197; also "Ice Erosion in the Cuillin Hills, Skye," *Trans. Roy. Soc. Edinb.*, vol. **40**, 1901–1902, pp. 234–237.

† This characteristic form of cirque, partly open at the head, is well brought out in a view published by Sir Andrew Ramsey as early as 1852 (*Quart. Jour. Geol. Soc.*, vol. **8**, p. 375).

‡ 'Argentine-Chilian Boundary in the Cordillera de los Andes.' 5 vols

§ R. S. Tarr, "Glaciers and Glaciation of Yakutat Bay, Alaska," *Bull. Am. Geogr. Soc.*, vol. **38**, 1906, p. 149.

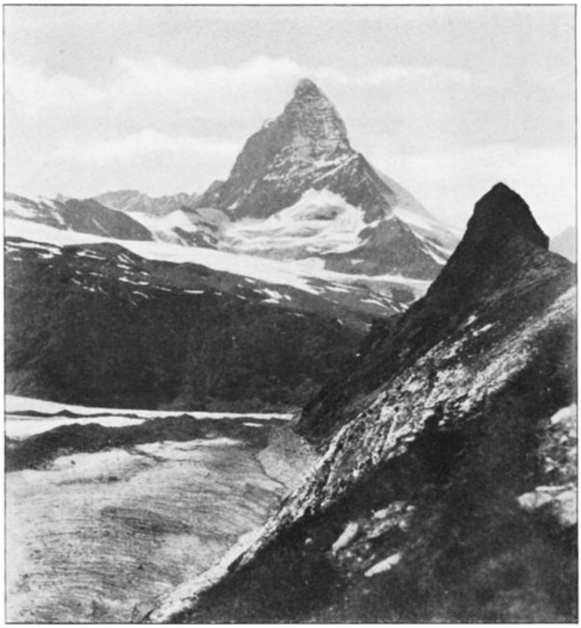

FIG. 18.—THE MATTERHORN FROM THE GORNER GRAT, NEAR THE RIFFELHORN.

FIG. 20.—COL OF THE OVERLOOK LOOKING ACROSS THE FOOT OF THE ILLECILLE-WAET GLACIER, SELKIRKS.

of glacier valleys to deepen rapidly in the higher altitudes, or, in Johnson's phrase, to get "down at the heel."

The Advancing Hemi-cycle.—With the augmentation of rigorous climatic conditions within any district where glaciers already exist, the latter will be continually more amply nourished, and must in consequence increase steadily in size. Such climatic changes may even be conceived so considerable that at last the entire range is submerged beneath snow and ice, thus producing an ice-cap.

Direct observation of the successive stages through which glaciers pass from their initiation to their culmination in an ice-cap, is of course impossible, for the reason that we live in a receding hemi-cycle in which practically all known glaciers, instead of expanding, are drawing in their margins; yet a synthetical reconstruction of the life-history is none the less possible. To employ an illustration already used in a different connection, in order to learn the life-history of a particular species of forest tree, it would not be necessary to sit down and observe an individual tree from the germination of its seed to the decadence of the full-grown tree. We may with equal profit go into the forest and observe trees of the same species in all stages of development. In the study of glaciers our opportunity is hardly so fortunate as this, for, as already stated, all glaciers appear to be in the declining stage, whereas it is the advancing hemi-cycle with which we are now concerned. The characters of glaciers as concerns their size and shape depend, however, in so large a measure upon the one element of alimentation, that if we neglect characters of a second order of magnitude, we may by inference construct the history with sufficient accuracy from existing examples.

(To be continued.)

SURVEY WORK ON THE BOLIVIA-BRAZIL BOUNDARY.

By Major P. H. FAWCETT, R.A., Chief Bolivian Commissioner.

THE Bolivian Boundary Commission continued its labours in 1909, completing the delimitation of the eastern boundary over the ground explored during the latter half of 1906. A sketch of that exploration, together with a *résumé* of the work already completed, was published in the *Journal* of the Society early in 1909.

The repetition of the work was rendered necessary by the unwillingness of the Brazilian commissioner, partly for political reasons and partly owing to the risks entailed in the breaking of unknown country, to join in an exploration which would have completed in one year of work a delimitation for which seven years had been anticipated. As I think I mentioned in the communication referred to, the party of exploration were speeded from Corumba to the utmost limits of civilization is of unique value in authority, its style of production would seem hardly to justify its price.

'Italy To-day.' By Bolton King and T. Okey. (London: Nisbet. 1909. Pp. xii., 414. 6s.) This volume has already been recognized as an authority on the intricate questions of Italian home affairs, and the new edition has not only been brought up to date, but considerably expanded. The student of economic geography will find here a plethora of facts and figures, the latter properly adapted to English usage.

'Grieben's Guide Books: Lakes of Northern Italy and Milan.' (London: Williams & Norgate. 1909. Pp. 153. *Maps.* 3s.) This seems to be a good ordinary guide, but suffers noticeably from indifferent translation in parts. Its chief recommendation is its handy size.

'Bosnia and Herzegovina.' By Maude M. Holbach. (London: Lane. 1910 (*sic*). Pp. 249. *Map and Illustrations.* 5s.) This volume, with its excellent photographs, gives an attractive account of a country little known to the tourist, but probably soon to become better known. The style is light and pleasant reading, and the book, though mostly a personal narrative, will be found serviceable to intending travellers in the country.

ASIA.

Sikkim and Bhutan.

'Sikhim and Bhutan: Twenty-one Years on the North-East Frontier.' By John Claude White. London: E. Arnold. 1909. 21s. *net.*

A veritable land of enchantment is that far end of the Himalayas which includes Sikhim and Bhutan—of enchantment, that is to say, in all that pertains to those lasting impressions which are derived from the most magnificent scenery that the world can produce. But it must be confessed that the enchantment is largely tempered by certain physical disadvantages, amongst which are to be reckoned a plague of leeches and the persistent trouble of a heavy rainfall. Possibly these two great plagues are intimately related. The memory of Bhutan (across an interval of nearly fifty years) recalls firstly the wide flat spaces of the Duars, thickly covered with dense grass, through which an elephant or a rhinoceros could push his way with difficulty, and beneath which tigers could sneak along the narrow tracks trodden by the hosts of smaller game. Then came the forest growth of the foothills, with magnificent trees and a spread of bamboo jungle such as is unknown in the undulating plains of the Indian peninsula. These filled the low steaming valleys and reached upwards to 10,000 feet of altitude. Beyond this, again, past the forests where the long grey beards of lichen drooping from the branches lent an air of venerable age to the moist scenery, and where leeches curled themselves in myriads in the tangled undergrowth, is the Bhutan of Mr. Claude White, spreading itself in majestic grandeur to the cold passes of Tibet; crowned with a magnificent array of snow-capped peaks, with here and there open valleys and grassy undulations, carpets of flowers, and all the glory of scarlet rhododendrons massed in such a blaze of colour that the eye is almost wearied with its profusion.

Mr. White is by training an engineer whose opportunities of dealing directly with the native officials of this Eastern frontier land specially qualified him for the interesting political duties which he was long ago called upon by the Indian Government to undertake. His sympathetic nature and power of ready adaptability to strange circumstances and surroundings have been valuable assets in the making of his career, but it is only his love of adventure and his deep appreciation of all that is beautiful in nature and art which render him capable of presenting to the public a book so full of interest as that which we have just read. It is not often that the one man who has the widest and most complete knowledge of his subject is able to render a faithful account of just those special characteristics of it which mark it as distinct from all others; and in this Mr. White has been largely assisted by his quite extraordinary skill as a photographer. Rarely has the beauty of Himalayan scenery been so well illustrated, and never have the idiosyncrasies of a strange people with the specialities of their most interesting form of architecture been so judiciously treated.

Bhutan is a new and strange land to most of us. There is not much literature about Bhutan. Those emissaries of the Indian Government who, at long intervals, have passed through it to Tibet, or endeavoured to frame commercial treaties since the days of Warren Hastings, have described their experiences and coloured their views according to the impressions left by the nature of their reception; and the result has been a very varied and confused general notion of the conditions, natural and social, which govern that country. Mr. White has had every temptation to write in an optimistic vein, for nothing could exceed the personal friendliness towards him which was everywhere expressed; but his observations were close and his mind is judicial, and we may learn from his book quite a new story about Bhutan and the Bhutanese. The only unpleasant reading in the book are the criticisms which he is forced to make on the shifting and unsatisfactory policy of the British Government, which has over and over again left its friends in the lurch, and wasted enormous sums of money over half-completed public works, owing to its fatal want of continuity as regards the north-eastern, or indeed any other part of our Indian frontier. Tibet, as Mr. White points out, is now absolutely Chinese; the Chumbi valley is Chinese, and the Lhasa expedition might never have been. How this will end it is impossible to say, but whilst the attitude of Bhutan towards the Indian Government is (thanks to such men as Messrs. Paul and White) one of friendly aspiration, these hopes are much tempered by their bitter experiences of what they consider to be want of good faith. They are very human, and not at all unreasonable. At present Bhutan may not count for much in Indian politics, but though the day may still be distant, the time will surely come when Bhutan in the north-east will be as important to Imperial interests as is Kashmir in the north-west—and for very similar reasons. It will certainly be a very long time before we are in a position to learn more about this not unimportant corner of the Himalayas than is to be learnt from Mr. White's book. The details of his story may well be left to those who wish to acquire sound information.

T. H. H.

'Through Persia from the Gulf to the Caspian.' By F. B. Bradley-Birt. (London: Smith, Elder. 1909. Pp. x., 331. *Map and Illustrations.* 12*s.* 6*d.*) The author, on a journey homeward from India, travelled up the Persian gulf to Bushire, and thence by Shiraz, Isfahan, and Teheran to the Caspian. His narrative makes interesting reading, and the fact that he claimed the assistance of Sir A. Houtum Schindler adds to the authority with which he writes of Persian social and political affairs.

'An Overland Trek from India.' By Edith F. Benn. (London: Longmans. 1909. Pp. xv., 343. *Map and Illustrations.* 15*s.*) This is an entirely personal narrative, not originally intended, we learn, for publication. The greater part deals with residence and travel in Persia, and as the writer's husband, Major Benn, occupied an official position there, she had peculiar opportunities for gathering knowledge about the country and its people.

'The Face of China.' By E. G. Kemp. (London: Chatto & Windus. 1909. Pp. xv., 271. *Map and Illustrations.* 20*s.*) The author's travels in China have been extensive, ranging from Peking to the furthest extremity of Yunnan. His chief specialized interest appears to have lain in religious and educational matters. He illustrates his own chapters with a large number of coloured and sepia drawings.

'China: its Marvel and Mystery.' By T. Hodgson Liddell. (London: Allen. 1909. Pp. xiii., 203. *Illustrations.* 21*s.*) This is primarily a picture-book, and the author-artist's sketches are beautiful and beautifully reproduced. Not only so; speaking purely from the artist's point of view, he broke a good deal of new ground, and though not a few of his scenes are familiar, he presents them, with both brush and pen, in new lights.

'A Scamper through the Far East.' By Major H. H. Austin. (London: Arnold. 1909. Pp. xvi., 336. *Maps and Illustrations.* 15*s.*) The general character of this book can be guessed from the title: it deals with a journey by the Trans-Siberian railway to Manchuria, and so to Korea and Japan. But the author has a good deal to say on recent and current affairs in the Far East, and his most interesting work in his topographical study of many of the principal battle-grounds in the Russo-Japanese War.

'My Thirty Years in India.' By Sir Edmund C. Cox. (London: Miles & Boon. 1909. Pp. x., 306. *Illustrations.* 8*s.*) This book deals mainly with personal experiences, but the author's intimacy with Indian police administration enables him to write with authority on some of its problems.

'Thirty-seven Years of Big Game Shooting in Cooch Behar, the Duars, and Assam.' By the Maharajah of Cooch Behar. (London: Ward. 1908. Pp. xxviiii., 461. *Map and Illustrations.* 21*s. net.*) These records of royal sport make a volume as heavy as the reading is light. They will be read with interest, and perhaps envy, by other sportsmen; but the author has not associated any science with his sport.

'A German Staff Officer in India.' By Count Hans von Königsmarck. (London: Kegan Paul. 1910. Pp. xiv., 340. *Illustrations.* 10*s.* 6*d.*) There is little but personal reminiscence in this volume, though it is a pleasure to read appreciation so unstinted from a foreigner. In his free use of colloquialism the translator has no doubt sought equivalents for the original German.

'The Place of India in the Empire.' By Lord Curzon. (London: Murray. 1909. Pp. 46. 1*s.*) This is an address delivered before the Philosophical Institute of Edinburgh, and contains a brief but suggestive analysis of the geographical position of India in regard to political and strategical considerations.

'Folk-lore of the Santal Parganas.' By C. H. Bompas. (London: Nutt. 1909. Pp. 483. 10*s.* 6*d. net.*) This volume consists principally of translations of the original native stories carefully collected and transcribed. They indicate the rich field which awaits investigators in this branch of ethnographical study. Both translations and the brief introduction are admirably done.

'Fryer's East India and Persia.' Vol. 1. Edited by W. Crooke. (London: Hakluyt Society. 1909. Pp. xxxix., 353. *Illustrations.*) John Fryer's narrative of his travels in 1672–1681 is full of interest both in matter and in manner. It is well that it should have been produced with the care which the Society always devotes to its publications. The editor's biographical introduction, moreover, is excellent, and his notes never appear to deserve the charge which he himself offers against them, of unreasonable length.

AFRICA.

African River Vegetation.

'Die Pflanzenbarren der Afrikanischen Flüsse.' (Münchener Geographische Studien, No. 24.) By Oswald Deuerling. München: 1909. 5*s.* 6*d.*

In this monograph Dr. Deuerling has brought together a very large amount of information bearing upon the blocking of river channels by vegetation, and, as the

THE CYCLE OF MOUNTAIN GLACIATION.*

By Prof. WILLIAM HERBERT HOBBS, University of Michigan.

The alimentation of glaciers is dependent upon the amount of precipitation and upon the temperature, the former being in large measure determined by the adaptability of the relief for local adiabatic and contact refrigeration of the air. The important factor, temperature, while a function of many variables, yet in a broad way varies directly with latitude and altitude. The size and the form of glaciers is, however, determined not solely by nourishment (mainly in the higher levels), but also to some extent by losses (particularly in the lower levels). In the main, however, the losses are controlled by the same factors as the gains, and maintain to them a determinate proportional relationship. Exceptions to this definite proportion occur when in high latitudes the glacier is attacked directly by the sea (tidewater glaciers), when it is suddenly melted by the heat of a volcanic eruption (Icelandic Jokülls), or when disturbed by a heavy earthquake (Muir glacier in 1899). In form glaciers will be in large degree determined by the existing topography of the upland, which may generally be assumed to be some product of sub-aërial erosion. Starting, therefore, with the puny glaciers of arid regions in low latitudes, and ending with the high latitude glaciers within areas of excessive precipitation, we run almost the whole gamut of glacier alimentation.

The initial forms of glaciers may be described as snowbank, "newborn" or nivation glaciers, and will at first be few in number and located with wide intervening spaces of upland. The continuance of the nivation process will deepen other intermediate small depressions upon the upland, so that with increasing snowfall additional glaciers will appear in the spaces between the first as the latter are developing their amphitheatres. These cirques, at first no wider than the valleys below, will later cut recesses on either side at the same time that the glacier is pushed farther down the valley and occupies its bed to a greater and greater depth. The grooved upland of this stage, through additional cirque recession in the highlands and through abrasion and plucking in the intermediate levels, becomes at last transformed into the fretted upland, with its network of projecting comb-ridges. Up to this point the glacier ice has perhaps been restrained within valleys, which it has discovered and has progressively widened and deepened. If the initial temperature continues to be lowered, there must come a time when the ice feet from the better-nourished glaciers, or from those with the shortest route to the foreland fronting the range, will debouch upon the plain, spreading as they do so into fans or aprons (see Fig. 21).

* Continued from p. 163.

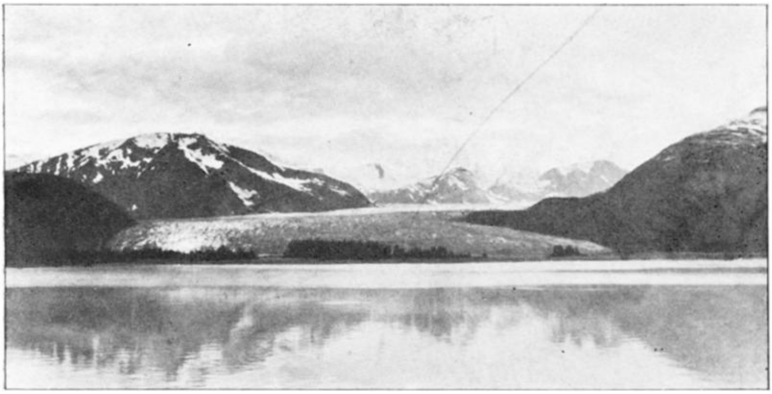

FIG. 21.—EXPANDED FORE-FOOT OF THE FOSTER GLACIER, ALASKA.

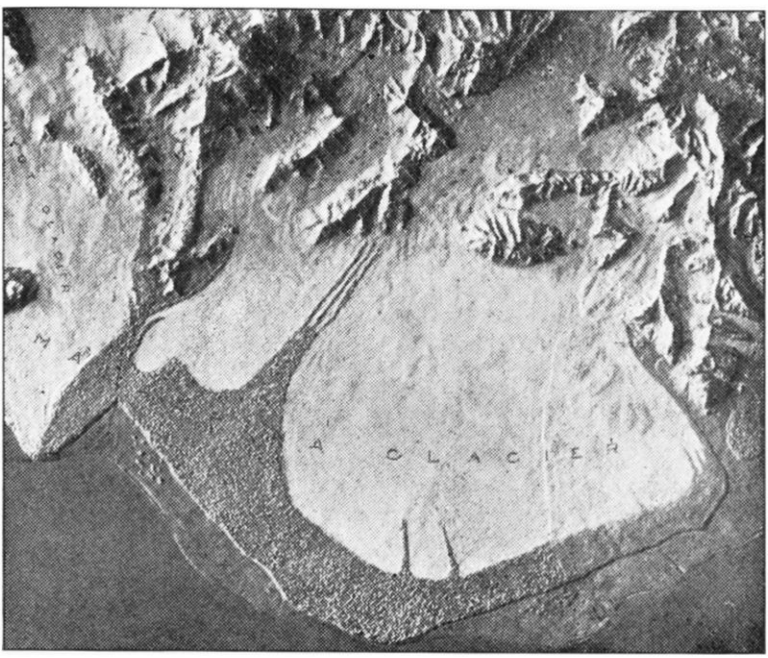

FIG. 22.—TYPE OF PIEDMONT GLACIER.

(*From a photograph of the new model of the Malaspina glacier made under the direction of Lawrence Martin.*)

FIG. 27.—A HANGING TRIBUTARY VALLEY MEETING A TRUNK GLACIER VALLEY ABOVE THE PRESENT WATER-LEVEL ON THE "INSIDE PASSAGE" TO ALASKA.

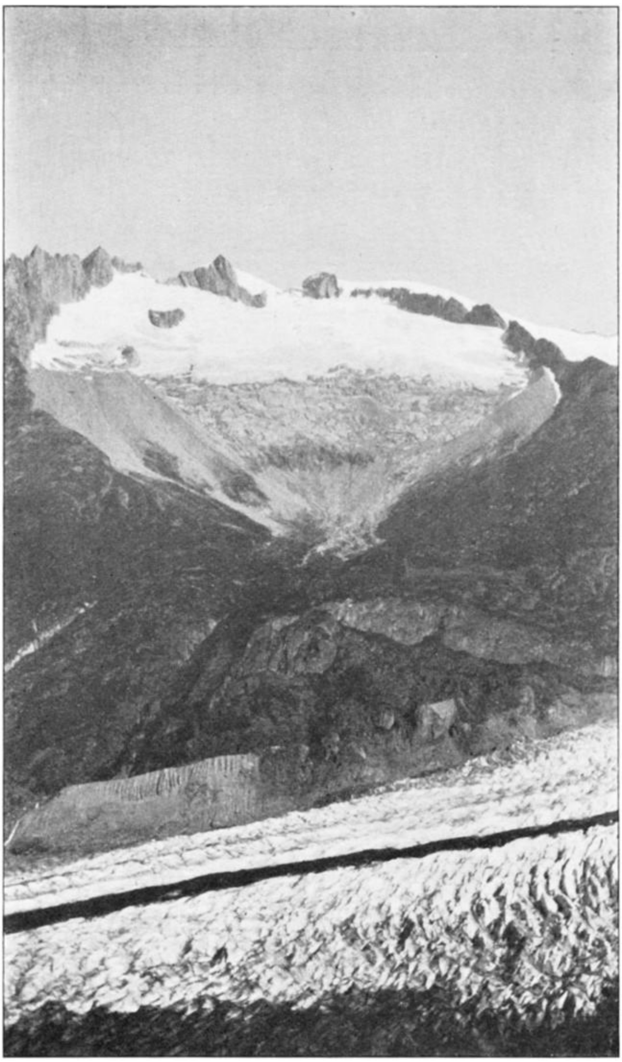

FIG. 28.—A HANGING GLACIERET, THE TRIEST GLACIER, ABOVE THE LOWER STRETCH OF THE GREAT ALETSCH GLACIER, SWITZERLAND.

Later all neighbouring glaciers may arrive at this stage, and by spreading upon the foreland, coalesce with one another to form a single broad apron, such as may be seen in the Malaspina glacier of Alaska. While the glaciers are thus pushing out upon the foreland they have been deepening in their valleys, and eventually come to overtop portions of the lateral comb-ridges of the fretted upland, thus moulding the sharpened needles into rounded shoulders of rock. In places the glaciers from adjacent valleys will flow together through the irregular depressions, separating peaks and producing islands or *nunataks*.

But the increased size of the individual glaciers of the range has corresponded to increased activity of cirque recession in the high altitudes, and this has resulted in the formation of cols or passes through the range. Snow which has been divided at the summit, as has water by a divide, may now be consolidated into glacier ice over the col before the separation is made. Thus it comes about that without a definite cirque, glaciers will transect the range flowing in opposite directions from a central icefield. Such a broad central icefield is found to-day between Mount Newton of the St. Elias group and Mount Logan to the eastward.*

The advance of the glacier ice up the sides of the valleys, so as partially to submerge the lateral comb-ridges, may not end until all are thus covered and the ice flows away from the central broad area, radiating in many directions. Here the process of cirque recession, which has mainly sculptured the rock in the higher altitudes, comes to an end as we reach the ice-cap stage of glaciation. Transitions toward such ice-cap glaciers are to be found to-day in the Elbruz and in the Kasbek region of the Caucasus, as well as in the Justedalsbräen of Norway, where a central elevated snow-field (fjeld) is the common *névé* of several glaciers radiating in as many directions.† It is of considerable interest to note that in the Caucasus district, at least, there is evidence that rocky comb-ridges are submerged beneath the ice and make their appearance so as to separate the marginal ice-tongues. The persistence of an ice-cap over a mountain region, as is clear from study of the glaciated mountains in Norway, tends to largely obliterate relief forms characteristic of mountain glaciers as they are replaced by the rounded shoulders of *roches moutonnées*. As soon, however, as nourishment has been so far reduced that the higher points once more appear from beneath their snow cover, cirque recession will begin again, and if long continued the evidence of the ice-cap will disappear. Lack of glacial scratches or polish in uplands sapped by this process should not be allowed to weigh too heavily in reconstructing the glacial history of the district.

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* Filippo di Filippi, 'The Ascent of Mount St. Elias (Alaska),' by H.R.H. Prince Luigi Amadeo di Savoia, Duke of the Abruzzi (English translation). Panorama at end of volume (unnumbered) from an elevation of 16,500 feet.

† H. Hess, 'Die Gletscher. Braunschweig,' 1904, pp. 65–68.

Classification of Glaciers based upon Comparative Alimentation.

Relation of Glacier to its Bed.—From what has been said in the preceding section concerning the changes of glaciers in correspondence to a progressive augmentation of glacial conditions, it must be evident that any attempt to use each circumscribed body of snow and ice as a unit in name or in type will lead to endless confusion. Ice bodies being extremely sensitive to changes in annual temperature, a difference of one degree may be sufficient to join many ice bodies into one, or to differentiate one body into many. If, however, we examine the distribution of snow and ice masses within the valley which they either wholly or partially occupy, it will be seen that there are relatively few distinct glacier types, and that the coalescence of smaller ice masses, or the breaking up of larger ones, does not necessarily alter the type exemplified.

The more important types called for by analysis on this basis do not differ greatly from those adopted by Chamberlin and Salisbury,* which seem to be the ones most generally recognized. The genetic relationships of these types are here first brought out, together with distinct and intermediate transitional forms. In the following table, excepting the initial type and the glaciers with inherited basins, the arrangement is in the main one of decreasing alimentation :—

Nivation type (Bighorn glaciers).
Ice-cap type (Jökulls of Iceland).
Piedmont type (Malaspina glacier).
Transection type (Yakutat glacier).
Expanded-foot type (Davidson glacier).
Valley type, normal subtype (Baltoro glacier).
  Hanging glacierets (Triest glacier).
  Cliff glacierets (Lefroy cliff glacieret).
Valley type, Tide-water sub-type (Harriman-Fjord glacier).
Inherited basin type (Illecillewaet glacier).
  Reconstructed type (Victoria-Lefroy glacier).
  Volcanic cone type (Nisqually glacier).
  Cauldron type (Caldera glacier).
Alpine type (Nicolaithal glacier).
Horseshoe type (Mount Lyell glacier).

Nivation Type.—This type of glacier has also been called "new-born" or "snowbank" glacier, and represents the initial stage of glaciation. Though small in size, such glaciers differ markedly from those of the same dimensions which cling to the steep walls of a large cirque (see horseshoe glaciers below), and which Tarr has referred to as "dying glaciers." † Numerous examples of snowbank glaciers are furnished by the Bighorn mountains of Wyoming. Other known types of mountain glaciers are all represented, and follow naturally in sequence during a receding hemicycle of glaciation. In their discussion we shall conceive

* 'Geology,' vol. 1, chap. v.

† R. S. Tarr, "Valley Glaciers of the Upper Nugsuak Peninsula, Greenland," *Am. Geol.*, vol. 19, 1897, p. 265 and fig. 2.

a mountain district to pass by slow stages from a culmination of glacial conditions toward a comparatively genial climate.

Ice-cap Type.—Though in form and general characters resembling so-called continental glaciers, the ice-caps by reason of their smaller dimensions form a connecting-link with mountain glaciers, and are usually developed upon small plateaus or uplands. They correspond to conditions of extremely heavy snow precipitation, and in consequence have not been found fully developed outside the Polar regions (see inherited basin glaciers below).

The normal type of ice-cap glacier is represented by the mantle over Redcliff peninsula, north of Inglefield gulf in Greenland.* It suffers no interruption from mountain peaks, but the ice creeps out in all directions from a central area, and sends out marginal lobes or tongues which much resemble, save for their whiter surface, the snouts of valley and alpine glaciers (see below). The Jökulls of Iceland are very similar, and form flatly arched or undulatory domes of ice having short lobes about their margins (see Plate II., Fig. 1). The largest of these, the Vatnajökull, has an area of 8500 square kilometres.† In Scandinavia the small plateau glaciers with marginal tongues of proportionately greater length, such as the Justedalsbräen, serve to connect this type with that of the valley glaciers (see Plate II. Fig. 2).‡ The *Richtofeneis* on Kerguelen island, recently described by the German South-polar Expedition, seems to be very similar.§ According to Meyer, the ice-mass upon the summit of Kilimandjaro in Africa is an "ice carapace," having much resemblance to the ice plateaus of Scandinavia.||

Piedmont Type.—Piedmont glaciers, like ice-caps, correspond to conditions of exceptionally heavy precipitation, and are only known from polar and sub-polar regions. In contrast to ice-caps, the existing examples are found in connection with mountains of strong relief, so that the snow and ice which in ice-caps find their way slowly out to the margin of a flat or gently sloping plateau, are in the piedmont glacier discharged through valleys from lofty highlands to debouch upon the foreland at the foot of the range. The well-known type is the Malaspina glacier of Alaska, explored and described by Russell (see Fig. 22 and Plate II. Fig. 3).¶ Near it and farther to the west is the

* T. C. Chamberlin, "Glacial Studies in Greenland," IV., V., *Jour. Geol.*, vol. **3**, 1895, pp. 199, 470.

† Th. Thoroddsen, "Island, Grundriss der Geographie und Geologie. V. Die Gletscher Islands," *Pet. Mitt.*, Erg. Bd. **32** (Nos. 152–153), 1906, pp. 163–208, map, pl. xii.

‡ H. Hess, 'Die Gletscher' (Map 3).

§ Emil Werth, 'Aufbau und Gestaltung von Kergulen. Sonderabd. aus Deutsch. Südpolar Expeditionen, 1901–1903,' vol. **2**, pp. 93–183, pls. 9–14, 3 maps.

|| Hans Meyer, 'Der Kilimandjaro, Reisen und Studien,' pp. 436. Berlin, 1898 (reviewed by Rabot).

¶ I. C. Russell, "An Expedition to Mount St. Elias," *Nat. Geogr. Mag.*, vol. **3**, 1891, pp. 52–204, pls. 2–20. See also Filippi, *loc. cit.*

PLATE II.—TYPES OF MOUNTAIN GLACIERS.

Fig. 1.—Ice-cap type, Vatnajökull, Iceland. (After Thoroddsen.)
Fig. 2.—Ice-cap type, Justedalsbräen, Norway. (After Hess.)
Fig. 3.—Piedmont type, Malaspina glacier, Alaska. (After Russell and Kerr.)
Fig. 4.—Valley type, Baltoro glacier, Karakorum-Himalayas. (After W. M. Conway.)
Fig. 5.—Valley type, Tasman glacier, New Zealand. (After v. Lendenfeld.)
Fig. 6.—Valley type (Tidewater glacier), Harriman fjord glacier, Alaska. (After Gannett.)
Fig. 7.—Alpine type, Nicolaithal glacier, Alps. (After Baedeker.)
Fig. 8.—Alpine type, Mer de Glace, Alps. (After Baedeker.)
Fig. 9.—Alpine type, Rathong glacier, Kangchengunga Himalayas. (After Garwood.)
Fig. 10.—Horseshoe type, Lhonak glacier, Kangchengunga Himalayas. (After Garwood.)
Fig. 11.—Horseshoe type, Asulkan glacier, Selkirks. (After A. O. Wheeler.)
Fig. 12.—Horseshoe type, Wenkchemna glacier, Canadian Rockies. (After A. O. Wheeler.)
Fig. 13.—Horseshoe type, Arapahoe glacier, Colorado. (After Fenneman.)
Fig. 14.—Inherited basin type, Great Aletsch glacier, Alps. (After Baedeker.)
Fig. 15.—Inherited basin type, Illecillewaet glacier, Selkirks. (After A. O. Wheeler.)
Fig. 16.—Inherited basin type (reconstructed glacier), Victoria glacier, Canadian Rockies. (After Scherzer.)

Bering glacier of about the same size.* To the east of the Malaspina glacier is the Alsek, a much smaller piedmont glacier.† In Chili south of 42° S. lat. are found other piedmont glaciers, among them the San Rafael.‡ During Pleistocene times piedmont glaciers existed in many mountain districts, notably, however, the Alps § and the Rocky mountains of North America.|| A transition from the piedmont type toward the continental glacier is illustrated by the Friederickshaab glacier in Greenland, which pushes its front out upon the foreland as an extension of the inland ice of that continent.

Above the ice apron and within the range, the piedmont glacier bears a close resemblance to the valley type (see below), though in general it may be said that its valleys are filled to a much greater depth. The largest stream feeding the fan of the Malaspina glacier has

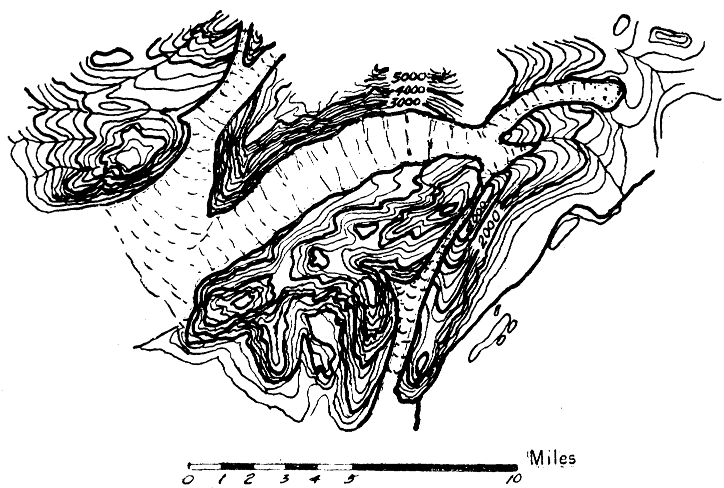

FIG. 23.—MAP OF A TRANSECTION GLACIER. THE SHERIDAN GLACIER NEAR THE COPPER RIVER IN ALASKA. (AFTER G. C. MARTIN.)

been named the Seward glacier, while other tributaries are known as the Agassiz and the Tyndall (see Fig. 2, Plate III.). It is interesting to note that however steep these feeders to the ice-apron may be, the

* Roughly outlined on map of Alaska to accompany "The Geography and Geology of Alaska," by Brooks (Prof. Pap. U.S. Geol. Surv., No. 45, 1906, plate in cover). For details of marginal portion and description, see G. C. Martin, 'Bull. 335 U.S. Geol. Surv.,' 1908, pp. 46–48, and pls. i., ii. and v.

† E. Blackwelder, "Glacial Features of the Alaskan Coast between Yakutat Bay and the Alsek River," *Jour. Geol.*, vol. **15**, 1907, pp. 428–432, map.

‡ See Rabot, 'La Géographie,' vol. **3**, 1901, p 270. See also Hess, 'Die Gletscher,' p. 63.

§ Penck u. Brückner, 'Die Alpen im Eiszeitalter, especially vol. **2**, 1909, map opposite p. 396.

|| Fred H. H. Calhoun, "The Montana Lobe of the Keewatin Ice-sheet" Prof. Pap. No. 50, U.S. Geol. Surv., 1906, pp. 14–21, map pl. i.

latter always shows an exceedingly flat slope, and is, moreover, relatively stagnant.

Transection Type.—In a late stage of augmenting glacial conditions or in an early stage of the receding hemi-cycle, what is essentially one body of ice may be divided over a pass and flow off in opposite directions toward different margins of the range. For this type, exemplified by the nunatak glacier of Alaska, Tarr has used the term "through glacier," * and Blackwelder has instanced the Yakutat glacier and perhaps the Beasley within the same region.† Such glaciers, which may be referred to as the *transection type*, are often the highways which give readiest access to the hinterland. A glacier of this type, which has been carefully mapped, is the Sheridan glacier near the mouth of the Copper river in Alaska (see Fig. 23).‡ An excellent panorama of one of the grandest transection glaciers has been furnished by Sella.§ The glaciation of the Grimsel pass in Switzerland clearly indicates that at one time a glacier of this type was parted over the present divide, one stream passing down the Rhone valley, and the other down the Häsli valley toward Meyringen. Far greater exhibits of the same sort are to be found in the Southern Andes.‖

Expanded-foot Type.—When a piedmont glacier draws in its margin as it shrinks with the coming of a warmer climate, the several ice-streams which feed the apron of ice upon the foreland end in small fans at the mouths of the individual valleys. Perhaps the best known example of such an expanded-foot glacier is the Davidson, on the Lynn canal in Alaska, though the Foster and Mendenhall glaciers of the same district are similar (see Fig. 22). The Miles and Childs glaciers, near the Copper river, are also of this type, and have been mapped by Martin (see Fig. 24 *a*).¶ The transection glacier known as the Sheridan is in the same vicinity, and has an expanded forefoot—a good illustration of the combination of these two types in one (see Fig. 23). A larger example of the expanded forefoot than any thus far mentioned is the Klutlan, in the Yukon basin, whose foot extends a number of miles beyond the front of the St. Elias range (see Fig. 24 *b*).** The Martin river glacier in the Copper river district affords another example, since it expands for a distance of over 20 miles. It is, however, partially restrained by a range of hills rising on its southern margin, and by

* *Bull. Am. Geogr. Soc.*, vol. **38**, 1906, p. 149. See also Prof. Pap. No. 64, U.S. Geol. Surv., **1909**, pp. 35-36, 105, pls. vii.-viii.

† *Jour. Geol.*, vol. **15**, 1907, p. 432.

‡ G. C. Martin, 'Bull. 284, U.S. Geol. Surv.,' 1906, pl. 12.

§ Filippi, *loc. cit.*

‖ Argentine-Chilian boundary, maps.

¶ G. C. Martin, *loc. cit.*

** C. W. Hayes, "An Expedition through the Yukon District," *Nat. Geogr. Mag.*, vol. **4**, 1892, pp. 152. See also map of Mendenhall and Schrader, Prof. Pap. U.S. Geol. Surv., No. 15, 1903, fig. 4, p. 41.

Martin has been considered intermediate between the piedmont and valley types.*

Valley or Dendritic Type.—Retiring within the range as warmer temperatures succeed to more rigorous conditions, glaciers are of necessity restricted to individual valleys and their tributaries. They come thus to have a plan as truly arborescent as that of water-drainage, and they may in this stage be called dendritic or valley glaciers. Unfortunately, the term "valley glaciers," in every way appropriate, has been generally applied to glaciers which occupy valley heads only, and hence the term must be redefined in its natural rather than its inherited

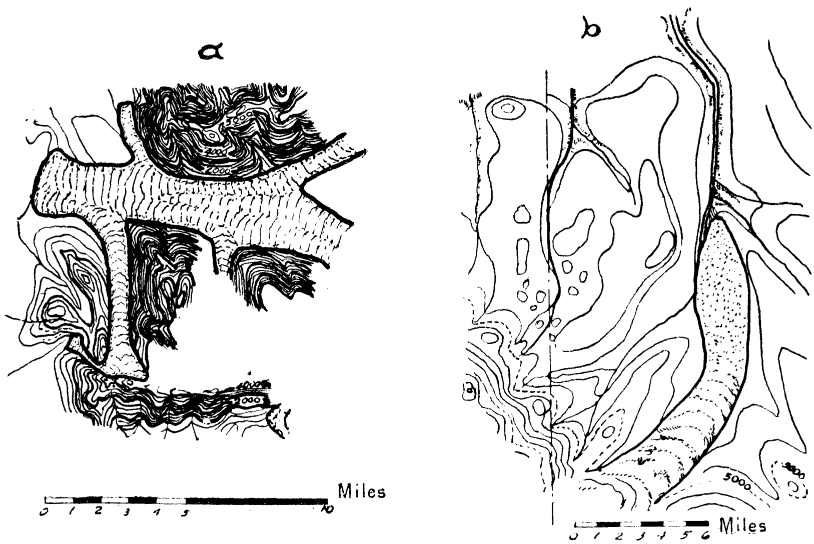

FIG. 24.—(*a*) MAP OF THE MILES GLACIER IN ALASKA (AFTER G. C. MARTIN); (*b*) MAP OF THE KLUTLAN GLACIER IN THE YUKON BASIN OF ALASKA (AFTER MENDENHALL AND SCHRADER).

significance. This glacier type geographers are most familiar with in restorations of Pleistocene glaciers,† but it is none the less a common form to-day in districts more distant from commercial centres, and hence less easily accessible for study. From the Karakoram Himalayas, the Baltoro, Hispar, and Biafo glaciers, all of this type, have been described and carefully mapped by Sir Martin Conway.‡ An outline map of the Baltoro glacier is reproduced in Plate II. Fig. 4, and one of the Hispar glacier in Fig. 25. Other valley glaciers, generally less extensive, have

* G. C. Martin, "Geology and Mineral Resources of the Controller Bay Region, Alaska," Bull. No. 335, U.S. Geol. Surv., 1908, pp. 48-49, pl. i., ii., and v.

† One of the best maps of such a restored valley glacier of Pleistocene age is that of the Kern valley of California (see Lawson, *loc. cit.*, pl. xxxi.).

‡ W. M. Conway, 'Climbing and Exploration in the Karakoram Himalayas,' maps and scientific reports. 1894.

been mapped by Garwood * from the Kangchenjunga Himalayas. In the Central Tian Shan mountains are other glaciers of this type.† In

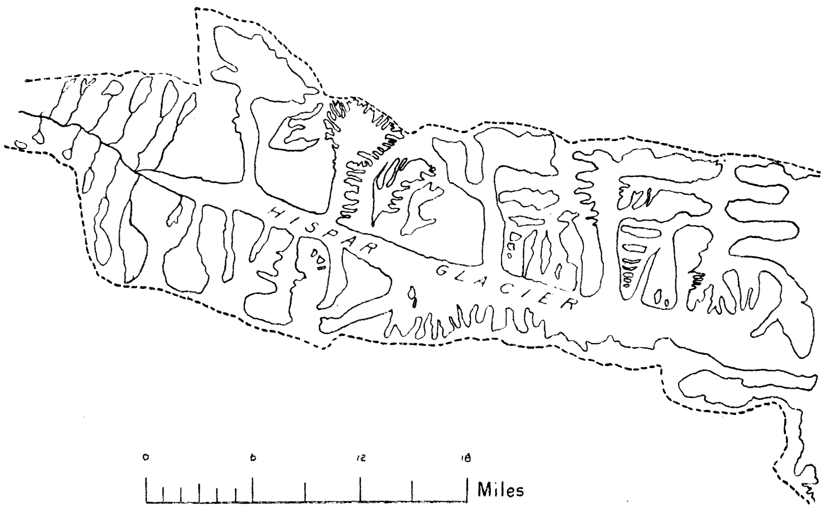

FIG. 25.—OUTLINE MAP OF THE HISPAR GLACIER, KARAKORAM HIMALAYAS. (AFTER CONWAY.)

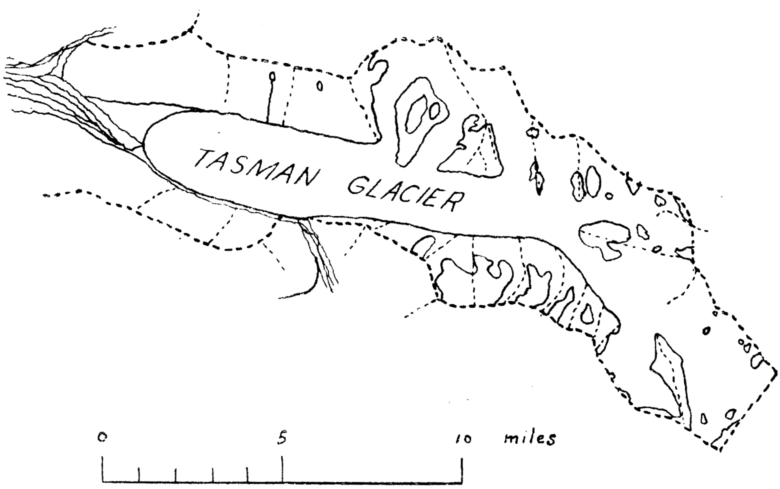

FIG. 26.—OUTLINE MAP OF THE TASMAN GLACIER, NEW ZEALAND. (AFTER V. LENDENFELD.)

* E. J. Garwood, "Notes on Map of the Glaciers of Kangchenjunga, with Remarks on some of the Physical Features of the District," *Geogr. Journ.*, vol. 20, 1902, pp. 13–24, plate.

† Max Friederichsen, "Die heutige Vergletscherung des Khan-Tengri-Massives und die Spuren einer diluvialen Eiszeit im Tiën-schan," *Zeit. f. Gletscher K.*, vol. 2, 1908, pp. 242–257.

the New Zealand Alps the Tasman glacier furnishes another example of the same valley type* (see Fig. 26 and Plate II., Fig. 5). Still other examples have been described from the mountains of Alaska, such, for example, as the Kennicott and Chistochina glaciers.†

Comparison of a number of examples of valley glaciers may illustrate as many different stages in the retreat of the glacier from a position in which it occupied its entire valley to the retirement almost within the mother cirque at the head. The examination of the vacated valley has taught us that the tributary glaciers erode their beds less deeply than the trunk stream lying in the main valley. It is the surfaces of the ice-streams only that are accordant, and hence a lack of accordance in the bed-levels has yielded the so-called hanging valleys with their characteristic ribbon falls. Nowhere can the hanging valleys be observed in greater perfection or on a grander scale than in the troughs, now largely abandoned of ice which enter the great fjords of the "inside passage" to Alaska (see Fig. 27).‡

As the foot of the trunk glacier retires up its valley, the lateral tributaries which are nearest the mouth of the valley are at first separated from it and develop their own front moraines. Later they are left high above the main stream as a series of *hanging glacierets* (see Fig. 28).§ The series of hanging glacierets, as will be observed in the maps of the Baltoro and Hispar glaciers, often persist above the main valley well below the foot of the trunk stream.

Inherited Basin Type.—The valley type of glacier hardly appears in the Alps at all, though the Great Aletsch glacier might perhaps be regarded as a small and imperfect example. The size and characters of the latter are, however, for the district in which it lies, abnormal and to be accounted for by the existence of a natural interior trough lying between the Berner Oberland on the one side and the high range north of the Rhone valley upon the other, from which basin small outlets only are found through the southern barrier (Plate II. Fig. 14). A

* R. v. Lendenfeld, "Der Tasman Gletscher und Seine Umrandung," *Pet. Mitt.* Erg. Bd., vol. **16**, 1884, pp. 1–80, map, plate I.

† W. C. Mendenhall and F. C. Schrader, "The Mineral Resources of the Mount Wrangell District, Alaska," Prof. Pap. U.S. Geol. Surv., No. 15, 1903, pl. iv. and ix. See also Brooks, Prof. Pap. U.S. Geol. Surv., No. 45, map, plate xxxiv.

‡ R. S. Tarr, "Glacier Ercsion in the Scottish Highlands," *Scot. Geogr. Mag.* vol. **24**, 1908, pp. 575–587.

§ The term "hanging glacier," now used in a variety of senses, is, it is believed, best retained with this restricted meaning. The term "cliff glacier," generally considered synonymous, may be restricted to the long strips of incipient glacier ice which sometimes parallel the main valleys on narrow terraces above precipitous cliffs which are primarily determined by the rock structure (see *ante*, p. 154; and also Matthes 'Appalachia,' vol. **10**, 1904, p. 262). In the sense here employed, a hanging glacier is the equivalent of the *Kahr Gletscher*, a term quite generally employed in Germany. The term "horseshoe" glacier we have here suggested for an essentially different type of glacieret (see below, p. 280).

better example, however, of this special type of glacier, in which the inherited topography has exercised a greater influence upon the glacier form than has the auto-sculpture, is furnished by the Illecillewaet glacier of the Selkirks (see Fig. 29), which, from a roughly rectangular

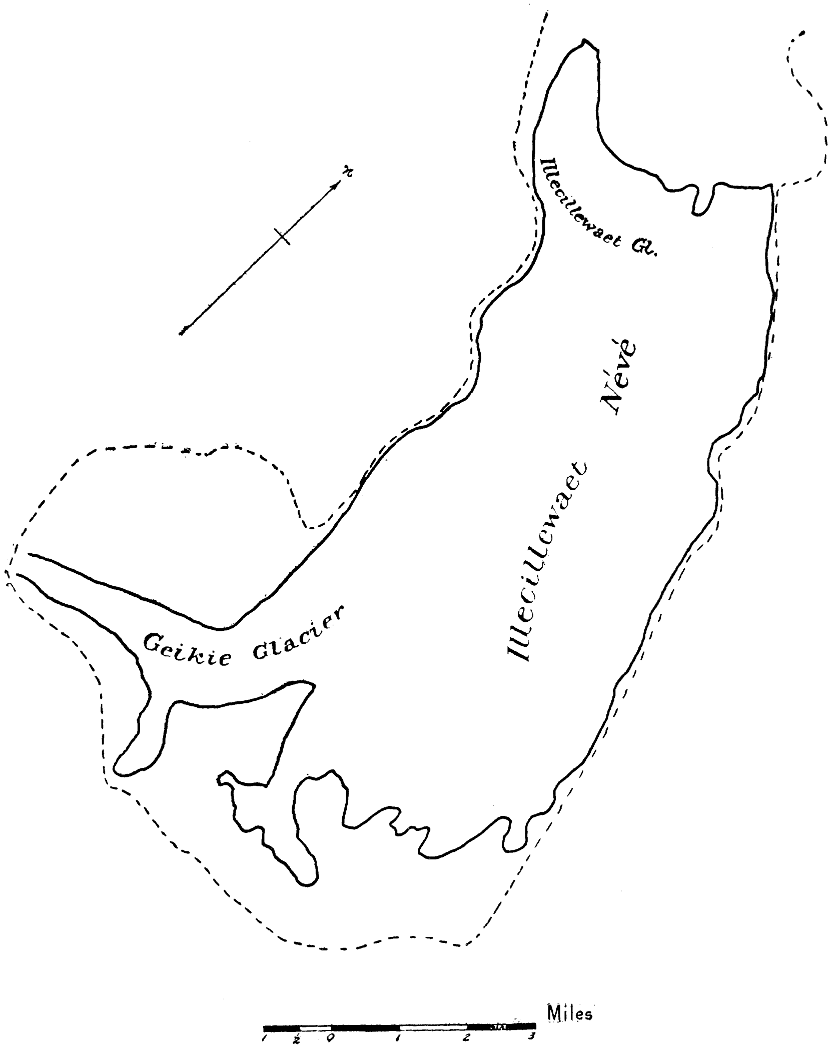

FIG. 29.—OUTLINE MAP OF AN INHERITED BASIN GLACIER, THE ILLECILLEWAET GLACIER OF THE SELKIRKS. (AFTER WHEELER.)

snow-icefield lying between parallel ridges, sends out short tongues leading in different directions. A glacier of this type, with a moderate increase only of alimentation, would produce a small ice-cap.

Another abnormal form of glacier due to the peculiarities of the basin which it inherited, is illustrated by the Victoria glacier in the

Canadian Rockies, a glacier having no cirque, but only a couloir (the so-called "death-trap") in its stead (see Fig. 30). In this case the *névé* which feeds the glacier is found high above upon the cliff—a true cliff glacieret—and this *névé* avalanches its compacted snow upon the surface of the Victoria glacier, which thus well illustrates the *reconstructed type.**

Again, glaciers may develop, not upon a gently domed and variously moulded pre-glacial upland such as we have thus far had under consideration, but upon the sharply conical volcanic peaks which in temperate and tropical regions push their heads from the mountain upland far up above the snow-line. In such cases, regular cirques cannot develop at the heads of the radiating ice-streams, but, on the contrary, very irregular and mutually destructive forms will result (see Fig. 31).† This is the more true because of the loosely consolidated tuffs of which such cones are always built up. If sufficiently lofty, the result may be a small carapace or ice-cap such as is found to-day upon the summit of Kilimandjaro in Africa. On the other hand, a partially ruined crater may furnish a *natural* basin or cauldron for a small glacier—*Cauldron Type.*‡

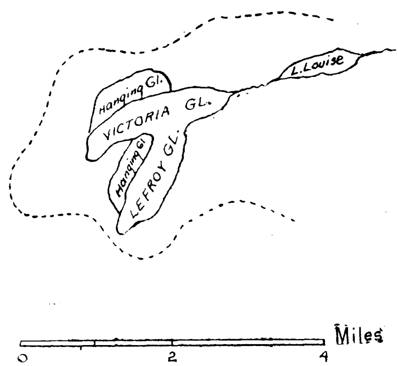

FIG. 30.—OUTLINE MAP OF RECONSTRUCTED GLACIER—THE VICTORIA AND LEFROY GLACIERS IN THE SELKIRKS. (AFTER WHEELER.)

Tide-water Type.—In high latitudes glaciers sometimes descend to the level of the tide-water in fjords which continue their valleys. In such cases, the glacier front is attacked mechanically by the waves and is further melted in the water. In place of the convexly rounded nose, so characteristic of the other types, there develops a precipitous cliff of ice from which bergs are calved, and the glacier front in consequence is rapidly retired (Plate II. Fig. 6). Unhappily, the local term "living glaciers" has been applied to this type in Alaska; "dead glaciers," in the same usage, being applied to glaciers which yield no icebergs. The slopes of the glacier surface and the measure of projection of the ice above the water-level both render it probable that in most cases, at least, the ice-foot everywhere rests on a solid basement.

* See map and description of this glacier by Scherzer, "Glaciers of the Canadian Rockies and Selkirks," Smith Contrib., No. 1692, 1907, chaps. 2-3.

† Cf. I. C. Russell, "Glaciers of Mount Ranier," 18th Ann. Rept. U.S. Geol. Surv., 1898, pp. 329-423.

‡ Hans Meyer, "Der Calderagletscher des Cerro Altar in Equador," *Zeit. f. Gletscherk.*, vol. 1, 1906-7, pp. 139-148.

On the other hand, the Turner glacier, debouching into Disenchantment bay, Alaska, shows a flat and relatively low front section, which is separated from the remaining and sloping portion of the glacier by a steep ice-fall. This has led Gilbert to think that the lowest terrace is floated in the water.*

Alpine Type.—A good deal of misunderstanding is current in regard to alpine glaciers, often unhappily referred to as valley glaciers. Examination of any good map of Switzerland suffices to show that with the possible exception of the Great Aletsch, an abnormal type, Swiss glaciers hardly extend into valleys at all. We have too long held the alpine glacier close before the eye, and so have much exaggerated its importance. When Alaskan, Himalayan, and New Zealand glaciers are brought into consideration, the real position of the Swiss type becomes apparent. In reality the glaciers of the Alps, far from occupying valleys, do not even fill the mother cirques at the valley heads. Here they lie, side by side, joined to one another like the radiating sticks within a lady's fan, for which reason they have been called *Zusammengesetzte Gletscher* (see Fig. 10 and Plate II., Fig. 7). The *mer de glace*, next to the Great Aletsch the largest in Switzerland, with its numerous tributaries, it is true, completely fills a cirque, but only that of a tributary valley (Plate II. Fig. 8).† Alpine glaciers are hence sheaves of small glaciers which are wholly included within the mother cirques, or which fill and extend out from the secondary or tributary cirques. In the Nicolai Valley of Switzerland, the Gorner glacier and its several tributaries (see Fig. 10), with the Findelen and Längenfluh, the Theodul, Furgen, and Z'Mütt glaciers together, but partially fill the mother cirque of which Zermatt is the centre. Lining the valley below upon either side are eighteen to twenty glacierets, all resting upon the *albs*, or high mountain meadows.

High up in the Chamonix valley, below the debouchure of the *mer de glace*, similar glacierets are lodged upon the ledge below the sharp needles of de Charmoz, de Blatière, du Plan, and du Midi, their frontal moraines making a continuous series of scallops above the shoulder of the valley. Similar but smaller series are shown in Figs. 20 and 32.

Horseshoe Type.—The final representative type in our series, unlike the alpine glacier, is no longer made up of streams joined together in

* G. K. Gilbert, 'Harriman Alaska Expedition,' vol. 3, "Glaciers," 1904, pp. 67-68. See also Tarr, "The Yakatat Bay Region, Alaska, Physiography and Glacial Geology." Prof. Paper No. 64, U.S. Geol. Surv., 1909, pp. 39, 40, pl. *xa*.

† This valley is a large hanging valley tributary to the Chamonix valley, which latter alone is comparable in size to those that form the beds of the Baltoro, Hispar, and Tasman glaciers. If at first it seems that confusion may result from the introduction of valleys of different orders of magnitude, a second thought suffices to show that the difficulty is of theoretical rather than of practical importance, at least so far as existing examples of glaciers are concerned.

FIG. 31.—IRREGULARLY BOUNDED NÉVÉS UPON THE VOLCANIC CONE OF MOUNT RANIER.

FIG. 32.—SERIES OF HANGING GLACIERETS WHICH EXTEND THE ASULKAN GLACIER IN THE SELKIRKS.

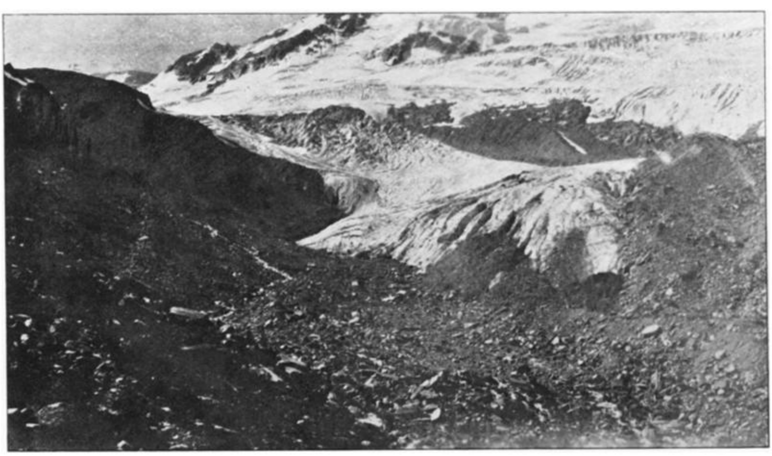

FIG. 33.—VIEW OF THE ASULKAN GLACIER, A HORSESHOE GLACIER IN THE SELKIRKS.

FIG. 35.—VIEW LOOKING DOWN THE VALLEY OF FISH CREEK FROM THE ASULKAN GLACIER, THE HERMIT RANGE IN THE DISTANCE. SELKIRK MOUNTAINS.

FIG. 37.—VIEW OF THE WENKCHEMNA GLACIER AT THE HEAD OF THE VALLEY OF THE TEN PEAKS IN THE CANADIAN ROCKIES.

sheaves. With further shrinking of alpine glaciers corresponding to higher air temperatures, the glacier front retires until it approaches the cirque wall. It now takes on, either as an individual or as a collection of small remnants, a broadly concave margin, which is in contrast to the convex or convexly scalloped front characteristic of all other glacier types. This type of glacieret has been sometimes described under the names hanging and cliff glaciers.* Reasons have been presented for restricting both these terms to special and different varieties

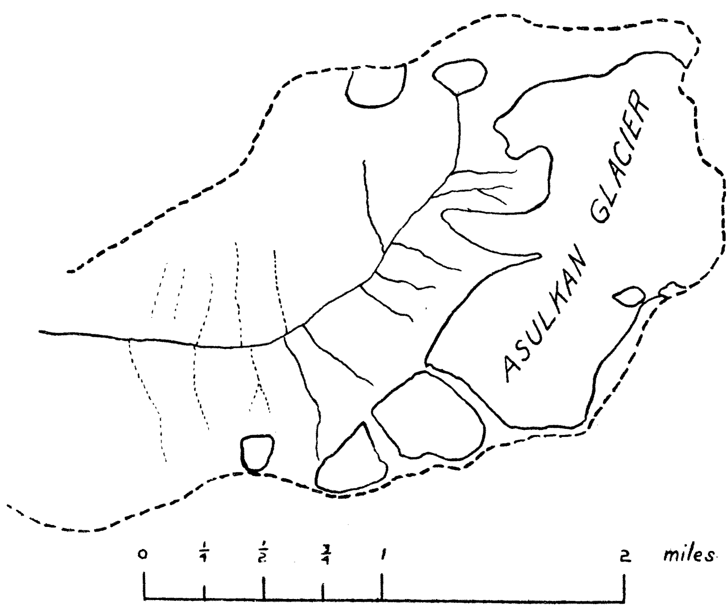

FIG. 34.—OUTLINE MAP OF THE ASULKAN GLACIER IN THE SELKIRKS.

of small glaciers or glacierets. It is proposed to use here the term "horseshoe glacier" for these last remnants of larger glaciers hugging the wall of the cirque. Most of the glaciers of North America outside of Alaska belong in this class. As already implied, they are generally broader than long, and usually have concave frontal margins. Excellent examples of this type are furnished by the "Horseshoe glacier" at the head of the Paradise valley in the Canadian Rockies and by the Asulkan glacier in the Selkirks (see Figs. 32–34.) The Mount Lyell glacier, long known and cited from the High Sierras of California, is, however, an equally good type.† For further illustration of the type the Wenkchemna glacier in the Canadian Rockies has been chosen (see

* See footnote on p. 277.

† I. C. Russell, "Existing Glaciers of the United States," 5th Ann. Rept. U.S. Geol. Surv., 1885, pp. 314–328, pl. 40.

Figs. 36, 37 and Plate II. Fig. 12). The Asulkan and Wenkchemna glaciers have both been described by Scherzer as belonging to the piedmont type. The former hugs the cirque wall with an incurving frontal margin, and is extended by a series of small hanging glacierets (see Fig. 32). Unlike the piedmont glaciers, it has no foreland on which to expand, but lies at the head of a typical U-shaped valley (see Fig. 35). The Wenkchemna glacier occupies a similar position in the great cirque outlined by the Ten Peaks at the head of a tributary valley to the Bow (see Figs. 36, 37).*

In Plate II. the various types of glacier are shown on approximately the same scale, and from this it will be appreciated that the size, directly dependent upon the alimentation of the glacier, must be a determining factor in classification. The ice-cap and piedmont glaciers will in this respect overlap, being differentiated by the accentuation of the relief of the land, though in the main the ice-cap is the larger. For the other types the proportion of the glacier-carved valley which is still occupied by the ice will determine the form and the more important characters of the existing glacier. It is important, therefore, in order to determine the type to which an individual glacier belongs, to map the divide surrounding the valley, as well as the boundaries of the glacier which lies within it.

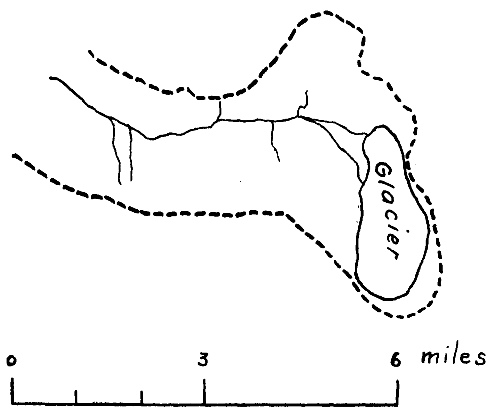

FIG. 36.—OUTLINE MAP OF THE WENKCHEMNA GLACIER IN THE CANADIAN ROCKIES.

Termination of the Cycle of Glaciation.

Configuration of the Glacier-bed when uncovered.—No one who has climbed a mountain glacier to its *névé* has failed to be struck by the alternation of plateau and precipitous slope, for the surfaces of mountain glaciers are, with few exceptions, broken into broad terraces. Each steep descent is well understood to overlie a corresponding fall in the glacier-bed. Perched upon the high cliffs which overlook the Pinnacle pass

* Sherzer, Smith Contrib., No. 1693, 1907, chaps. iv. and vii. The only resemblance to the piedmont glacier is in the shape. Neither glacier expands upon a foreland, but both lie in cirques at the heads of U-shaped valleys. They have no appreciable tributaries, and, as already pointed out, piedmont glaciers are necessarily of large size, corresponding to excessive precipitation.

during his first attack upon Mount St. Elias, the late Professor Russell wrote of these terraces *—

"Were the snow removed and the rock beneath exposed, we should find terraces separated by scarps sweeping across the bed of the glacier from side to side. Similar terraces occur in glaciated cañons in the Rocky mountains and the Sierra Nevadas, but their origin has never been explained. The glacier is here at work sculpturing similar forms, but still it is impossible to understand how the process is initiated."

The generalized description of uncovered glacier-beds within the High Sierras of California—perhaps as well as any that has been penned—lays the emphasis upon the more essential and impressive characters †—

"The amphitheatre bottom terminated forward in either a cross cliff or a cascade stairway, descending, between high walls, to yet another flat. In this manner, in steps from flat to flat, common enough to be characteristic, the canyon made descent. In height, however, the initial cross cliff at the head dominated all. The tread of the steps in the long stairway, as far as the eye could follow, greatly lengthened in down-canyon order."

The grade in the treads of the giant stairway is often reversed, so that they come to be occupied by the characteristic rock-basin lakes, long and ribbon-like, or strung along the valley like pearls upon a thread.

Since Russell's meditation above the Pinnacle pass, nearly a score of years ago, considerable study has been given to the subject of erosion upon the glacier-bed. In the Alps Penck and Brückner have enunciated their "law of adjusted cross-sections." The glacier, on invading the mature river-valley, characterized by uniformly forward grades and by accordance of trunk with side valleys, will, in general, be so modified that a small cross-section corresponds to a deepening of the valley.‡ Thus will be brought about the hanging side valley, and a local modification of, and perhaps even a reversal of, direction in the grade of the main valley.

If the rock be not homogeneous throughout, or if it be unequally intersected by joint planes, further abrupt changes in grade will result. The two processes which are effective in deepening the bed of the valley are well recognized to be abrasion and plucking. Greater softness in the rock will correspond to greater depth of abrasion, while the perfection of the parting planes will directly determine the amount of quarrying in the rock by plucking. Abrasion being greatest on the

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* I. C. Russell, "Expedition to Mount St. Elias," *Nat. Geogr. Mag.*, vol. **3**, 1891, pp. 132-133.

† Johnson, *Journ. Geol.*, vol. **12**, 1904, pp. 570-571.

‡ A. Penck, *Journ. Geol.*, vol. **12**, 1904, pp. 1-19.

upstream side of any irregularity in the bed, and plucking being largely restricted to the downstream side, the tendency of these processes working together will be to produce steps of flat tread but steep riser, the latter coinciding with the nearly perpendicular planes of jointing.

It is further probable that the cliffs at the lower margins of the terraces are in many cases, at least, considerably recessed through the operation of a sapping process in every way analogous to that which obtains at the base of the Bergschrund, or *Randspalte*. So soon as the rock-cliff has been formed, either below a narrowing of the valley or where a hard layer of rock transects it, the glacier will descend over it in an ice-fall, showing gaping transverse crevasses. These fissures in the ice may be sufficiently profound to admit the warm air at midday to the rock joints, and so bring about with the nightly fall of temperature a mechanical rending of the rock.

Basal cliff sapping being downward as well as backward, the reversed grades of the treads in the staircase could be thus explained. In the Alps, Penck distinguishes especially one larger cliff in the staircase which separates the head cirque from the trough valley (*Trogthal*).

Water-erosion within the Valley during Retirement of the Glacier.—The staircase left by the ice, with its rock-basin lakes high up in the valley and its morainal lakes in the lower reaches, undergoes a rapid transformation under the influence of running water so soon as the ice has largely vacated the valley. Flowing from the waning remnant of the glacier, this water is overburdened with sediment. Its current is sluggish on the treads of the steps, but develops a cascade over the cliffs between. The coarser *débris* which it carries is thus quickly dropped upon the treads to fill the lake-basins, and with the aid of the finer material, the rock obstructions are cut through in narrow cañons and with a marvellous rapidity. Where a barrier of more resistant rock has hemmed in a portion of the valley (*Riegel*), narrow picturesque gorges have been cut, such as the *Aarschlucht* and the gorge of the Gorner.* The lateral moraines, having slid down their slopes with the retirement of the ice, are rapidly buried under the talus of the rock-slides from the steep valley walls, thus partially obscuring the characteristic U of the valley section. Sufficiently clear marks are left, however, so that there is seldom serious difficulty in restoring the main outlines of the glacial history of the district.

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* Some of the Swiss gorges were described by Tyndall ('Hours of Exercise in the Alps,' pp. 224–230).

'The Historic Thames.' By H. Belloc. (London: Dent. 1909. Pp. 204. 3*s*. 6*d*). This little book is by a master of a pleasant style, and presents the story of the Thames in a characteristically pleasant vein, without any effort towards originality. The volume is hardly so well produced as those of other similar series.

"Cambridge County Geographies." 'Cambridgeshire.' By T. McK. and Mary C. Hughes. (Pp. xiii., 271.) 'Cheshire.' By T. A. Coward. (Pp. x., 207.) (Cambridge: University Press. *Maps and Illustrations.* 1*s*. 6*d*. each.) The authors, editor, and publishers of this series continue a good work. These volumes bulk larger than earlier ones, and maintain their standard, that on Cambridgeshire being especially well done. Moreover, it possesses an index—an adjunct which has not been regarded as necessary in other volumes, and this is a move in the right direction.

'High Albania.' By M. Edith Durham. (London: Arnold. 1909. Pp. xii., 348. *Maps and Illustrations.* 14*s*.) From this authoress we anticipate, by experience, a volume full of entertainment and clever observation on any part of the Balkans which she may have visited. The present work is no disappointment, and renews our admiration at once for her writing and for her boldness as a traveller, for her wanderings in Albania were often over almost untrodden roads.

'A Military Consul in Turkey.' By Captain A. F. Townshend. (London: Seeley. 1910. Pp. 328. *Illustrations.* 16*s*.) The author is able to discourse both gravely about Turkish political and administrative problems and gaily about his own peculiar experiences. His official duties led him far afield, and his book would be well worth the attention of intending travellers to Asia Minor.

ASIA.

TIBET.

'Trans-Himalaya: Discoveries and Adventures in Tibet.' By Sven Hedin. In two volumes. London: Macmillan & Co., Ltd. 1909. 30*s*. *net*.

There is no necessity for a long or detailed examination of this book from a geographical point of view, because it is the popular edition, and will hereafter be followed by one on a still larger scale with scientific results and finished maps. Moreover, in this *Journal* of April, 1909, Hedin's paper on his journeys is published, as are the discussions and his reply which followed. It is therefore now considered less as a contribution to the science of geography than as a narrative of the author's travels and trials. These were unquestionably many and great, some natural, others provided by men, but were overcome by a perseverance, resource, and courage which command our admiration.

Dr. Hedin left Stockholm in October, 1905, and travelled by Constantinople to Seistan, on the East of Persia; thence to Nushki and Quetta, eventually arriving at Simla in May, 1906. Here he found that he was prohibited from entering Tibet from British India, but was made a guest by Lord Minto, the Viceroy, and during his stay at the Viceregal Lodge shared in various festivities which are well and amusingly described. Here, too, he hatched plots whereby he might effect his purpose, and in furtherance of them he set forth to Srinagar, where he stayed with Sir Francis Younghusband. Soon he went on to Leh, where his camp was finally arranged, and departing thence, ostensibly for Khotan and Turkistan, he found himself ere long in Aksai Chin, in north-west Tibet or on its border. For, as he says, this is a country which belongs to no Power. Is it part of Kashmir, or Tibet, or China? There are neither boundaries nor boundary stones. "From here, therefore, I could move eastwards without acting in direct opposition to the wishes of the English Government, and the Chinese would certainly forgive me for not using their passport."

So he set off, and had a rough time on the way to Lake Lighten, on which he and his canvas boat went through many graphically described perils, but escaped. Thence he passed Lake Markham and turned southwards across Chang-tang to the Ngangtse lake, on which he spent the last night of 1906. Then, after the usual delays and deliberations consequent on the Tibetan authorities desiring him to return the way he came, and his natural repugnance to that course, they suddenly came to the conclusion that the simplest way of getting rid of responsibility was to pass him on to the next province across the Brahmaputra. This suited the traveller's plans, and to that decision Sven Hedin and his readers owe some most interesting chapters about Shigatse, Tashi-Lunpo, the Tashi Lama, and the ways and customs of the lamas. He was present at the losar, or new year's festival, which lasts fifteen days, the greatest of the four annual ceremonies. It celebrates the victory of true religion over infidelity, and is held early in February. The country people flock there and all are admitted, no distinction being made between rich and poor. The descriptions of the ceremonies, illustrated as they are by some of Hedin's extremely clever sketches, are of great interest to many besides geographers. The Tashi Lama made a favourable impression on the author, and is greatly praised.

Leaving Shigatse, he marched up the Brahmaputra, and remarks on "the violent storms from noon onwards which blew in our faces;" that is, from the west. "We were pestered with sand, which grated under our teeth, irritated our backs, and made our eyes smart. Where the valley was contracted, the compressed wind blew with double strength, and the sand-clouds rolled in a greyish-yellow mass along the Brahmaputra valley." Farther on he describes the peculiar country he was passing through on the northern bank; lakes and swamps surrounded by sandhills 26 feet high, and responsible for a plague of gnats. Here floods wash away the driftsand and deposit it lower down, but as the river falls fresh sand accumulates and new dunes are made. The country reminded him of Lob in Chinese Turkistan and the struggle there between sand and water.

On this journey Hedin diverged southwards to investigate the headwaters of the Kubi-Tsangpo, which he states is the chief source of the Brahmaputra, and thence he proceeded to the famous lakes Mánasarowar and Rákas-tál, the former of which furnishes drink for the gods and is sacred to them, whilst the latter, judging from its name, is the lake of evil spirits. With Mánasarowar Hedin was enchanted, and he apostrophizes it thus: "Wonderful, attractive, enchanting lake! Theme of story and legend, playground of storms and changes of colour, apple of the eye of gods and men; goal of weary, yearning pilgrims, holiest of the holiest of all the lakes of the world, art thou, Tso-mavang, lake of all lakes. . . . That is Mánasarowar, the pearl of all the lakes of the world."

On Rákas-tál he was blown in a storm to an island, a single rock falling sheer into the water. It is a breeding-place for wild geese in spring, and even when he was there he found thousands of eggs in nests of stone and sand.

The celebrated mountain Kailás lies north of these lakes, and is a great place of pilgrimage for Hindus and Tibetans. Its peak bears a striking likeness to the dome of a Hindu temple, whence, some say, comes the veneration accorded; the Tibetans call it Kung-rinpoche, "The holy ice mountain," and find its shape similar to a chorten.

From this neighbourhood, say within a radius of a hundred miles from Kailás, four rivers rise: the Indus and Sutlej, eventually flowing westwards and south; the Brahmaputra flowing east and south; and the Mapcha-kamba, or Karnali, which falls into the Ganges. These rivers are known as the lion, the elephant, the horse, and the peacock.

Hedin was sent back towards Leh, but before arrival he turned north and again found his way east to make another crossing of the unknown land; he finally returned to Simla by the Sutlej route.

Though discovery in its full sense is scarcely the word to be used in connection with his travels, Hedin has undoubtedly made great additions to our knowledge of these parts. By traversing in several directions the corrugated mass of hills which lie within the blank portion of the Society's map of Tibet (1906), south of the routes of Nain Singh, Bower, Littledale, and others, and north of the Tsangpo or Brahmaputra, he has unquestionably reduced the space which bears the word "UNEXPLORED." For this he is entitled to our warm congratulations and thanks, though, with Colonel Burrard, we realize that at present we have to be content with approximations to truth; in respect, however, to the discoveries of the chief sources of the Indus, Sutlej, and Brahmaputra, whilst fully recognizing the value of his work, we hold that claims to have found the true source of this river or that are of little value. The source or sources of every river are the areas of the catchment basin, the ultimate source being the rain or snowfall. One source or channel may carry more water one day, another more the next, and to dogmatize as to one stream rather than another being the true source of a river is unprofitable at any time, and probably incorrect till minute and accurate surveys have been made and discharges observed.

The author is anxious to have the range through which he has travelled called Trans-Himalaya, whilst others object to that designation. There is no doubt that name is open to objection for the sufficient reason that when placed north of it, it becomes Cis-Himalaya; yet many persons well qualified to form an opinion are content that it should be adopted. In this country the feeling seems to be that the name does not matter much, and therefore the traveller's wish may be respected; in India it is believed that the senior officers of the Survey Department dislike the name, preferring the old name, Kailás range. The dispute is one of those matters which, if left alone, will settle itself.

It may be noted that the author, whilst paying deserved tributes to the Survey officers and to the pundits who visited the country many years ago, has a somewhat unfortunate way of referring to the relative importance of his work and theirs. This is a pity; when the country is accurately surveyed—should that ever happen —his present sketch-maps will be found to require many corrections, yet that does not detract from their present value.

The volumes, which have been rapidly put together, would have gained by judicious compression; even as they are, the story is incomplete and a third volume is promised; but it is fair to add that they abound in interest and will appeal to a considerable and important section of the public. It is not quite clear whether Sir Sven Hedin—for he is now K.C.I.E.—is responsible for the English edition; an announcement was made in the *Athenæum* that "the rendering it embodies was made for Messrs. Macmilian & Co. by Mr. W. A. Taylor." This is not very clear, but, anyhow, there are few mistakes, and they are of little consequence. The illustrations are numerous and good, those from the author's pencil being conclusive as to his artistic skill. The publishers, too, are to be congratulated on the good type and general turn-out of the book.

W. BROADFOOT.

A JAPANESE PILGRIM IN TIBET.

'Three Years in Tibet.' By the Shramana Ekai Kawaguchi. London and Madras: Theosophical Publishing Co. 1909. *Map and Illustrations. Price 16s. net.*

This narrative, from the pen of a Japanese monk, deals with three years' exploration and residence in Tibet. Much of its peculiar interest arises from the fact that it presents us with a faithful picture of that strange country from an Asiatic and not from a European point of view, and thus reminds us strongly of Sarat Chandra Das's well-known journals. The similitude is not surprising considering that the author spent most of the year 1898 in Darjeeling, and thus had the advantage of receiving both instruction and counsel from the redoubtable S.C.D., who appears to enjoy quite a dignified position there. Mr. Kawaguchi then passed on to Tsarang, in Nepal, where he stayed about fourteen months. All this time he was diligently studying Tibetan, so that when he finally set off for the forbidden land by a pass leading in the direction of Lake Manasarowar, he had quite mastered the Tibetan language. His route lay round the lake and Mount Kailas, and then eastward to Lhasa, along the northern side of the Sanpo by way of Tadum and Shigatze. In the course of this journey the author suffered extraordinary privations owing to inadequate equipment, as well as to the fact that for the first part of the route his only companions were two sheep, which carried his provisions and stores. On arrival at Lhasa, he applied for admission to the Sera monastery, and through his knowledge of the Buddhist scriptures and skill as a doctor he established a good reputation and became very popular. Eventually he was presented to the Dalai Lama, who received him very favourably. This was previous to the despatch of the Younghusband Expedition, and the prevalent feeling at that time was strongly anti-British. The daily life in Lhasa, the manners and customs of the Tibetans, their trade and industries, and the curious negotiations with Russia, culminating in the despatch of several camel-loads of firearms and ammunition,—all these topics are handled in most interesting fashion. Mr. Kawaguchi's book is put together with more literary skill than Sarat Chandra Das's older narratives, and its fuller and more recent information combine to make it probably the best and most up-to-date description of a country which is bound for some time to come to exercise a mysterious fascination over the Western reader.

AFRICA.

The Partition of Africa.

'The Map of Africa by Treaty.' By the late Sir E. Hertslet, K.C.B. Third edition, in three volumes, and a collection of maps. Revised and completed to the end of 1908 by R. W. Brant, Librarian and Keeper of the Papers, and H. L. Sherwood, of the Foreign Office. London: Printed for His Majesty's Stationery Office by Harrison & Sons, St. Martin's Lane. *Price* £3.

Sir Edward Hertslet's 'The Map of Africa by Treaty' was first published in 1895; a year later a revised edition appeared. Since 1896 changes of importance in the political colouring of the map have been made, such as the wresting of the Eastern Sudan from the Khalifa and the renunciation by Italy of her claim to a protectorate over Abyssinia. Minor changes, caused chiefly by the delimitation of boundaries, have been very numerous. Hence the appearance of a third edition of the book is very welcome. The work of revision has been ably accomplished by Messrs. Brant and Sherwood, who have included all treaties and agreements involving territorial changes in Africa concluded down to the end of 1908. The first volume is now devoted entirely to British colonies, protectorates, and other possessions. These have been grouped in three distinct divisions: (1) West Africa, (2) South and Central Africa, (3) East Africa. (The Anglo-Egyptian Sudan, which owns a double sovereignty, is given under Egypt.) In the second edition, British possessions had been given alphabetically, and were not placed in a separate volume. The new arrangement will be found convenient. In this first volume can be traced the successive steps by which the boundaries of British possessions have been fixed, references being given to the texts of the agreements between Great Britain and other Powers contained in volumes 2 and 3, where also will be found all treaties between states other than the United Kingdom. Colonel Close's valuable map default of much more conclusive evidence than is offered by the superficial similarity of mottled pottery in Crete and Turkestan, this opinion conflicts too greatly with probabilities to carry conviction. The authors refer to the possibility, advanced in a certain *Times* article, that Crete was "Atlantis," and seem to favour it: but so far as the general situation and local topography of Atlantis are defined in the poetical accounts which are our only authorities, they do not square well with those of Cretan Cnossus. The book is very readable.

D. G. H.

ASIA.

The Western Himalaya.

'Peaks and Glaciers of Nun Kun. A Record of Pioneer-Exploration and Mountaineering in the Punjab Himalaya.' By Fanny Bullock Workman and William Hunter Workman. London: Constable & Co. 18*s*. *net*.

This handsome volume is the detailed account of an adventurous exploration of the comparatively little known locality east of Srinagar, and the route over the Zoji-la to Dras, south of Suru, and north-west of the well-known Maru Wardwan. A short account, read by Dr. Workman, in November, 1907, at a meeting of the Society, was published in the *Geographical Journal*, vol. **31**, p. 12.

Preparations for the expedition were made chiefly at Srinagar, a noticeable departure from ordinary usage being the engagement of six porters and the guide, Cyprien Savoye, from Courmayeur. The porters were to carry camp outfit to points above those which coolies could climb, and they were to do their own cooking. One of them seemed to be a *chef*, for he had medals from Italian cooking societies. They had a tent-servant to help and wash dishes, "but they prepared the rest of their food over a native hearth, and, in the snows, over a primus stove, and were entirely satisfied with the arrangement. It saved us a lot of trouble, for they had everything needed, lived well, and there were no complaints."

So far good; but there was plenty of trouble with the local coolies, remedied chiefly by means of "bakhshish" in copper and silver, where in cases the variety known as "bamboo" was certainly appropriate and deserved, though possibly injudicious to bestow. For in many instances they were probably obeying the orders of some local dignitary. However, difficulties were overcome, and the journey was successfully made to the base camp, 15,100 feet high, up the Shafat glacier. A sportsman had been there the preceding summer, whose servants had made stone shelters, which were immediately appropriated by the coolies. Whether he found game is unknown, but Dr. and Mrs. Workman saw no big game, and merely mention an eagle which succeeded in carrying off a leg of mutton, and that chikor, a bird almost identical with the French partridge, abounded near the camp. Thence explorations were made, and high snow-camps were formed, to which the names "Nieve Penitente," "White Needle," "Camp Italia" (20,632 feet), and "Camp America" (21,300 feet) were given. From Camp America the final ascent was successfully accomplished, and the party stood at 23,000 feet. "By this ascent Mrs. Bullock Workman not only broke her last record-ascent for women of 22,568 feet, but won a place with Dr. Workman in the small band of mountaineers who have reached a height of over 23,000 feet." It was a great feat, specially for the lady, but all the party may be congratulated.

The return journey was by the Barmal-la to Suru, where the coolies were paid off, the guide and porters started on their return to Europe *viâ* Srinagar, and the final adjustments connected with the expedition were made. The last chapter contains the authors' views about Nieve Penitente, and deserves careful consideration. The whole story is agreeably told; where reference to the great work of the

Indian Survey Department is made (p. 162), it is in a proper and appreciative spirit. The map is ample for its purpose, whilst the illustrations, made in Germany from photographs taken by the authors, deserve much praise.

W. BROADFOOT.

AFRICA.

ABYSSINIA.

'Jean Duchesne-Fournet.' Mission en Ethiopie (1901–1903). 2 vols. By MM. Henri Froidevaux, O. Collat, J. Blanchart, Dr. Verneau, and others. Paris: Masson & Co. (1909), and Atlas (1908).

These handsome volumes form a worthy memorial of a young explorer who, unhappily, is no longer in the ranks of the living. Jean Duchesne-Fournet (a son of the well-known French senator, Mons. Paul Duchesne) died in 1904, aged 29. Young as he was, he had given proof of the possession of exceptional qualities, well fitting him to take rank with the travellers of modern days, who go prepared by previous study to make as complete an examination as possible of the various aspects of the unknown or little-known regions they visit. The scientific mission to Abyssinia organized and led by Jean Duchesne-Fournet lasted from October, 1901, to January, 1903. The main results of the work done by it had been made public in magazine articles before the appearance of this work. Nevertheless, the family of the explorer have been well advised to publish this account, not alone as an act of homage to a gallant youth, but for the valuable and varied information which it gives in easily accessible form.

The mission, of which throughout Duchesne was the guiding star, made its way from Jibuti to Adis Ababa by a new route through the Danakil country; thence, by roads partly unknown, it traversed the plateaus of Shoa and Gojam to Lake Tsana, which was encircled on foot; and finally the leader paid a visit to the Wallaga gold region. There were no great topographical discoveries to be made, though the rectifications in the map of Abyssinia were not unimportant. The mission, however, devoted special attention to geology, ethnology, zoology, and the social and economic condition of the country. To aid him in his task, the leader had obtained the services of several distinguished men. Among them were Lieut (now Captain) O. Collat, second in command, and the cartographer of the expedition; H. Arsandaux and Dr. Moreau, geologists, and Dr. Goffin, anthropologist. Nor should mention be omitted of the late Edouard Comboul, an engineer who had made a detailed mineralogical study of the Wallaga country, and who aided Duchesne in his researches in that region.

The *Mission en Ethiopie* is divided into eight parts. The story of the expedition is ably told by Henri Froidevaux from the material left by Duchesne and from information obtained from his comrades, judicious use being made of other books for descriptive passages. Captain Collat discusses the economic condition of Abyssinia; Mons. Arsandaux deals with geology, Dr. R. Verneau with anthropology and ethnography, and Pierre Lesne with insects (this last a brief section of six pages). Mons. G. Hutin has drawn the maps from the itineraries and notes of Captain Collat. A bibliography of 347 works, given by Mons. Ch. Regismanset of the French colonial office, includes 106 books which Jean Duchesne had in his library, and had consulted before setting out on his journey, an example of thoroughness of preparation much to be commended. Finally, there is a valuable section by J. Blanchart on the Abyssinian manuscripts obtained by the mission. Of these a seventeenth-century version of the life of the Saint Tekla Haymanot is of considerable value, and a translation thereof is given in full. When it is added that these various sections are illustrated by numerous maps, nearly 200 illustrations

GLACIER EXPLORATION IN THE EASTERN KARAKORAM.*

By T. G. LONGSTAFF, M.A., M.D. Oxon.

Of the mountain regions of High Asia which are politically accessible to the ordinary traveller, there is none concerning which detailed information is more scanty than the eastern section of the great Karakoram range. Between Younghusband's Muztagh pass and the Karakoram pass on the Leh-Yarkand trade-route, a distance of 100 miles as the crow flies, we have no record of any passage across the main axis of elevation having ever been effected by a European. There are, however, traditions relating to an old route known as the Saltoro pass, and it was the elucidation of this latter problem at which I aimed last year.

Concerning the country east of K_2, Burrard wrote in 1907 : "There is no more likely spot than this for great undiscovered peaks to be existing" (Burrard and Hayden's 'Sketch of the Geography and Geology of the Himalaya Mountains and Tibet,' p. 100). So confident was I of the accuracy of this forecast by one of our greatest authorities on Himalayan problems, that I provided myself with an instrument for the special purpose of measuring these peaks, choosing on Mr. Reeves' recommendation the Indian Survey clinometer.

East of 77° E. and north of 35° 30′ N. lies an area roughly measuring a degree in each direction into which no traveller has ever penetrated, and which has never been surveyed. We know that it is a region of snow-clad mountains, and that it is quite uninhabited. The known area may be regarded as limited on the south by the conscientious labours of the G.T.S. of India (*vide* quarter-sheets 44*a* south-west and south-east, which shows the head of the Nubra valley bounded by the main water-parting in the latitude of the Karakoram pass); on the east by the headwaters of the Yarkand river, explored by the intrepid Hayward under such exceptionally difficult circumstances in 1868 (*J.R.G.S.*, 1870, vol. 40, p. 52). On the north by Raskam, the scene of so many bloody raids by the Kanjutis; and on the west by Younghusband's discoveries around the glacier sources of the Oprang river in 1889 ('The Heart of a Continent,' chap. x.), of which more anon.

Two other travellers have knocked at these closed doors. In the year 1835 Vigne attempted to find the Saltoro pass, of the existence of which he had heard from the natives. He reached a point some 5 miles up the Saltoro or Bilafond glacier, but was forced to return owing to the inclemency of the weather, the lateness of the season, and the unwillingness of the Khapalu men to proceed (Vigne, 'Travels in Kashmir,' vol. 2, p. 382). In 1848, Henry Strachey visited the Siachen glacier, from which the Nubra river takes its rise, and forced his way

* Read at the Royal Geographical Society, April 18, 1910. Map, p. 744.

up it for 2 miles ('Physical Geography of Western Tibet,' p. 53; also *J.R.G.S.*, vol. 23, p. 53).

It was natural, therefore, that I made this region my goal last year, well assured that nowhere else could my alpine experience be turned to better use. Sir Francis Younghusband, then Resident in Kashmir, and to whose kindly assistance I am indebted far more than I can say, showed me the original field-books and maps containing the records of his explorations at the sources of the Oprang river in 1888. On this occasion he had been despatched on an important mission from which he turned aside for a short time to investigate the native reports as to the existence of a pass—the Saltoro pass—leading into Baltistan. His longitudes depended very largely on the identification of a high peak which he sketched. From the old survey maps with which he had been supplied, it was natural to suppose that this great peak was none other than K_2. But H.R.H. the Duke of the Abruzzi had been able to demonstrate that it was probably Gusherbrum. The latitudes were quite beyond dispute, but in spite of this, we found that the compilers of the well-known 'Map to illustrate the Explorations of Captain Younghusband' had drawn his route much too far to the south in order to fill in the curious blank V-shaped patch south-east of K_2. After a laborious three days' ascent of a glacier, named by him the Urdok glacier, Younghusband camped on the ice at an altitude of 15,355 feet. His latitude was 35° 41′ 20″. Proceeding southward the next day, he saw a gap in the ridge about 3 miles distant. Through this gap he saw peaks rising to the south. His men believed this to be the Saltoro pass. But avalanches made further progress extremely dangerous; and, having ascertained what he wished to know—that there was no practicable route into Kashmir territory—he returned by the way he had come. Before I left he gave me a diagram showing where he considered the main water-parting really lay, and in the end it was found that his anticipations were in almost complete accordance with fact.

My party originally consisted of only Lieut. A. M. Slingsby and myself. At the last moment that well-known mountaineer, Dr. Arthur Neve, of Srinagar, found himself free to join us for a few weeks. I have to thank Colonel M. J. Tighe, D.S.O., 56th Rifles Frontier Force, for his kindness in obtaining special leave for Slingsby to join me, and also for allowing the latter to bring two sepoys, Gulab Khan and Attar Khan, with him. Let me say once for all that their services were quite invaluable. I have also to thank Colonel Longe, R.E., Surveyor-General of India, for his very considerate offer of the services of an Indian surveyor, an offer which I felt unable to accept because all his time would have been wasted had we been unable to cross the Saltoro pass.

We left Srinagar on May 20, and thanks to the excellent arrangements made for us by Captain D. G. Oliver, Assistant Resident and

British Joint Commissioner for Ladak, crossed the Zogi La (11,300 feet) on May 26 by the winter route, and reached Kharmang on the Indus on June 1. From Kharmang (8150 feet) Neve took the baggage down the Indus to its junction with the Shyok, the Northern Indus of earlier writers, where he ferried across the united streams. Then proceeding along the right bank of the Shyok he reached Khapalu after another exciting passage of the river on zaks.

Slingsby and I crossed the Ganse La (17,100 feet) direct to Khapalu. We were told at Kharmang that the passage would not be possible "until the apricots were ripe." Scenting trouble, we took only four coolies, and when these struck work on the morning of the second day, we sent them home rejoicing, and carried our own loads over the pass, reaching Khapalu (8350 feet) on the third day. Slingsby's orderlies saved the situation. As usual, this lenient treatment of the local people aided us in our future dealings. A traveller gains far more by showing his own superiority over these people than by coercing them, and we never had any more trouble.

At Khapalu, thanks to a letter of introduction from Sir Francis Younghusband, we were most hospitably entertained by Rajah Shere Ali Khan and Rajah Nasr Ali Khan. Shere Ali Khan informed us that the Saltoro pass lay at the head of the Bilafond glacier, and that beyond it were two routes, one leading to Nubra and one to Yarkand. But we were too much obsessed with the ideas imbibed from the study of our maps to appreciate the full significance of this statement. The route was said to have been abandoned when the Leh-Yarkand trade-route *viâ* the Karakoram pass was rendered safe by the intervention of the British Raj. But the desuetude into which so many glacier passes across the ranges of High Asia have fallen in recent times is so frequent an occurrence that I cannot accept this explanation. I should rather look for changes in the glaciers themselves, but as I have previously pointed out (*G.J.*, vol. 31, p. 382) by no means necessarily an advance or increase of the ice. Dr. Stein could probably give us some information on this subject. Further, I find that in 1848, Thomson ('Travels in Tibet,' p. 463), in reference to Vigne's attempt, says that he has been unable to find any one who had crossed the Saltoro pass, and that in Nubra all knowledge of any road either to Khapalu or Yarkand was denied.

Neve rejoined us on June 5, and with the ever-ready assistance of Shere Ali Khan we started again for the Saltoro valley on June 7, Abdal Kerim, one of the rajah's wazirs, being sent with us to make arrangements for coolies and supplies. Crossing the spur behind Khapalu, we dropped down to the Shyok, and at Chogogron ferried across to the right bank on zaks. Our route now led us along the south (left) bank of the Saltoro river. Up to Dansam the valley is deep and wide, the river winding along over its flood plain in several

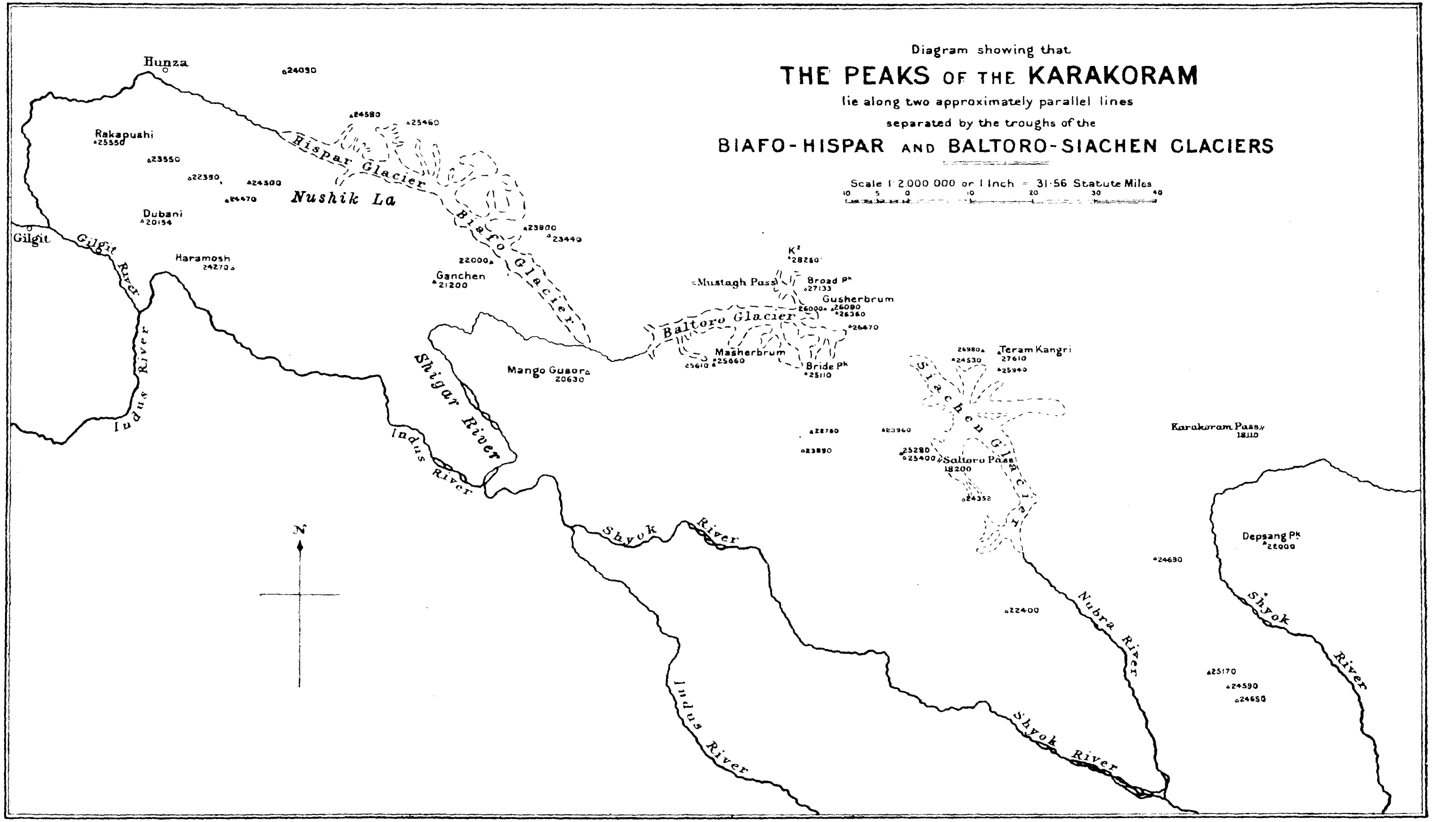


Diagram showing that
THE PEAKS OF THE KARAKORAM
lie along two approximately parallel lines
separated by the troughs of the
BIAFO-HISPAR AND BALTORO-SIACHEN GLACIERS
Scale 1:2,000,000 or 1 Inch = 31·56 Statute Miles
Hunza
Rakapushi
Dubani
Gilgit
Gilgit River
Haramosh
Nushik La
Hispar Glacier
Biafo Glacier
Ganchen
Mango Gusor
Shigar River
Indus River
Baltoro Glacier
Mustagh Pass
K²
Broad Pk
Gusherbrum
Masherbrum
Bride Pk
Teram Kangri
Siachen Glacier
Saltoro Pass
Karakoram Pass
Depsang Pk
Nubra River
Shyok River
N

channels and sweeping round the bases of several large alluvial fans, each irrigated, and hence presenting a pleasant green contrast to the prevailing brown of the crags on either bank. Opposite Paro sheer spires of granite shoot straight up from the river to a height of 5000 feet or more, forming one of the most tremendous palisades I have ever seen—"one adamantine dominion and rigid authority of rock."

At Dansam the Kondus river from the north joins the main stream of the Saltoro, and there is a considerable rise in the level of the valley-floor, with a corresponding waterfall in the river. This is a constantly recurring feature in both the Karakoram and the Himalaya as the glacier region is approached, and I cannot help referring it to the conservative action of the glaciers which descended to these levels in recent geological times. I find it very difficult to believe that glaciers are capable of the degree of spade work claimed for them by most modern geologists. I cannot conceive that solid water is a more powerful denuding agent than liquid water. The etiology of the "tread and riser" formation seems to me to be more explicable on conservative grounds than by means of the elaborate laws evolved by the advanced supporters of the "plucking" theory. At Palit fragments of the old lateral moraines still cling in sheltered places to the valley walls 1000 feet above the level of the stream-bed. The rocks on the north side of the valley appear to consist exclusively of granites, but the high splintered crest on the south is of slate.

At Goma (10,800 feet), the highest village, we turned up the Ghyari nala towards the Saltoro pass. On the right side of the nala three steep narrow glaciers descend through deep gashes in the granite palisade, terminating among the shrubs of the valley floor. They are all actively advancing. The people say that this has been going on for ten or twelve years. As the snouts are approximately in the position shown on the G.T.S. map (1861), it is evident that there has also been at least one period of local retreat since that date. In this part of Baltistan the word *rüzu* was consistently employed to designate a glacier as apart from snow (*kha*).

The Saltoro valley splits at its head (Goma) into three main glens. The glaciers in these—the Bilafond-Chumik, the Rgyong, and in a lesser degree the Chulung—are of the valley type, which, with the doubtful exception of the Aletsch, is unknown in the Alps. They are dendritic, and in all cases secondary glaciers descend right down into the main valley below the present termination of the trunk-streams.

On June 11 we established our base camp in an extensive thicket a few hundred yards from the snout of the Bilafond glacier (12,400 feet). The place is known as Ghyari, and is annually visited by shepherds. A pair of ibis-billed curlew (*Ibidorhynchus struthersi*) frequented this spot. They were evidently nesting. We did not know that the eggs of this rare bird had never been found, and so made no proper search for them. Eastern Baltistan and Ladak are relatively treeless countries, and the demand for fuel leads to great destruction of shrubs in the neighbourhood of villages, but it is usual to find a luxuriant growth of pencil cedar, *shukpa* (*Juniperus excelsa*), willow, and tamarisk, with broom, vetch, and borage, and sometimes wild-currant and rose bushes, near the snouts of the larger glaciers. This holds good as far east as the snout of the Siachen glacier in Nubra, but was not observed at the snout of the Remo glacier, where conditions are more completely Tibetan.

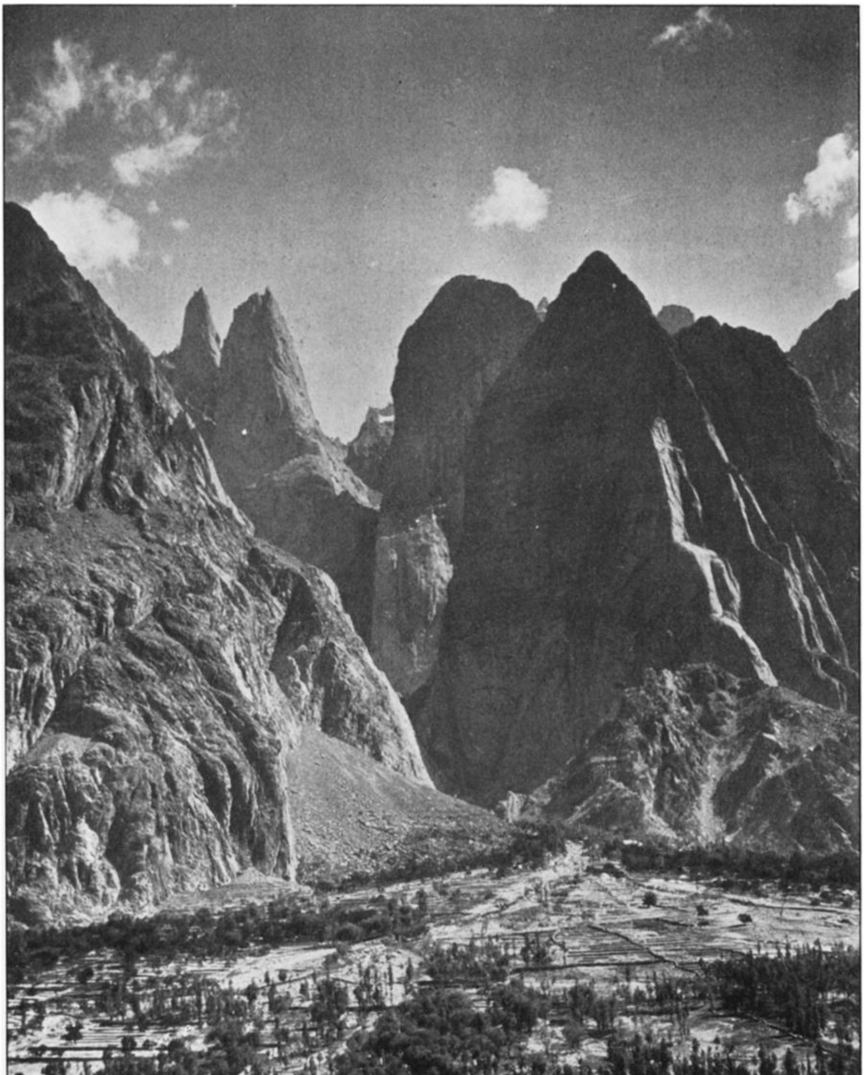
In September, 1835, Vigne camped at this spot. Next day he went 5 miles up the Bilafond to a spot he called Ali Bransa, and which is so marked on the G.T.S. map. He was compelled to turn back owing to bad weather. He speaks of there being two lofty ridges to cross, and two or three more nights to be spent on the ice "before the northern end of the Nubra valley is reached." He appears here to refer to the mountain wall which has always been supposed to close the Nubra valley on the north, 20 miles above the snout of the Siachen glacier.

The Bilafond glacier is the most northerly and largest of the three glacier systems from which the Saltoro river heads, and had it not already a well-accepted local name, might well be termed the Saltoro glacier, for tradition and usage have given the name of Saltoro to the pass we had set out to explore, and it was so used in conversation by the Rajahs of Khapalu. But locally the pass is called the Bilafond La. The Chumik glacier has united with the Bilafond, and the ice now definitely enters the main Ghyari nala. This advance has been a matter of local interest and comment for the last ten years or so. The Chumik glacier was said to have joined the Bilafond about fifteen years ago. Comparison with the old survey indicates an advance of about 2 miles of the combined trunk stream. The advancing ice has actually involved the thickets of alder and juniper on its left bank, and has flowed over the sheep-track which led to the little pasture situated there. The glacier appears to be over-topping its lateral moraine, but there was no observed advance of the snout between June 11 and June 27.

After a day's work with the plane-table from a spur (14,900 feet) above camp, we set out on June 13 up the Bilafond glacier. We had eighteen laden coolies carrying tents, provisions, and wood for our party of twenty-five all told. Our headman was Mullah Halim, of Goma, a very fine fellow. Keeping as close as possible to the right bank, we made our way over horribly unstable moraine. Well disposed glaciers leave a road between themselves and their containing wall, but the Bilafond is an overbearing monster, full to the brim, and steadily advancing, piling its moraines in fearful confusion against the very bases of its confining cliffs. After seven hours' grind, having covered 6 miles, we got off the ice on to the steep grassy slopes of the right bank, and camped about the spot marked "Ali Bransa" on the G.T.S. map, probably after Vigne. The real Ali Bransa is some 6 miles further on. Our camping-place appeared to be known as Naram (14,400 feet): there was a clear sight back to my last station.

One word as to the old survey. In reference to the Saltoro region, the Report ('Synopsis of Results, G.T.S.,' vol. 7, p. xxxiii$_c$.) states that "Mr. Ryall made a rapid sketch of the country, but with sufficient precision to give a good general idea of its physical formation." This is a thoroughly accurate description of what was done in 1861. No claim is made to a detailed topographical survey. The whole basin of the Kondus and Saltoro rivers was under examination, and it was quite impossible that the glaciers should be explored. The triangulation of the high peaks, on which my map is based, was a very different affair, having been effected several years previously by Montgomerie's assistants with the greatest precision. But none of these points are represented as being on the line of the water-parting; they are all correctly shown to the south or west of it. It should not be necessary to point out that, while a mountain range can only be accurately mapped by means of a theodolite triangulation, it is quite impossible to lay down the actual line of water-parting except by supplemental topographical methods. For the latter class of work the great glaciers of the Kondus valley still remain an almost virgin field.

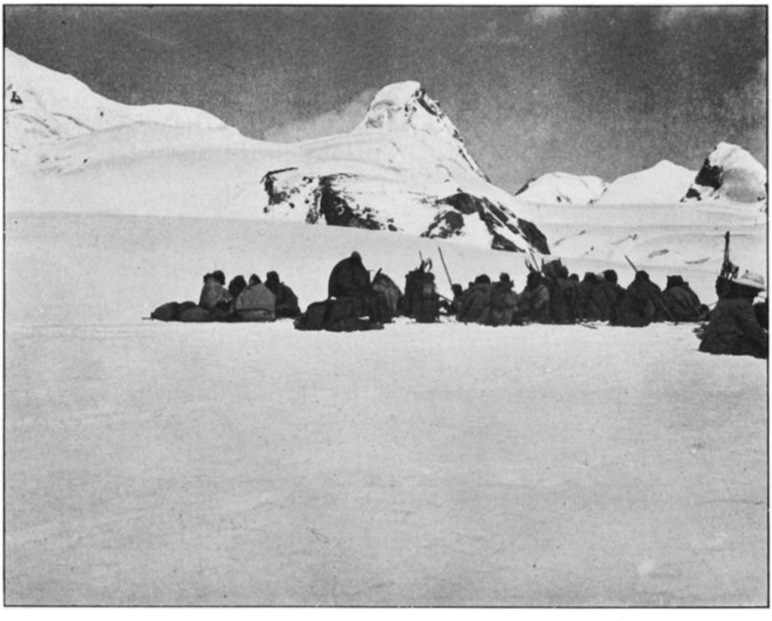
On June 14 we continued on up the glacier. The going was much better, there being a choice of either the well-made moraines or the clear alleys of ice between them, for, owing to the numerous large secondary glaciers which join the Bilafond, the medial morains are multiple. About the junction of the middle and upper thirds of this glacier these moraines are four in number, and each about 50 feet above the level of the rest of the glacier. This height is not due to the actual depth of moraine stuff, for melting is here greatly retarded, so that the ice is really raised underneath the protecting covering of stones. The ice of these moraine-weals is a clear blue or green, while on the bare surface of the glacier the ice is white and finely honeycombed. Besides the Chumik, two large glaciers enter on the left bank. On the right they are more numerous but smaller. Glacier tables of large size are common, being situated usually beside the raised moraines, from the summits of which they had originally fallen. On the right bank of the main glacier, jutting out from two salient angles, are a gigantic pillar of rock, and about a mile further on an almost equally extraordinary pointed tower. The moraines, and, so far as I could see, the two confining ridges also, consist entirely of granite, and on the right bank the former present an almost continuous palisade of gothic spires. If these were ever covered by an ice-cap, that ice-cap has singularly failed in leaving its mark upon them. It is inconceivable that any re-weathering can have produced forms so abrupt and on so gigantic a scale.



SALTORO SPIRES.

(*All photos by T. G. Longstaff.*)

THE BILAFOND GLACIER.



SUMMIT OF THE SALTORO PASS.

As we proceeded the moraines diminished, and crevasses, often covered by sodden snow, became more troublesome, so that we had recourse to the rope. This, of course, delayed the coolies, and it took seven hours from Naram camp to reach the spur on the left bank of the glacier where Ali Bransa was reputed to be. None of our men could exactly locate the old halting-place. In consequence we climbed up a steep slope, and camped in a most uncomfortable and exposed spot (16,700 feet). There were several snow and hail storms, with tempestuous wind all night.

On June 15 we started at 7 a.m. Snow was lying on the ground, and the going was very bad. Regaining the glacier, we soon came to the real Ali Bransa, consisting of three low stone walls (*bransa*) on a strip of solid moraine tucked away under a cliff. The *bransa* yielded not the slightest trace of human occupation. I think it is certain that it had not been visited for at least a generation, for our men could have made themselves fairly comfortable here, instead of passing a wretched night on the exposed spur. Our last camp had involved great labour in building platforms for the shelter tents with which we had provided them. We had constant difficulties with concealed crevasses, but of course were roped together in suitable parties. At 9.30 a.m. we reached the foot of the steep slope leading up to the pass, and the coolies going very well, reached the summit (18,200 feet) at 10.50.

The summit of the pass consists of a level snowfield with a very gentle slope towards the north-east, succeeded by a steeper drop. There was thus a good deal of dead ground on either side of us, which, added to the clouds already covering the highest peaks, considerably detracted from the results obtained by camera and plane-table. We could see that from our pass a broad glacier led gently downwards in a north-easterly direction, and joined a still larger glacier at right angles, which at first seemed to us to flow northwards, we supposed into the Oprang valley through some gap in Younghusband's wall. But that same afternoon we approached sufficiently near to see that the main glacier was flowing to the south. Beyond this was a wall of very lofty peaks, their summits hidden by cloud, which we assumed formed part of the Aghil range. We very naturally believed that we had crossed the main divide of the Karakoram, and that therefore this huge ice-stream must curve round to the east and discharge into the Yarkand river. At 11.50 we began the descent. The snow was appallingly soft, and the leader sank to the waist at every step. Crawling on hands and knees scarcely relieved the labour, and even when some sort of a track was broken it was grinding work for our laden coolies, who wished to camp on the snowfield until the night frost hardened the crust. However, they persevered manfully, and at 4.30 we camped (16,900 feet) on bare ice close to the birthplace of the right lateral moraine. The creaks and groans emitted by the slowly moving ice so frightened our men that, in spite of the cold, they left their tents and passed the night huddled up in the open.

Next day we made only a short march. It was impossible to get off the ice on to the right bank, owing to a confusion of huge seracs and impassable crevasses. We eventually camped at the spot where the left lateral moraine of our glacier effected a junction with the right lateral moraine of the main ice-stream (15,875 feet). Here there was a depression in the glacier-level, and an inexhaustible supply of stones to lay on the ice under our tents. Water was obtainable from surface pools close at hand. Two coolies told us that they had heard of this glacier, and that it was called Tĕrăm (or Teṛm). They said that it would lead eventually to "Chang Thang," by which I concluded they meant the country north of the Karakoram pass. We naturally christened our glacier "Teram glacier," being quite unaware of the fact that it was really the undiscovered upper portion of the Siachen glacier of Nubra.

From our camp we now saw that we were upon an enormous glacier, fully 3 miles in breadth, and by far the biggest any of us had ever seen. It was flowing from north-west to south-east, or approximately from the direction of Conway's "Hidden peak." Near its head and distant about 15 miles was a gap, which I at once connected with the sketch of Younghusband's "Saltoro pass" which I had seen in his report. It is possible that in former times there was a route from the Oprang valley over Younghusband's saddle, and either down the upper Siachen into Nubra, or into Baltistan over the true Saltoro pass, or by some other pass over the Kondus ridge. But I cannot believe that natives would ever have undertaken so dangerous and arduous an enterprise; for we had been told that animals had never crossed the Saltoro pass, and thus travellers from the Oprang side would have had to carry their own food and fuel on their backs, possibly from Raskam. Under the best conditions, the passage of the glaciers alone could not have occupied less than a week. I believe that the Saltoro pass was never used except as a short cut from Baltistan into Nubra. If a direct pass from Nubra to the Pamir formerly existed, it is almost inconceivable that Muhammed Haidar should not have crossed it in 1535, when the treachery of Rashid Sultan compelled him to seek safety in Badakshan, and when, in fact, he fled from Ladak by way of the Karakoram pass and Raskam. It should be noted that both Hayward and Gordon refer to an old pass leading from the head of the Kufelung glen into Nubra, necessarily *viâ* the Siachen glacier. On our side a great secondary glacier swept gently down from this very direction.

None of the trigonometrically fixed peaks of the G.T.S. were visible, and although I had carried my plane-table sketch down to this camp, so sceptical was I of its accuracy, owing to the many difficulties I had had to contend with, that I decided to start afresh with a new base-line on the approximately level surface of the main ice-stream. This was accomplished on June 17 with the indispensable assistance of Neve and Slingsby. From the two ends of this base I roughly sketched in the topography of the 25 miles of glacier in view, and took altitudes to the principal peaks. Meanwhile Slingsby despatched Gulab Khan with our two best Baltis down the glacier. They were absent over 13 hours. On their return Gulab Khan reported that they had descended for 7 or 8 miles, but had seen no indication of the termination of the glacier, and further that it showed no intention of turning to the east, but even turned still more to the south. They brought back a primula, a sedum, and a saxifrage, and reported having seen ibex on the east bank. They also said that the main surface stream was quite impassable a few miles below our camp.

Pyramidal ice-pinnacles as much as 3 feet high are a great feature of this glacier. The surface of the ice was also honeycombed to an extent I have never seen in any other mountain region. The hollows were round or oval, having a level bottom, floored with a sprinkling of stone fragments, varying in size from slaty slabs about 6 inches in diameter to fine grit, and covered by 1 to 6 inches of water. The edges rose steeply from the bottom in beautiful fluted cones to a height of from 6 to 18 inches. A spirited attempt has recently been made to classify as nieves penitentes all sorts of varieties of ice and snow pinnacles prevalent in the Karakoram, including even "glacier tables." I hardly think the position is tenable, because the genesis and composition of so many of these structures are so different to those of the well-known Andean formation. Hooker, in 1848, appears to have been the first to notice these cones in the Himalaya (*Himalayan Journals*, vol. 1, p. 252).

Owing to the numerous large secondary glaciers which join the trunk-stream on either hand, there are four moraines (possibly five) which may be termed medial moraines. Those on the right half of the glacier appeared to consist entirely of various granites, and are of a uniform light grey or brown colour. This was in accordance with our observations of the petrological character of that range of the Karakoram across which we had passed. But from the moraines on the left half of the glacier we obtained specimens of hornblende schist, mica schist, dark slate, and white or grey marbles of various kinds, some of the latter being of exceptionally good quality. Gulab Khan also brought back a beautiful fragment of alabaster from near the left edge of the glacier. Thus in marked contrast to the light greys and browns of the right moraines, those on the left presented a much darker hue, appearing almost black in contrast to the blocks of white marble scattered on the surface. The latter appear to be derived from the upper section of the central peaks, while the lower strata of the range appears to be of slate and dark schists. Altogether we seem justified in assuming that the valley is a tectonic one.

The huge wall of peaks * to the north-east was obviously of very great altitude, as Burrard had predicted. But it has been very truly said that the discovery of a new peak is of little interest or importance unless its actual height is ascertained, and I must therefore anticipate somewhat by giving the results of my measurements of the highest point in this new cluster, which I have named Teram Kangri. I got a good sight of it from the west end of my base-line, but by the time I got to work with the clinometer at the east end, the highest peak was in the clouds. I got another sight from the Saltoro pass on my return. I estimated it at the time as being over 25,000 feet; but when my observations were worked out at Dehra Dun, its altitude appeared to exceed that of Everest. This was too much for Colonel Burrard, in spite of his own prophecy. The angles which the peak subtended could not well be called in question, for the Indian Survey clinometer is a very simple instrument and quite easy to use. I tested it at Dehra Dun, observing to the neighbouring hills against another observer with a theodolite. But the determination of the exact location of the peak really depended on two rays only—those from the two ends of my 1000-yards base-line; for the third ray from the Saltoro pass was of little or no additional value. My distance from the peak was, therefore, quite likely to be in error, and, after consultation, I moved the highest peak 2 miles and the second highest 1 mile nearer to my observing-station. The result of this manœuvre may be tabulated as follows:—

Angle from station.	Distance from peak.	Altitude above station.	Altitude of observing station.	Observed altitude of peak.
10° 50′	12 miles	12,200 feet	16,000 feet	28,200 feet
4° 50′	20 „	9,150 „	18,200 „	27,350 „

It is to be noted that the value 18,200 feet given for the Saltoro pass is deduced from Watkin aneroid observations (*v. post*). The angle by clinometer from my base station gave to the pass a height of 18,780 feet. If the latter value be accepted, the value for the second observation would work out at 27,940 feet. On July 2, from the summit of the Rgyong La (18,700 feet), Slingsby and I saw to the northward a group of very lofty peaks, far overtopping the general level of the snowy ranges spread before us, which we identified as the Teram group. Owing to the anticipation of greater difficulties than we actually experienced, we had taken no coolies with us, and I had shirked carrying up either my large clinometer or my plane-table. Nor did I, indeed, expect to see these peaks, for I had not realized the probability of their extreme height. I had with me a small geological clinometer, with a swinging arm. For greater accuracy I rested this along the straight edge of my ice-axe, while Slingsby read the dial half a dozen times.

* The dip appeared to be towards the north-north-east.

We made the angle about 3° 40′. The Rgyong La is 33 miles from the peak according to my map. Were these figures correct, the peak would work out at something like 30,000 feet. But with such rough methods the probability of error becomes a certainty. Yet this observation, crude though it be, combined with the photograph of the group taken from the same spot and which I have shown on the screen this evening, tends to confirm my previous results. After full allowance has been made for a slight downward tilting of the camera (f.l. 118 mm.), the highest peak still appears to rise at an angle of at least 3° above the horizontal. This is equivalent to an altitude of about 27,700 feet. But considering that the discrepancies between the different observations are very considerable, I wished at first, for obvious reasons, to suppress the actual figures I obtained, and to content myself with saying that the peak was a very lofty one. I was subsequently advised to publish the figures for what they are worth, and to give the nominal value 27,610 feet to the peak; but it must be distinctly understood that the Survey can take no responsibility for this or any other of the results I am putting before you. They have, however, accepted my nomenclature, which is in conformity with the advice officially tendered to travellers by this Society. The Tibetan form Kangri, instead of the more correct Ladaki form Gangri, has been adopted for the sake of uniformity with modern usage, as in the case of Aling Kangri, Kulha Kangri, and so on.

I have thought it well to deal fully with my reasons for attributing so great a height to an unknown peak. Not since 1858 has a peak approaching this height been discovered. It is to be noted that, until last year *all* those mountains known to exceed 27,000 feet have been brought to light by the scientific operations of the Survey of India. If Teram Kangri attains such a height, it seems to me incredible that it can have eluded the theodolites of Montgomerie's surveyors. Yet at its feet winds one of the greatest glaciers in High Asia, unsuspected until last year. That Teram Kangri has been seen before, probably by Neve and Oliver from the Murgisthang saddle, and possibly by Ryall, I cannot doubt.* Hayward must have seen it from the north (*op. cit.*, p. 57). But its remote inaccessibility and the screen of high peaks west and south of it appear to have prevented its identification, though its existence was obviously suspected by Burrard.

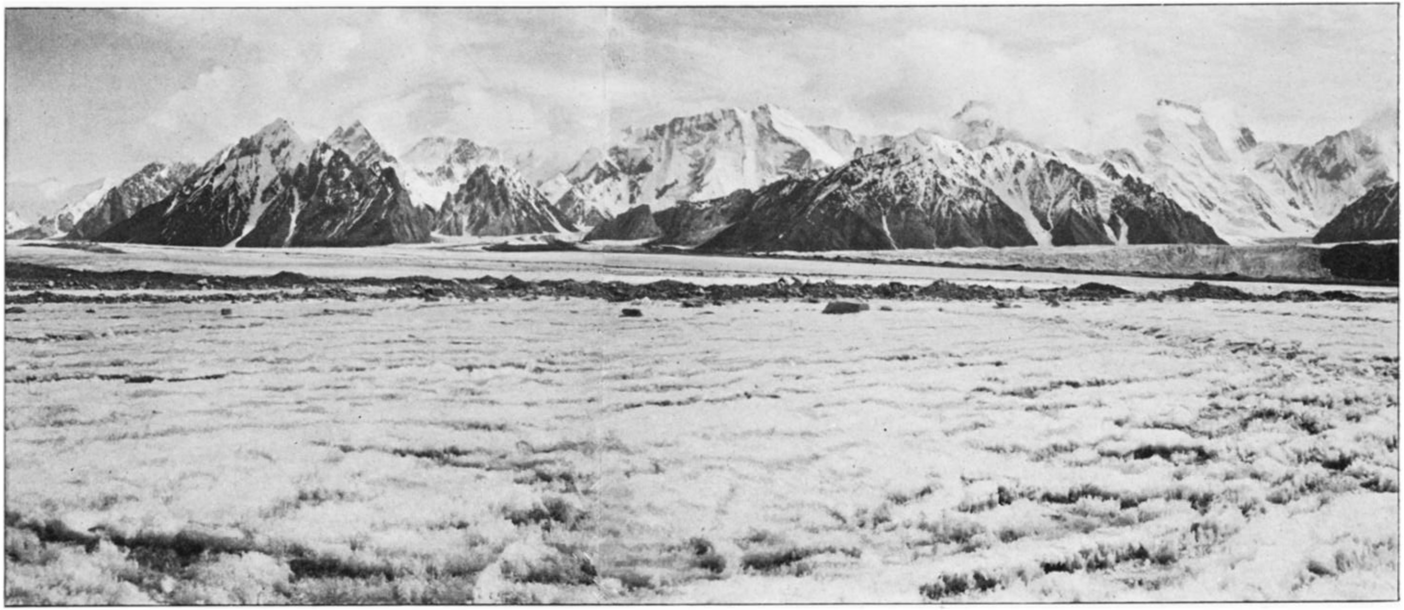
When I had first planned this expedition, my idea had been to force a pass over the range which has always been shown at the head of the Siachen glacier, from upper Nubra into the head of the Oprang valley, and endeavour to return from thence by the Saltoro pass. But Neve and Oliver had already attempted to reach the Siachen glacier, and they entertained the project of renewing their explorations there in the autumn of 1909. Though they offered to waive their prior claims in my

* Apparently also by Sir Martin Conway and Major the Hon. C. G. Bruce from Pioneer Peak.

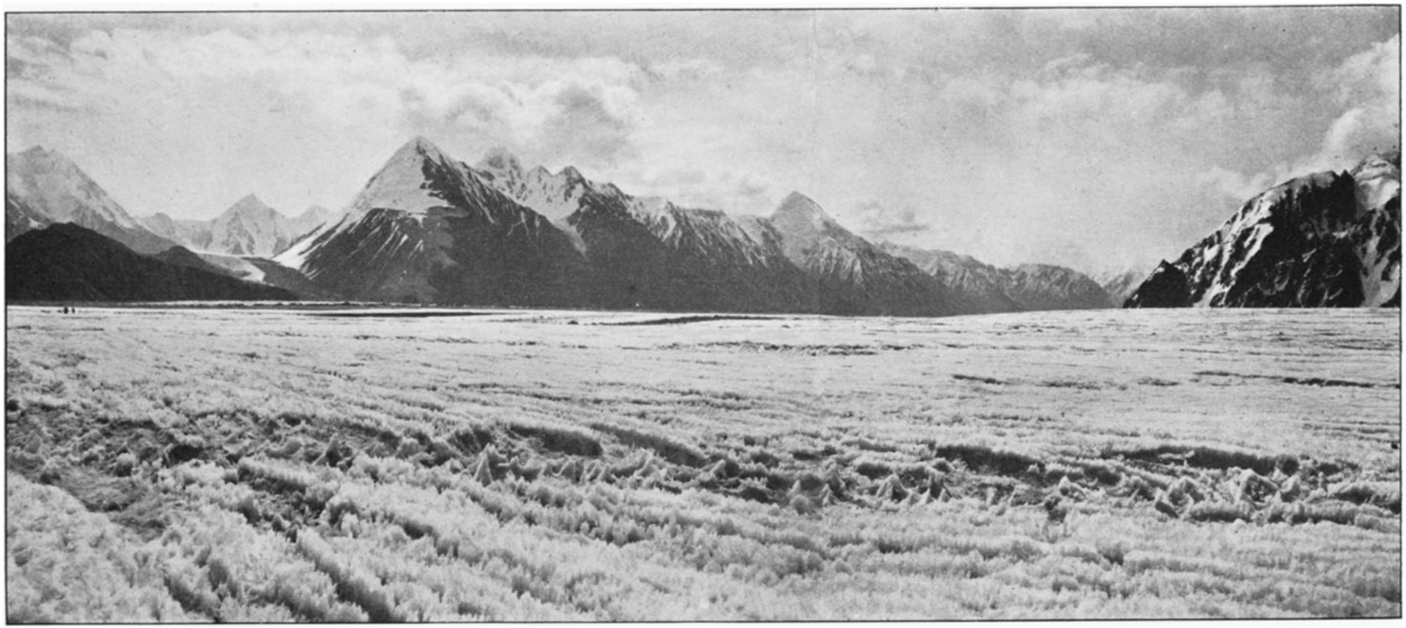
favour, I accepted their suggestion that Slingsby and I should attempt the Saltoro pass first. We hoped by this means to effect a practical junction of our routes, even if both parties were compelled merely to retrace their steps on the return journey. Neve and Oliver accepted the Survey map as essentially correct, regarding the Siachen basin. It will thus be seen that we were all thoroughly obsessed with the idea that there was a mountain barrier between our "Teram" glacier and the Siachen, and believed that, in spite of all appearances to the contrary, the outlet of our glacier must be towards Kufelung and the Yarkand river, an uninhabited region quite destitute of supplies. Under such circumstances, it seemed unfair to compel the coolies, already becoming alarmed, to continue down the glacier, and we decided, wrongly as it turned out, to recross the Saltoro pass back into Baltistan. Remembering our former difficulties, we realized that a heavy fall of snow would cut off our retreat, or at least retard it for more days than our supplies would hold out. So as the night of June 17–18 was clear and frosty, we decided to rush the pass while all was well, and at 5.20 a.m. on the 18th we started back, roping up before we left camp. The coolies went very well now that their faces were turned towards home, and, taking a much better line on the glacier, we regained the Saltoro pass at 10 a.m., having come very fast all the way. I set up the plane-table and clinometer again, but had no time for photography. Luckily, my head was aching sufficiently to enable me to dispense with lunch! On the far side the snow was already in bad condition, and the weather threatened a storm; but, by forcing the pace, we had the satisfaction of reaching our old camp at Naram in twelve hours from the start, where we much appreciated sleeping once more on solid earth. On the 19th we gave the coolies a day's rest at Naram. Neve botanized; Slingsby went off after a herd of ibex; and I went a few miles up the large secondary glacier, which joins the Bilafond opposite Naram and appears to rise in the snowfields of K_{12}, an elusive peak which I was never able to identify to my entire satisfaction. It snowed most of that afternoon and all the following night, rendering the descent of the moraines to Ghyari more exasperating than ever, and we felt we were well out of what might have been an awkward fix.

The task we now set ourselves was to find a pass over the head of one or other of the Saltoro group of glaciers which would lead us down directly into upper Nubra. The only known way into that valley would lead us back to Khapulu and up along the Shyok to its junction with the Nubra river, a very trying route at this time of year.

On June 23 we set out up the Chumik ("water-eye" = spring) glacier, camping at 15,500 feet. Its southern boundary is formed by a serrated wall of unscaleable peaks draped with traceries of fluted snow of indescribable beauty, but literally raining avalanches on to the glacier below. The rocks were composed of various granites, but



TERAM KANGRI ACROSS THE UPPER SIACHEN GLACIER.



LOOKING DOWN THE UPPER SIACHEN GLACIER.

from the middle moraine I obtained specimens of actinolite schist and a badly weathered dyke rock (? minette).

The character of the Chumik glacier was in general very similar to that of the Bilafond. The pass at its head was obviously much too steep for coolies, and greatly to Slingsby's disappointment we did not attempt it, but contented ourselves with mapping and photography. On our return journey to Ghyari (June 25), Slingsby and I reached a height of 17,150 feet on the steep ice-fall of the upper Chumik glacier north of our last camp. The danger of avalanches from the peaks above prevented our reaching its highest *névé*, but I have ventured to reduce its area very considerably on my map. Neve had now to return to Srinagar, and we parted at Goma on June 27 with mutual regrets. The influence of his reputation as a healer had been of the greatest use to us in our dealings with the Baltis. His skill in the operation for cataract, which he performs by the roadside with the greatest success, is an inestimable boon to these people. It was an honour to be associated with him in such work, in however slight a degree.

At Goma we heard that there was a tradition of a route into Chorbat (Shyok valley) over the head of the Chulung nala. But we decided first to thoroughly explore the Rgyong valley. We accordingly left Goma on June 29, and crossing the Saltoro river by a temporary and extremely rickety bridge, entered a peculiarly narrow and steep-sided defile, and ascended beside a series of waterfalls and cataracts. The gorge, as usual, opened out higher up, and the river wound broad and shallow over a gravel flood plain, cutting the bases of several *débris* fans.

Our camp (13,250 feet) was pitched among stunted willow, birch, and pencil cedar, below the first large glacier descending from the north. On later examination this proved to be in a state of active advance. It terminates in a perpendicular wall of ice, finely castellated at the two sides, and from which great blocks of ice constantly roll down into the scrub jungle at its foot. On June 30 we continued up the valley, reaching the main glacier after about an hour's walking. We found the snout about a mile below the point marked on the Survey. It had all the characteristics of active advance, but there was no observed advance of the snout between June 30 and July 3. We kept along the right edge of the glacier, making use of the lateral moraine as much as possible. As a rule, the glacier filled the nala from edge to edge, but occasionally we could travel in the hollow between the moraine and the valley wall. On one such spot (15,000 feet) we camped early in the afternoon to take shelter from an impending storm. We had had light snow squalls all day long. On July 1 we soon reached bare ice, where the going was easier. In two hours we reached the point (15,850 feet), where the glacier divides into two great arms. One flows from the two Survey peaks, 21,720 feet and 20,960 feet, to the south; and the other swept down from an invisible saddle to the north-east. The latter was obviously our goal, and we camped on the highest available spot (16,700 feet) on the right bank. Just above us we noticed an old native cairn. It was the highest spot on this trip at which we saw the little mouse-hare, a friendly beast, very aptly named *shippi*—"the whisperer."

Next morning, taking only two men with us, we started at 5.45 for the Rgyong La, as we named our hypothetical pass. We expected considerable difficulties, but except for some fatiguing step-cutting we raced up without a hitch, and reached the pass (18,700 feet) in very good time, at 8.40. The rocks of the crest are granite. To my great surprise we found the remains of a cairn on the summit, so that probably the pass has been crossed by natives. We looked down on to a feeder of the Siachen glacier of Nubra, but the descent is extremely steep, and we were not willing to risk the lives of our coolies by making them carry our heavy baggage down it. The panorama spread before us was a magnificent one. To the west we looked back over the mazes of the Rgyong glacier. To the south was a sea of magnificent peaks separating us from the Shyok valley. But it was a vista of distant snows, through a break in the hills to the north, that held our attention. There a group of four peaks far over-topped everything else in sight. We had no doubt that this was the massif north-east of our "Teram" glacier, but until this moment we had no idea of their commanding altitude. I took bearings to these peaks, and also to K_{19} and K_{32} of the Survey map. Presuming that these two latter identifications were correct, the observed position of Teram Kangri agrees with that shown on my map. It is extremely unlikely, for many reasons, that the high peaks we saw were any others than the Teram Kangri cluster. I have already detailed my attempt to measure the highest peak.

After spending an hour and three-quarters on the pass, we descended rapidly to our last camp, and striking it at once, the whole party started back down the glacier, reaching our first glacier camp (15,000 feet) easily by 5 p.m. On the way down we witnessed a fine glacier burst. It was heralded by a loud and prolonged roaring sound, quite unlike anything I have ever heard. We soon located it, bursting from a side glacier in a ravine high above the right bank of the main ice-stream. The whole hillside seemed to be moving, as a torrent of black muddy water rolled great masses of ice and rock down its bare slopes. We found our camping-place, a low sheltered spot beside the glacier, had been very nearly flooded by the torrent thus set loose. Next day we ascended a prominent spur (16,070 feet) to examine the great secondary glacier marked on the survey map as discharging into the Rgyong Valley on the north-east. But again, as with the corresponding branch of the Chumik, I was constrained to reduce its area very greatly. We marked our station with a large cairn, visible from the valley below. On July 4 we again reached Goma village.

The Chulung ("water-valley," or valley of streams) was now the only remaining terminal of the Saltoro valley system to be explored. We left Goma for the last time on July 6. There was the usual steep rise beside a waterfall from the level of the Saltoro river into the Chulung gorge, where the Chulung river has cut out a fine cañon. The right bank of the cañon is of granite, and the left of slaty schists, and lying beside the torrent are boulders of beautiful green serpentinous and mica schists. The latter probably came from the ridges to the south-west, and are no doubt ice-borne. Several secondary glaciers are visible in ravines on either side.

The magnificent granite spire of Gharkun (17,060 feet) was constantly in view as we ascended the valley. A second steep rise brought us into the open upper valley. We camped at Malla Mani, the highest hamlet (13,400 feet). It is, of course, only occupied during the summer. The grazing is good, but there are no shrubs at this altitude, and fuel has to be fetched up from lower down the valley. Marmots and ibex are numerous.

After three days' rain the weather cleared, and we started on up the nala with 28 coolies. The Bawoni glacier, advancing from the south-west, has descended right into the valley, and abuts against the right bank of the nala a little below the Beltus glacier, where a bed of phyllite underlies the prevalent granites. At no other spot did we see such a profusion of flowers—acres of ground were completely carpeted with eidelweiss, over which flew flocks of buntings. We next passed along the edge of an old lake-bed through which the stream wound in several channels to force its way eventually under the ice-barrier of the Bawoni glacier. Snow fell heavily, and we camped at noon (14,300 feet) below the granite walls of Gharkun. Opposite our camp a small but very beautiful glacier descended almost to the valley floor, ending in green cliffs of ice.

Slingsby discovered a fine glacier pass at the head of the main Chulung glacier which would obviously lead us over into Chorbat, and on July 10 led me and his two orderlies from our camp to the summit (18,300 feet) in 5 hours 40 minutes. From the pass a small portion of the Teram Kangri group was visible to the north, but at this distance (45 miles), and with so limited a view of the range, I was unable to identify the actual peaks in sight. To the south we looked across to the ranges beyond the Shyok river, and beyond these thought we recognized the two great peaks of Nun Kun. The descent on the south side of the pass, which we named the Chulung La, led over steep rolling *névés* and seemed practicable for laden coolies. We therefore decided to attempt its passage with our entire caravan. While waiting for fine weather and to collect food for the coolies, I worked a good deal at my map, and find a note in my diary under July 11, to the effect that our Teram glacier seems likely to turn out to be the Siachen.

On July 12 we got under way at 7 a.m. with thirty coolies led by Abdal Kerim, secretly hoping to cross the pass that day. As usual the coolies lost a lot of time by sticking to the lateral moraines instead of taking to bare ice. By noon we reached the highest possible camping-place, which looked so desolate and forbidding that the coolies were easily persuaded to try the pass that day. I went on ahead with Ahmedu, the only decent Kashmiri of this class we had encountered, in the hope of doing some more plane-tabling, but I did not reach the pass till 2.45 p.m., by which time clouds greatly interfered with my work.

On Slingsby and his two orderlies, ably supported by Abdal Kerim, fell the trying task of assisting and persuading the coolies to face the steep snow-slopes, now softened by the heat of the day. I think very few men would have succeeded as he did. By 4 p.m. all five parties were close to the pass, and I started down to mark the route for the descent. The snow was very soft, and the glacier soon degenerated into a maze of crevasses concealed by a most deceptive covering of new snow, through which the heavily laden coolies were constantly breaking. I quite expected that we should have to spend the night upon the Korisa glacier, but just as it got dark Slingsby found a way off the ice through the difficult seracs on the right bank. We ourselves waited till the last coolie had reached solid ground, and quitted the ice at 8.45 p.m. (16,100 feet).

Our arrival at the hamlet of Korisa next morning created great surprise among the shepherds there. The men are of the Ladaki type, but Mussulman and not Bhuddist. After a long walk we dropped down a deep descent into Chulunka village (9350 feet) on the Shyok river, along the right bank of which we were to travel 50 miles. Between Siksa of Chorbat, and Thirit of Nubra, a distance of 80 miles, the Shyok is unbridged, but it is possible to cross on zaks where the latter opens out opposite Deskit, just below the entrance of the Nubra river.

The track is extremely bad between Chulunka and Biagdangdo, and the coolies were unable to carry their loads across one particularly awkward parri. Here we took two hours to make 300 yards, and nearly lost a coolie, who was hit on the head by a falling stone. Attar Khan caught him as he fell, or he would have dropped straight into the Shyok, roaring in full flood below, The chief villages are all on the northern bank, where alluvial fans are irrigated by means of the lateral streams descending from the glaciers to the north. Barley, buckwheat, and apricots are the chief produce.

At Biagdangdo we left the river-bank to visit Waris, reaching the first Buddhists at the farm and chorten of Zdongpolas, 12,494 feet, for we now enter Lower Nubra. Here we saw shapu (*Ovis vignei*); this is possibly the first record of its occurrence north of the Shyok; their ancestors probably crossed during some very hard winter. Continued bad weather prevented us from attempting to find a pass from the Thusa glaciers into Upper Nubra, and on July 20 we descended again into the Shyok valley. On this day our route lay along the Chunik La ridge past the "La Chunik Pole, 13,470 feet" of the Survey. From this point the view up and down the wild Shyok river hemmed in on either side by mile after mile of gaunt brown crag, is indescribably grand, its unrelieved and elemental savagery producing in an unusual degree a feeling of exaltation and intense remoteness from humanity.

Beside the Pastan stream we encountered deposits of boulders and gravel cemented together with fine hard silicious mud. These beds were obviously quite different to the fluviatile deposits we had seen high above the Indus when approaching Kharmang. The larger boulders are angular or faceted. Some of the largest capping typical earth-pillars. The commonest rocks represented are hornblende and other granites, but I also found conglomerate, calcareous schists, quartz with chrysocolla, calcite with a little malachite, and red jasper. A careful search yielded no trace of shells or other organic remains. The bed rock forming the sides of the nala turned out to be metamorphic, a highly silicious greenish limestone. These beds must be of glacial origin. We passed other deposits, apparently quite similar, further up the Shyok valley. In the Nubra valley they are never out of sight. They are seen hanging like martins' nests in sheltered spots to the bare rocks of the slopes above the river, and about 1000 feet above its present level. In the Upper Nubra valley itself they were occasionally so continuous on both sides of the nala as to make me think they were the actual remnants of the lateral moraines of the glacier which formerly filled that valley.

We struck the Shyok river again just as it gathers itself together to dash through a very precipitous defile cut in the living rock. The narrowed waters sweep over an obstructing ledge, a portion of which, even at this time of flood, formed an islet in mid-stream. From this point onwards to the junction of the Nubra with the Shyok the valley gradually widens out, until at Deskit the river-channels spread themselves over a breadth of 2 miles. Horizontal beds of fine gravel and sand, especially on the south bank of the river, appeared to point to a former lake-like expansion of the river before the defile was sufficiently deeply eroded to carry off the full volume of water. Several curved bays in the wide flood-plain were covered with sand-dunes on which a scanty growth of tamarisk maintained a precarious foothold. Beyond Mondari the valley presents a wide open prospect which was most pleasing to us after the confined granite trenches of the Saltoro region. Great bushes of wild lavender, with a constant succession of Buddhist chortens and mendongs, added to the picturesqueness of the scene. The banks are quite arid, except where irrigation is possible; but beside the river are dense jungles of amber-berried hippophæ full of small birds, chakor, and hares.

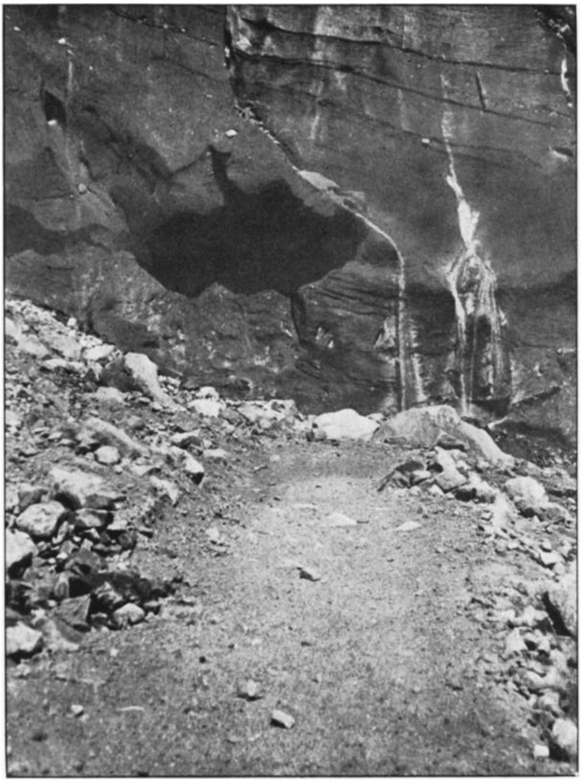
On July 22 we made a twelve-hour march from Mondari to Charasa, rounding the bold rocky promontory, at the foot of which the Nubra river enters the Shyok at an unusually acute angle. Taking the average courses of these two rivers, the general angle of junction is 50°. The angle at the great south-to-west bend of the Shyok, 50 miles further upstream, is also acute, being about 60°. It is evident that the valleys of the Nubra and the Shyok, like the Indus valley, are tectonic. Drew observes that the rocks on the east side of the Nubra are of light brown granite, while those on the west are of a different and much darker crystalline rock. Glaciers have left their marks in these valleys, but the rivers were antecedent.

As we approached the Nubra-Shyok junction at the steep corner mentioned above, we continually passed beds of relatively recent moraine stuff with perched blocks. The solid rock for hundreds of feet above the river was polished, rounded, and scratched at this point of pressure. But the very convexity of their form shows how relatively slight has been the erosion. The striæ showed that the glacier had swung round the corner into the Shyok valley without any alteration of level, just as the river does now. This more than confirms Drew's surmise that the great Nubra glacier must have extended as far as the Shyok valley. On the floor of the Nubra valley itself are many islands of hard rock ("metamorphosed slate," Drew) perfectly worn into polished *roches moutonées*, which have resisted through unknown ages the passage over them of a glacier at least 1000 feet in depth. Whymper pointed out long ago that *roches moutonées* cannot be signs of great erosion, for *flat* and not convex forms are thereby produced. Drew gives the glacier a depth of 4000 feet, but I think some of his arguments can be accounted for by the action of the very large secondary glaciers which must have joined the trunk-stream from the lofty ranges on either side of the valley. The chief lateral glens which I saw or visited may all be described as hanging valleys, their lowest sections having been cut down by water now given a free hand by the retreat of the ice. As a result, the mouths of great lateral valleys such as Chamshing, Popache, and Thalambuti appear quite insignificant when seen from the main valley.

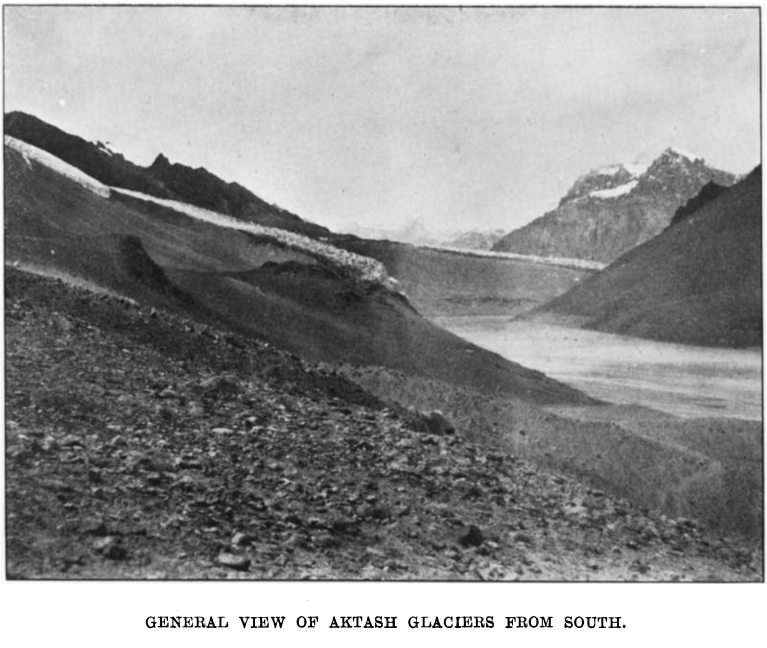
Charasa is situated on one of the ice-worn rock islands I have just mentioned. It is the ancient capital of Nubra, and probably that "Mutadar" which Muhammad Haidar captured with some difficulty from Bur Kapa (? Bagra Mir-Francke) in 1532. Here we unsuccessfully attempted to ford the Nubra river. Its very size might have led us to expect that the Siachen glacier was much larger than is shown on the Survey map. For though the Nubra river has a course of only 45 miles, and receives no tributaries of any importance, the water was sweeping down with a very rapid current through numerous channels covering about a mile in width, and in some of these with a minimum

TERAM KANGRI FROM THE RGYONG LA.

LOOKING UP THE LOWER SIACHEN GLACIER.



AKTASH GLACIER LYING ACROSS ROAD.



GENERAL VIEW OF AKTASH GLACIERS FROM SOUTH.

depth of over 4 feet. It was the strength of the current that really stopped us. However, we managed to cross the river just below Kubet on July 25. Fortunately for us some fifty ponies and yaks belonging to the Nubra people were waiting to cross to Panamik, the highest village of any importance in the valley, where they would be hired out to the Yarkandi and Khotani merchants. We entered the river at noon, and the passage of the different channels occupied three hours. We reached the eastern bank just below the village of Panamik, and about 2 miles lower down than the spot where we first took to the water. One pony was swept away, but managed to make the western bank a mile or so lower down. We were most ably led by the Trampa of Kubet, and a most resolute lama, against whose spells the demons of the waters were powerless. Oliver had most kindly sent news from Leh that we were coming from the west, and had given orders that we were to receive all possible assistance.

The upper Nubra valley was visited in 1821 by Moorcroft, that extraordinary man whose end is still shrouded in mystery; by Vigne about 1835; by Thomson, the first European to reach the Karakoram pass, and by Henry Strachey, in 1848; and later by Drew, whose general description of the valley has never since been improved upon. I will, therefore, only refer to one excursion that we made from Panamik. This was to the glaciers under the great Nubra-Shyok peak 25,170 of the Survey, the Changlung Gipfel of Hermann Schlagintweit. We left most of our baggage at Panamik, and on July 28 entered the Pokachu ravine, or Popache lungma as it is locally called. As usual, the comparatively broad open upper valley is reached through a deeply cut rocky gorge, through which the glacier torrent tumbles in a series of tumultuous cascades. This defile is quite impassable for baggage animals; indeed, it is only just practicable for laden coolies. Instead of a more or less even valley-slope from the water-parting to the Nubra river, we have a hanging valley with a step-like descent, each step representing, as I take it, different levels, and possibly different cycles of glaciation. The head of the valley is divided into two main branches, each holding a large glacier; these sweep round a salient spur, behind which, and at the foot of the culminating peak of the range, their névés are almost in contact, the result being a nunatak. Unfortunately, I selected the northerly of these two glens, and beside its glacier (16,500 feet) we camped on July 29. Continuing up the glacier next day, we camped on bare moraine at 18,200 feet. Here the weather stepped in, snow falling steadily for twenty-four hours, and we were finally compelled to beat a retreat to Panamik on August 1. The highest peaks, best approached from the south-west, presented some steep faces of exposed rock. This was very light in colour, and possibly composed of calcite or marble. On the moraines of the southern glacier I collected specimens of white and green marble, very similar to the specimens obtained from the upper Siachen ("Teram") glacier. The valley visited by Neve, Millais, and Tynedale-Biscoe in 1899, from the uncharted glacier at the head of which they ascended Panamik peak, 21,000 feet, lies between the Popache and Chamshing ravines directly behind the village of Panamik (Neve's 'Picturesque Kashmir,' p. 140). I have indicated this glacier on my map.

The weather had been most disappointing. Nubra has often been indicated as a suitable field for high mountaineering, owing to its scanty rainfall. This may be relatively true, but from July 24 to September 12 rain fell almost every day at Panamik, and, since fresh snow was visible on the lower hills almost daily, the snowfall above the line of permanent snow must have been considerable. We were first told that this was unprecedented, and then that it had occurred only during the last fifteen years. But the same story was told to Moorcroft in 1821. I feel certain that the weather between mid-July and mid-September is just as bad as in the western Karakoram, and that June is the most suitable month for high mountaineering. Miss Duncan notes that in 1904 rain fell at Khapalu throughout August.

On August 4, Slingsby left me to rejoin his regiment. My debts to him during our joint expedition are quite beyond acknowledgment. I parted with Gulab Khan and Attar Khan with feelings of sincere regret. It must be the strong element of personal government which lies at the root of all military organization, which makes the Indian sepoy so very satisfactory to deal with.

I had obtained leave to cross the Karakoram pass and search in the direction of Kufelang for the lower end of the "Teram" glacier. But at Panamik I received letters both from Sir Francis Younghusband and Colonel Burrard, each independently assuring me that it must have been some upper reach of the Siachen glacier which we had found on the further side of the Saltoro pass. Appreciating the weight of advice from such sources, advice for which I can never be sufficiently grateful, I decided to attempt to prove or disprove the theory before starting on what might have been, and in the circumstances would have been, an expensive wild-goose chase.

On August 12 I was joined by Captain D. G. Oliver, British Joint Commissioner for Ladak. In 1908, in company with Arthur Neve, he had attempted to reach the Siachen glacier at the head of the Nubra valley. But they had been defeated by the size of the river. He considered that the water was too high for us at the present time, and I therefore spent a month with him in working out some problems connected with the trade-route to Yarkand, which was under his control. I hope to deal with his journey across the Kumdan glaciers to the source of the Shyok in a future number of our *Journal*.

On our return to Panamik in September, Oliver considered that the Nubra river had fallen sufficiently to enable us to reach the Siachen glacier. Owing to the steep cliffs of granite that hem it in on either bank, and against the foot of which it sweeps at several points, the Nubra river has to be forded several times. We left on September 13 with a small pony-caravan. Tsering Spalzung, the headman of Panamik, and the most water-wise man in the valley, was our leader; Satan was the name of his most able assistant. At every doubtful point, and especially where quicksands were feared, we all awaited their verdict before trying a ford. We first crossed the river from Takshay on the east to Ayi on the west bank. The mendongs by the roadside now consist largely of waterworn slabs of white marble. A few miles above Aranu, and marking a just perceptible step in the old valley floor, we passed over the remnants of a recent moraine. It was formed around and beside the snout of the Siachen glacier during a temporary cessation of retreat opposite the Thalam-buti spur. We reached Gonpo (gom-pa—a monastery—10,900 feet) on September 14. Here there is a red-cap monastery belonging to Himis. High above the monastery to the south-west, suspended above magnificent cliffs of granite, towers a spire of perfect snow—Shelma, "The Crystal One" (Francke)—an object of veneration to these humble folk. The monks turned out to receive Oliver, and we entered camp to the impressive deep rolling boom of their drums, the long rending blare of six-foot trumpets, and the clashing of cymbals, a music perfectly harmonizing with the wild setting of the scene.

Beyond Gonpo the valley is uninhabited, though a plot of ground at Warshi is cultivated by the lamas every three years. A mile above the monastery the river sweeps into the base of the cliffs on the right bank, and it is necessary to ford across to the left bank. It was here that Oliver and Neve were stopped in 1908, but we found it only up to our girths on the morning of September 15. The Shosholing glacier tumbles down a narrow, wedge-shaped ravine to within 1 mile of the Nubra river, and we were told by the lamas that it had advanced rapidly during the last three years.

On September 16 we again forded the river, the water coming up to our saddle-flaps, and the current very strong. That afternoon we reached the foot of the Siachen glacier, camping beside a small jungle of autumn tinted willow trees and red dog-roses. I make the height of our camp, which was level with the snout of the glacier, 11,600 feet. The official Gazetteer of Ladak gives 11,700 feet for the snout of the glacier. If these two figures are accurate, they would represent an advance of the ice (since 1862) about commensurate with that which I have shown on my map.

Though this spot has certainly been reached by sportsmen, the glacier, so far as I can ascertain, has been previously visited only by Henry Strachey. In October, 1848, he ascended the glacier for two miles; he was unable to see the head of either of the two branches into which it divides about 5 miles from the snout. He remarks upon the even level maintained by the glacier, the abrupt contact of the ice with its confining walls of granite, the unusually large amount of bare ice exposed by the moraines, and the excessive crevassation of the glacier, rendering its passage very difficult and toilsome. He concludes a description, upon which I cannot improve, with the characteristically modest remark that the understanding of glacial phenomena requires much time, study, and experience (*op. cit.*).* The survey name, Saichar, is more properly written Sia-chen (rose-place). It is said to be derived from the clumps of rose-bushes below a patch of grazing-ground on the right bank of the glacier, which have now been destroyed by advance of the ice.

We started up the glacier on September 17, taking thirteen coolies with us. We kept to the left side of the glacier, making very slow progress, as we were unable to leave the ice, and had often to cut steps up and down awkward seracs between the numerous crevasses. The first feeder on the western side might easily be passed unnoticed, for it is so smooth and is covered with such finely divided moraine stuff, that only strong glasses revealed the ice beneath. In the centre of the main glacier are numerous ice-cones, brilliantly white, and of such size and symmetry as I have only seen on the Kumdan glaciers of the upper Shyok. After about five hours we came to a deep steep-sided level-floored nala entering from the north-west. I estimated that its bed was about 400 feet below the level of the ice on which we stood.

There was a small milky stream winding along its sandy bed; it was a typical "glacial trench," but no glacier was visible in the 4 or 5 miles we could see of it. The Siachen glacier had literally overflowed or bulged into its mouth, presenting a most unusual appearance, for the floor of the glen is so level, that when facing up it we could easily imagine that we were standing on the snout of a glacier which terminated here in the usual manner. I imagine that a small catchment area, combined with the south-west aspect of its enormous granite walls, render the maintenance of a glacier impossible in this glen under present conditions, but the absence of *débris* fans showed that it had only recently been evacuated. The fact that its floor was on a level with that of the main valley shows that the huge trunk-stream of the great Siachen glacier had effected no "over-deepening" of its own bed. Owing to the chaotic jumble of seracs at this point, it was impossible to reach the valley floor for closer examination, and indeed it was some time before we found a route by which we could continue our way up the main Siachen glacier.

We eventually camped on a small grassy slope on the left bank of the glacier (13,000 feet), having come about 6 miles up the glacier in

* I have since had the privilege of discussing this expedition with Colonel Henry Strachey, whose memory, at ninety-five years of age, is happily still quite clear, and whose interest in exploration is still as keen as when he solved the problem of Mansarowar in 1846.

seven hours' actual walking. This is the best place for a first camp for any one proceeding up the glacier. Water is hard to get, but there is plenty of dead juniper for fuel. Unfortunately, Oliver had received an official message which compelled him to turn back at once, and he left early the following morning. It was very hard lines, as he had made the whole of the arrangements for this trip, and indeed, without his assistance, it is improbable that I should have been able to get any transport to follow me beyond Gonpo.

On September 18 I started on alone with Ahmadu, prepared to sleep out if necessary. The right moraines were pale grey, obviously of granite, while the left moraines consisted of black schists with slate, limestones, and various marbles. I now felt practically certain that it was the upper portion of this, the Siachen glacier, which we had reached after crossing the Saltoro pass in June. After two hours' hard walking I reached the point where the glacier makes its second great bend, sweeping down from the north-east through a steep-sided gorge about a mile in breadth, distinctly narrower than at any other part of its length. This gorge is quite invisible from below, and the idea that the Siachen glacier was bounded by a great mountain wall at this point, as shown on the Survey, on Thomson's, and on Strachey's maps, was quite a natural supposition under the circumstances.

With some difficulty I got off the glacier on to solid ground on its left bank. The ice rose 200 to 300 feet above me as I stood in the trough at its side. A steep climb of 1000 feet landed me at 12.15 on a narrow ridge (14,300 feet), from whence I had a magnificent view up the glacier. This point is about 10 miles from the snout of the Siachen glacier, and on it we erected a cairn which is visible from the glacier below. Directly on the further side of the ridge was the peculiar empty glen I have already described. Up to this point the cliffs of the left bank appeared to consist exclusively of granite; further up the glacier, but only on the left bank, I could see what I took for beds of black schist. Though I could not, of course, see the broad upper reach of the glacier on which I had camped with Neve and Slingsby three months previously, I think I can safely say that their continuity is established. It will be seen that the identical peaks on the true right bank of the glacier occur in both the last photograph taken looking down the "Teram" glacier, and in that taken from my last point of observation looking up the lower Siachen glacier.

This glacier appears to be not less than 45 miles in length, and according to Burrard and Hayden (*op. cit.*, p. 194), is the largest in the Himalaya or Karakoram systems, if not in the world, the polar and sub-polar regions excepted. Just as the Biafo glacier may be regarded as the complement of the Hispar, so may the Siachen be represented as the complement of the Baltoro. That it has escaped detection for so long is due to the difficulties of access, difficulties which must be my excuse for the numerous imperfections of the preliminary survey which I have presented to you. Whatever the real height of Teram Kangri may be, my observations fulfil Burrard's remarkable prophecy, while Younghusband's views as to the northward extension of the Indo-Turkestan water-parting have been definitely established. H.R.H. the Duke of the Abruzzi has made the startling discovery that Conway's Broad peak attains an altitude of 27,132 feet. Also that both this peak and the four Gusherbrums are composed of marbles and conglomerates. The massif of Teram Kangri is a continuation of this range; its base appears to consist of schists and slates, and its peaks of marbles and calcites. There are indications that the same formation occurs in the Nubra-Shyok peaks; certainly the high peaks in the range south of the Depsang plains, which continues south-eastwards for an unknown distance some few miles back from the left bank of the Shyok river, consist chiefly of calcite. It would, therefore, appear that at least half of the main line of elevation of the Karakoram, the second highest range in the world, must be coincident with an axis of limestone.

NOTE.

The words "right" and "left" are always used in their strict orographical sense in this paper.

The map is based on the fixed points of the Survey of India. Much of the southern and eastern portions of it must be regarded merely as a route-sketch based directly upon the G.T.S. atlas sheets. The Bilafond-Chumik and Rgyari basins are from a plane-table sketch, on the scale of 2 miles to 1 inch. The depth and narrowness of the glacier valleys rendered the identification of the trigonometrical points a matter of great difficulty. When possible, I oriented my table by cutting in from three such points, but had frequently to fall back on secondary points or stations which I had fixed myself, and was sometimes compelled to rely on the box compass. Occasionally I made use of a prismatic compass. The sketch of the upper Siachen basin, and the position of the peaks around it depend on a base of 1000 yards measured on the level glacier. This was effected by means of carefully measured lengths of alpine rope, checked occasionally by a 50-feet steel tape. An allowance of 2 per cent. was made for sagging. The measurement is, of course, a rough one, but was made as carefully as possible under the circumstances. From the two ends of this base the peaks given in the opposite table were fixed.

A fairly good junction of the different sheets was effected at the Saltoro pass (N. 35° 23′ 30″, E. 76° 56′ 30″) and on the lower Siachen glacier. On the north-west my work, so far as it goes, is in full accord with Younghusband's. Colonel Burrard very kindly had an outline map on the scale of 4 miles to 1 inch made from my material. I have worked this up with the help of photographs, and it forms the basis of the map accompanying this paper. Sir Francis Younghusband's route on the Oprang glaciers has been re-plotted from his field-books. His route from Raskam by the Aghil pass is from published maps. Hayward's route is taken from his map in *J.R.G.S.*, vol. 40. The area thus enclosed has never been surveyed, and its delineation is therefore hypothetical. The line of peaks on the water-parting at the head of the Baltoro glacier is taken by permission from the new map by H.R.H. the Duke of the Abruzzi.

The heights of passes and camps placed in brackets in the text have been fixed from Watkin aneroid and hypsometer observations calculated from Leh Observatory.

These have been deduced by the Indian Meteorological Department by the kindness of Dr. Gilbert Walker, F.R.S. They are unusually consistent, but I found that the aneroid gave results from 350 feet to 720 feet (average, 530 feet) below those obtained by the hypsometer. This difference I have halved, and the responsibility for the actual figures given is mine. The heights of the passes, deduced only from aneroid observations, are probably too low.

Temporary sign and name.	Observed alt.	No. of rays for position.	No. of rays for alt.	Lat. N. approximate.	Long. E. approximate.
				° ′ ″	° ′ ″
L_1 Bilafond peak ...	22,200	2*	2	35 22 0	76 56 30
L_2 "Tent peak" ...	—	2*	0	27 0	57 40
L_3 "Cornice peak" ...	22,140	2	2	34 0	53 30
L_4	22,400	2	1	38 10	49 35
L_5 "Spire"	21,030	2	2	38 40	55 0
L_6 "Slate peak" ...	24,530	2	1	38 10	77 1 0
L_7	26,980	2	1	39 30	5 0
L_8 Teram Kangri ...	27,610	2*	1†	38 30	7 30
L_9	25,940	2*	2†	36 30	7 50
L_{11}	—	2	0	31 25	20 0
L_{12} "Cone"	—	2	0	28 0	15 0
L_{13} "Snow dome" ...	—	2	0	21 0	12 0
L_{14}	21,010	2	1	26 0	2 0

The rock specimens are in the museum of the Geological Survey at Calcutta, and have been very kindly identified for me by the Curator, as I have no knowledge of petrology.

APPENDIX.

Notes on the Glaciers of the Upper Shyok Valley.

Caravans travelling from Leh to the Karakoram pass have a choice of two possible routes. They may cross the Khardong pass directly behind Leh, and travelling up the valley of Upper Nubra, cross the Sasir pass into the highest reach of the Shyok valley; this is the present summer route, and along it, at great labour and expense, a pony track has been constructed by the Government of India. Or they may cross the Digar pass east of Leh, and march direct up the whole of the Upper Shyok valley; although no road has been constructed along this route, it is still used during the winter months, when the water of the Shyok river is sufficiently low to permit of its being forded without danger.

Both routes will approximately meet below the eastern foot of the Sasir pass. Here, again, there may be a choice of routes. The present road leads eastward to Murgo, and then northward by the difficult gorges of the Kizil Su to the Depsang plains and so to the Karakoram pass. But the natural route continues straight on beside the Shyok river to the small plain of Yapchan below the great Remo glaciers, where the Shyok river is left for the Chipchak or Tsaka ("salty") Chu which leads eastward over easy ground to the Karakoram pass. This last section of the Shyok valley, which would otherwise be the natural route, is now closed by the advance of the Kumdan glaciers, which, rising in the neighbourhood of peak K_{32} of the G.T.S. sheet 44A South-East, flow into the main valley at right angles to its course.

These glaciers have been named from Turki sources by Captain D. G. Oliver, the present British Joint Commissioner for Ladak, whose nomenclature is followed in these notes. The first is the Kichik (little) Aktash; the second is the Aktash

* Third rays from Saltoro pass; good for L_1 and L_2; no additional value for L_8 or L_9.

† Additional ray from Saltoro pass.

(white rock), so named from an outcrop of marble near its snout; the third is the Kichik Kumdan; and the fourth the Chong (great) Kumdan.

During their minor cycles of advance, one or more of these glaciers have on different occasions thrust their snouts right across the course of the Shyok river, only to be stopped by the great cliffs on its left bank. By the making and breaking of these dams of living ice, the Shyok valley has been the scene of many disastrous inundations, the suddenness of such cataclysms entailing much loss of life in the riverine villages of Lower Nubra and Chorbat.

The great Indus floods of 1841, 1858, and 1865 have been frequently attributed to this cause; but it is now well known that the first was caused by a landslip at Gor, below Bunji, that the second originated near Hunza, and the third near Gilgit.

I believe there is no other minor problem connected with the ranges of High Asia concerning which a greater confusion of ideas has prevailed in the past, and even, I dare say, at the present time. The fact that early writers of the time of Moorcroft and Vigne invariably write of the *Shyok* river as rising in a lake which they name the *Nubra* Tso, but which they correctly place on their maps in the neighbourhood of Yapchan, has, I believe, been a stumbling-block to later writers. Again, the closing of the first or lower portion of the Shyok valley route by the normal summer flood has been confounded with the blocking of the second or Kumdan section of that route by glacier advance. This advance again, instead of being attributed to normal periodic variations, has been accounted for by the wildest theories. The glaciers have been said to have broken their backs and suddenly slid down their respective valleys into the river, no particular cause being assigned for such extraordinary behaviour. Even the rapid advance of the Upper Aktash glacier during the winter of 1902–3 is paralleled, if not exceeded, by the advance of such glaciers as the Yengutsa and Hassanabad glaciers of Hunza ('Records Geological Survey of India,' vol. **35**, p. 134).

I have endeavoured to sift the historical evidence supplied by writers of last century. The chief authorities are: Elphinstone's 'Kingdom of Cabul' (see under Mir Izzet Ullah); Vigne's 'Travels in Kashmir' (vol. **2**, p. 362); Cunningham's 'Ladak' (p. 154); Thomson's 'Travels in Tibet' (pp. 200, 438); Henry Strachey's 'Physical Geography of Western Tibet' (p. 55); Shaw's 'High Tartary' (p. 432); Drew's 'Jummoo and Kashmir' (p. 414); Gordon's 'Roof of the World' (chap. ii. and five illustrations); Bellew's 'Kashmir and Kashgar' (p. 161). Strachey obtained evidence of a big flood about 1780. In 1812, and probably earlier, the Kumdan route was open and remained so till about 1824, some time after which date it was closed by glacier advance. In 1835 a most disastrous flood occurred, followed by smaller ones in 1839 and 1842. In August, 1848, Thomson found the snouts of the Aktash and Kichik Kumdan extending into, and even partly across, the river, his onward path being thereby completely barred. He crossed the Aktash glacier a long way above its snout on this occasion. He either did not see or more probably did not recognize, the Chong Kumdan glacier. It is more covered by moraine than any of the others. This region appears to have been surveyed by E. C. Ryall in 1862; the Aktash glacier is marked one mile, and the Kichik Kumdan half a mile, back from the river. The Chong Kumdan is shown, and labelled as closing the road; but this is probably a later addition to the map, for W. H. Johnson returned from Ilchi by this route in 1865, and in July, 1869, on his return from Kashgaria, Shaw also followed it. The projecting snout of the Chong Kumdan glacier compelled the latter traveller to ford the Shyok, and at this point he nearly lost two of his horses in a quicksand. Lower down he found that the Kichik Kumdan had completely blocked the road, though one of his guides had passed that way only three months before. The glacier had advanced right up to the cliffs, the river forcing its way through a tunnel in the ice. He had to abandon his baggage, and, sending his horses back to make the round by the Depsang plains and Murgo, he crossed the glacier on foot with two men. On the further side he had a narrow escape from drowning at another ford. On the third day he forced his way over the Sasir pass, reaching Upper Nubra in an exhausted condition. In October, 1873, Gordon and other members of the Kashgar Mission easily made their way round the snouts of the Kichik and Chong Kumdan glaciers. He gives pictures of both. He does not mention the Aktash glaciers, which presumably had not approached the river-bed. A short time afterwards W. H. Johnson, then Governor of Ladak, returned down this route to see if a road could be constructed along it. It was considered too expensive, but it appears that the ice was not too far advanced to render such a project by any means impossible.

Captain Oliver has supplied me with the following more recent information. Probably the last European caravan to traverse this route was that of Messrs. Church and Phelps, about 1894. About 1899 the then Joint Commissioner commenced building a road along this route; it was carried beyond the present site of the Aktash glacier, but progress was subsequently arrested by the advance of the Kichik Kumdan. Until the winter of 1902–3 traders continued to make use of the Kumdan route during the cold weather, passing round the snouts of the two Kumdan glaciers by wading or fording when necessary. In the winter of 1902–3 the Kichik Kumdan advanced rapidly, and completely blocked the route. How rapid this advance was we do not know. Oliver was told that the glacier advanced several miles during that winter. Native testimony cannot be absolutely trusted on such a subject, but it should be remembered that a similar transverse glacier in Hunza, the Hassanabad, appears to have recently advanced 6 miles in two and a half months. In 1903 a bad flood occurred, which Oliver attributes to the bursting of the Kichik Kumdan dam. There are still traces of the former existence of a lake or lakes in the broad flood-plain between the Kichik and Chong Kumdan glaciers. In 1905 the Aktash glacier advanced across the river-bed, but the river forced a passage under the ice, and no lake formed behind the dam. At the present time the route is blocked by all three glaciers.

It is probable that the explanation of such periodic glacier variations as I have described must be sought in the periodic variations of rainfall. But in attempting to correlate such variations we are met at the outset by the difficulty that hardly any two glaciers have equal feeding-grounds, aspects, lengths, or slopes of bed. Hence, by the time the effect of such a general cause reaches the snouts of different glaciers we must not expect any universal coincidence of date. In the present instance none of the glaciers under discussion have been surveyed in detail. So far as it goes, the evidence points to advance of the two larger Kumdan glaciers being by no means synchronous with that of the two smaller Aktash glaciers, and hence we can form but a rough idea of their periodicity of advance and retreat. Flood-periods occurred in 1780, 1833–1842, and 1903—that is, at intervals of between fifty and sixty years. The Kumdan route was probably open before 1800. It was closed from about 1825 until about 1860. It was again usually open between 1865 and 1902. The "open" periods seem to last for about thirty-five years, and the only complete "closed" period that we know of also lasted about thirty-five years. I have already indicated that this curious agreement with Brückner cycles must be regarded as largely a matter of accident. I have recorded the recent advance of the Saltoro glaciers, and of the great Siachen glacier of Nubra, in my previous paper.

In August, 1908, Captain Oliver visited and photographed the Kichik Aktash and the Aktash glaciers. The latter he attempted to cross, but failed owing to want of proper appliances. When, in the following year, he met me at Panamik in Upper Nubra, he decided to repeat the attempt. We therefore crossed the Sasir pass (17,600 feet), perhaps the strangest pass in constant use. The summit glacier, some 3 miles in length, is saddle-shaped. The pommel points north; the cantle is represented by ice-fields flowing down to the pass from the south; one saddle-flap leads up to the pass from the west, or Nubra side; the right saddle-flap slopes down into the Shyok valley towards the east. We camped on August 17 at the halting-place known as Sasir, on the right bank of the Shyok. Looking up the valley, we saw the river flowing in a narrow flood-plain. Continuous steep cliffs shot straight up from its left bank, but the right side of the valley was of a much gentler slope. Snow-capped spurs swept down in great curves to a broad sloping valley-shelf, down which streamed several glaciers. Their surface was moulded into the most fantastic cones and spires, and very little moraine stuff was visible.

We started up the valley on August 18, following the old bridle path. The first glacier, a small nameless one, is soon passed. It descends to within a few hundred yards of the track, which here lies about half a mile back from the river. It lies on the top of beds of gravel and scree which cover the sloping valley-shelf, without having cut out a bed for itself or ploughed up the ground in front of it, although it is actively advancing. A glacier is not a steam-plough: it does not slide downwards as a whole; its different layers, so obvious as "bands," glide smoothly one over another. Hence in spite of more rapid melting of the upper layers, an actively advancing glacier usually presents a vertical terminal face as opposed to the receding forehead prevalent during the stationary or decadent phases.

The Kichik Aktash ends in a cliff of ice about 30 feet high just above the brink of the river-bed, so that we had to descend into the flood-plain, on to the edge of which blocks of ice are occasionally discharged. Oliver decided, from the evidence of his own photographs, that the glacier had advanced a few yards since his previous visit.

Along the edge of the river and over the dry flood-plain masses of white glacier ice had been stranded. We scrambled over outcrops of black slate towards the "White Rock," a bed of white marble which gives its name to the Aktash glacier. Just before this glacier is reached, an island of rock divides the Shyok river into two branches. The current was rapid, and the water full of blocks of ice. These greatly increase the danger of the ford between Sasir and Murgo. We found the snout of the Aktash glacier projecting into deep water; it terminated in a sheer wall of ice, round which we were quite unable to pass, and from which great blocks of ice fell into the river as we watched. Oliver said that the ice had not retreated since his previous visit. Therefore at this point the glacier is actively advancing, but the river at present is able to keep its channel clear by undercutting the ice.

The lower part of this glacier lies upon the valley shelf without cutting out a bed for itself to any appreciable extent. The ice has crossed the pony-track commenced about ten years ago. The path, showing hardly a sign of dislocation, is abruptly terminated by the steep face of ice presented by the edge of the glacier. We had no time, subsequently, to search for its point of emergence on the other side. We ascended the valley-shelf for about 2 miles. A gradually developing lateral moraine is piled beside the glacier, and soon conceals from view the rows of ice-cones which form such a feature from more distant view points. Thus seen from the moraine, the glacier appears to be embedded in a trough; but at a little distance the appearance is quite reversed, the moraines resembling high canal banks raised well above the level of the valley-shelf.

We camped about 1000 feet above the river, and at once proceeded to look for a practicable route across the glacier. The lateral moraine here presents a steep face of hard silicious moraine-stuff towards the glacier, so that it is necessary to climb down into a deep trench, and climb up on to the glacier through steep seracs. Both operations were difficult at the time of our visit, and some of the crevasses delayed us considerably. Eventually a way was found through a great valley of ice, probably representing a closed crevasse, and in 1½ hour we reached the further bank. We had cairned our route, and the return occupied only an hour, the distance exceeding half a mile. Our camp had been pitched beside the glacier, and we reached it at 8 p.m.

On August 19 Oliver despatched Rasul Gulwan with the caravan back to Sasir camp, with orders to proceed *viâ* Murgo and across the Depsang plains to meet us at the old camping-ground of Yapchan, near the source of the Shyok river. Oliver took only twelve coolies and his Ladaki shikari, with my man Ahmedu, now a fairly expert ice-man, as cook. We did not leave camp till 1.45 p.m. In half an hour we reached the glacier. The whole party was supplied with crampons, and roped together until the difficulties were passed. We crossed in 1½ hour—good time under the circumstances. We saw that the Aktash glacier expanded somewhat at its snout, some huge masses of ice resting on the farther bank at the foot of high limestone cliffs, which weather to a warm red colour. On September 8 Oliver again crossed this glacier, and found that all our cairns had been destroyed by the normal activity of the onward flow of the ice. The Aktash glacier flows down through a fine steep-sided glen from the direction of K_{32}, but, owing to bad weather, we could not see its upper reaches. We camped at 5.15 near a small tarn beside the Kichik Kumdan glacier, and about 1½ mile from the river.

From our camp we could see the snout of the Kichik Kumdan glacier. It appeared to be quite impassable from the river-bed. On August 20 we crossed the glacier in one and a half hour. It was less difficult than the Aktash, but without crampons our coolies could hardly have crossed in safety. We saw that the snout expanded into a sort of ice-foot, this form, no doubt, being due to the force of its impact against the cliffs of the left bank. Great masses of dead glacier-ice were lying at the foot of the cliffs across the river. Between these and the living glacier the river had cut a channel. Probably this channel is not a continuous one. The middle section of the snout appeared to bridge the river, which must flow in an ice-tunnel beneath it. Where we crossed the ice, the glacier was nearly a mile broad. I estimated the greatest breadth of its expanded snout at about 2 miles. This is the identical condition described by Gordon in 1873.

After quitting the glacier we continued a short way along the valley-shelf, and then descended steep slopes of scree to the level of the river, whose broad bed here resembled a lacustrine plain. Straight ahead the lower portion of the great Kumdan glacier was visible, its last mile almost covered by moraine, though a few huge white ice-cones are thrust up through it. We struck the glacier at 2.30, at a point about 5 miles above the snout of the Kichik Kumdan glacier. The walking was tiring, but much easier than on either of the others. The glacier is nearly 2 miles broad where we crossed it (in 2½ hours). A long way up the valley we saw a high snow-peak, which I believe was K_{32} itself. We had great difficulty in getting off the glacier. A very steep slope of ice has to be negotiated, and this is constantly raked by stones falling from the moraine heaps at its edge. Steps were cut down this slope, and the coolies descended safely. Oliver waited above with a rope until the last man had got safely down. While he was descending the ice-steps an avalanche of boulders caught him, carrying him off his feet and hurling him down the slope. We thought he must be killed, but he escaped with some bad cuts and bruises. It was now 5 p.m., and the lateral glacier-torrent which emerges from the side of the glacier about half a mile higher up presented a serious obstacle. We were in a dangerous spot, and had to ford it at once; we camped on a soft bed of fine shingle beside the main river. The snout of the Chong Kumdan projected far into the river, but owing to a sharp bend in its course we were unable to see whether any part of it reached the farther bank. If any road is made it must follow the left bank of the river, and at this corner must be blasted out of the solid rock.

On August 21 we had a very tiring march up the Shyok. Between 8.30 a.m. and 4 p.m. we covered only about 4 miles, having constantly to climb up and down the cliffs of the right bank, in one place mounting more than 1000 feet, only to be forced back to the river-bed a short way further on. The rocks were of limestone and grey calcite, weathering to a beautiful red, which was very remarkable on the high peaks to the east across the river. The main valley now widens out very markedly and the river flows in several channels over a wide flood-plain. If the river were blocked this flood-plain alone would form a lake from half to a mile broad, and extending to the foot of the Remo glacier. Next day we moved our camp up to the old stage (15,700 feet), known as Yapchan (= a woody plant). Fire-blackened stones and horses' skeletons indicated considerable previous occupation. Just above Yapchan the Shyok makes a sharp turn; flowing east from the Remo glacier it bends suddenly due south. This angle is filled by a rolling, somewhat waterlogged plain, much of which is covered by tufts of grass and small woody plants, providing both fodder and fuel. Large numbers of female antelope (*Pantholops hodgsoni*), attended by a few wolves, pick up a living on these plains, and I shot a couple of the former for our coolies, who were now on rather short commons.

On the evening of August 22 Rasul Gulwan turned up with the caravan, having come round from Sasir in three days, a very remarkable performance. Rasul the Horse Thief belies his name. He has travelled with Littledale, Barrett, Phelps, and Church, and has always been spoken of very highly by his employers.

On August 23 we noticed the first signs of winter, the pools beside the Shyok being frozen at their edges. At 8.45 I rode off with Oliver to look at the Remo glacier. The ground was full of the burrows of a large ochotona which was new to me. It was about the size of a small rabbit, and had a low whistling note, much stronger than the "whisper" of *shippi*. The ordinary white-capped black redstart of Ladak (*Chimarrhornis leucocephala*) is replaced by another very similar bird, but with white patches on its wings (probably *Ruticilla erythrogaster*). Most of the hollows are impassable bogs, due to infiltration from the glaciers to the west. Many are encrusted with an efflorescence of saltpetre. We passed a kidney-shaped lake, about 300 yards long, lying in a rock basin, which was most obviously *not* due to glacial erosion. Beyond it, three hours from camp, we reached a rocky knoll of limestone, and the glorious expanse of the Remo glacier was before us, a sight which Shaw described as being in itself worth a journey from Europe to see.

I have not been able to find any mention of the Remo glacier prior to Johnson's survey season of 1864, nor can I find any definite statement in the G.T.S. Reports as to who sketched its topography. The present condition of the Remo glacier is now identical with that shown in Gordon's picture of it taken in 1873 (*op. cit.*, p. 19). Rasul Gulwan was of opinion that it had advanced somewhat during the ten years which had elapsed since he had last seen it. But such advance must necessarily, owing to the great breadth of the ice-foot, be a very gradual affair. I am rather doubtful whether its delineation on the Survey map (44A south-east) can be accepted as true of the date (about 1864) which it must represent. For if it was correct the Remo glacier and the two large glaciers in the valleys to the north and south of it must each have advanced 8 miles or more, and united to form a huge expanded ice-foot at least 2 miles wide at their point of junction; all this in the course of one decade at the outside, and during a period not signalized by active advance of the Kumdan and Aktash glaciers. It appears certain that no one has ever crossed the Remo ice-foot. Has any one actually travelled up the northernmost of the Remo valleys which is represented as originating just west of the Karakoram pass, and running west and then south for 30 miles, till it reaches the present site of the Remo ice-foot? If this valley exists as shown, there must be a very big lake in it, for the Remo dams it completely. But judging merely from what I saw later, on my way to the Karakoram pass, I cannot help thinking that a mistake has been made, and that the source of the Shyok is really the Remo glacier, and not a small rivulet visible from near the foot of the Karakoram pass. I suspect that this westward flowing rivulet eventually drains towards Shahidula, and that the northerly Remo glen is closed by a mountain wall about 15 miles from the snout of the glacier.

This huge ice-foot presents a truly magnificent sight. Although four large glaciers unite to form it, only one medial moraine is visible, which is slightly expanded at the snout. The rest of the surface is split up into beautiful cones and spires of ice, brilliantly white, and all of an even height, so that, at a distance, the glacier resembles some great white lake whose storm-tossed waves have suddenly been struck motionless. None of the snow-peaks visible up the different valleys seemed to be of remarkable altitude, though, as our station was very little above the level of the glacier, this is hardly surprising. But it is certain that such great ice-streams must derive their stores of ice from some very lofty group; it does not seem possible that they can be directly derived from Teram Kangri. These glaciers would undoubtedly afford a most interesting and profitable field for exploration, for their aggregate area must rival that of any of the four great primary glaciers of the Karakoram range.

After visiting Dalgleish's cairn just across the Karakoram pass, Oliver spent some time in trying to find a way from the Shyok valley, below Kataklik, over on to the Changchenmo. It is a very wild region of snow-clad limestone hills and deep defiles. At our farthest point we came across the remains of an old fireplace. Our Ladakis instantly referred this to Johnson, who is remembered by the natives as the most resolute of all the explorers of this desolate region.

I have to thank General Sir T. E. Gordon for kindly looking over these notes, and for giving me the opportunity of examining the sketches of the Kumdan and Remo glaciers which he made in 1873.

The President (before the paper): Dr. Longstaff is so well known to us all that I really think hardly anything need be said by me on this occasion. He had already done excellent mountaineering work both in the Alps, in the Caucasus, and in the Himalaya, when he made his first expedition to Asia, a political mission in Western Tibet. Perhaps the most noteworthy feat he had yet accomplished was the ascent of Mount Trisul, a mountain over 23,000 feet high. The present expedition, which he is going to describe to us to-night, deals with a little-known part of the Karakoram range. Dr. Longstaff is one of those explorers who always takes great pains before he visits a place to make himself thoroughly acquainted with all that other explorers have done, and he never makes any claim whatever to have done a thing until that claim can be absolutely established.

Lieut.-Colonel Godwin-Austen: I must first congratulate Dr. Longstaff on the excellent piece of exploring work which he did last summer. He has added a very valuable addition to the topography of the Himalayas, especially of that portion of

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77°
36°
EAST
From Aghil Pass
Durbin Jungle
Oprang River
Gusherbrum Jilga
Staircase Pk
24078
Windy Gap
20450
K2
28250
Gusherbrum Gl.
Oprang Glaciers
Broad Pk
27133
13880
Urdok Glacier
Gusherbrum
26000
26090
26360
Baltoro Glacier
Hidden Pk
26470
15355
Masherbrum
25660
25610
Younghusband's Saddle
Pioneer Pk
23000
Bride Pk
25110
Kondus Glacier
Teram Kangri
27610
25940
22140
Siachen Glacier
22750
23960
Sher-pi-gang Glacier
23890
25280
25400
Saltoro Pass
Bilafond Pk
Ali Bransa
Bilafond Glacier
K12
24352
Chumik Glacier
Kondus River
Saltoro River
Dansam
K13
21870
13700
Khapalu
14240
16950
Goma
Rgyong Glacier
Rayong La

EXPLORATIONS
in the
EASTERN KARAKORAM
by
T. G. LONGSTAFF, M.A., M.D.
1909.
Scale 1:500,000 or 1 Inch = 7·89 Stat. Miles.
5 4 3 2 1 0 5 10 15
Reference
Routes traversed by Dr. T. G. Longstaff, and in parts by Lt. A. M. Slingsby, Dr. A. Neve, and Capt. D. G. Oliver.
Route traversed by Sir F. E. Younghusband K.C.I.E. in 1889
" " " Dr. A. Neve
Camps
E.G. Encamping grounds
21360 Heights in feet from Survey of India
25940 " " " determined by Dr. T. G. Longstaff from clinometer, Watkin aneroid, and hypsometrical observations.
77°
Dr. T. G. Longstaff's route 1909
Sir F. Younghusband's " 1887
G. W. Hayward's " 1868
Position of water parting on previous maps
Oprang
K A R
36
Mustagh Passes
Baltoro
Askole
INDUS RIVER
Khapalu
BALT
35
Kharmang
Kargil
From Srinagar
Khartse
76
Oprang Glaciers
Teram Kangri
27610
25940
22140
Saltoro Pass
18200
Bilafond Pk
22200
Ali Brangsa
Siachen Glacier
Chumik Glacier
Rimo Glacier
Chong Kumdan Glacier
Kichik Kumdan Glacier
Rayong Glacier
Murgisthang Saddle
Ford Yapchan
18700


ORAM
les.
15
Dr T. G. Longstaff's route 1909
Sir F. Younghusband's " 1887 & 1889
G. W. Hayward's " 1868
Position of water parting on previous maps
Scale 1: 2,000,000 or 1 Inch = 31·56 Statute Miles.
10 5 0 10 20 30
To Yarkand
Shahidulla
Raskam
Yarkand River
Oprang River
Aghil Pass 15256
Kufelang
36
KARAKORAM RANGE
Mustagh Passes
K.2 28250
Gasherbrum 26360
Hidden Pk. 26470
Urdok Glacier
Baltoro Glacier
Askole
Masherbrum 25660
25110
Younghusband's Saddle
Teram Kangri 27610
Source of Yarkand R.
Karatagh Pass
To Leh
Siachen Glacier
Karakoram Pass 18110
22750
23880
Saltoro Pass 18200
Bilafond Glacier
Siachen Glacier
Depsang Pk. 22000
Saltoro River
Khapalu
Chamik Gl.
Kyagar La 18700
BALTISTAN
Nubra River
Sasir Pass 17600
35
INDUS RIVER
Kharmang
Shyok River
21620
19820
19810
22163
Kargil
From Srinagar
20288
21780
INDUS RIVER
Shyok River
LADAK
Khartse
Fotu La
Kharding Pass 17500
Leh
76
77
78
Karakoram Pass 18110
Daulat Beg Uldi
Tsaka Chu or Chipchak R.
Tsaka Chu or Chipchak R.
Depsang Plains
Pass
Ford Yapchan 15700
17000 - 18000
Pass
Chong Kumdan Glacier
Depsang Pk 22000
Kizil Angur E.G.
Burtsa Gunma E.G.
Kichik Kumdan Glacier
Murgi-thang Saddle

Kondus Gla
Sher-pi-gang Glacier
Saltoro Pass
Bilafond Pk
Ali Bransa
Bilafond Glacier
Chumik Glacier
Kondus River
Saltoro River
Dansam
Khapalu
Chogogrom
Goma
Rgyong Glacier
Rayeng La
Gharkun Pk
Chulung Glacier
Chulung La
Shyok River
Siksa
Chulunka
Biagdangdo
35°
77°
AFGHANISTAN
Kabul
Gilgit
KARAKORAM MTS
Srinagar
Indus
CHINESE EMPIRE
TIBET
HIMALAYA MOUNTAINS
Lahore
Punjab
Gartok
Quetta
Sutlej
Lhasa
Brahmaputra
Delhi
Bareilly
NEPAL
BHUTAN
Agra
Lucknow
Gwalior
Karachi
Allahabad
Patna
Ganges
INDIA
Bengal
Almadabad
Baroda
Calcutta
Scale, 1:30,000,000
Area of General Map
NOTE.
The map is based on the fixed points of the Survey of India. M
and eastern portions of it must be regarded merely as a route-sketch
the G.T.S. atlas sheets, from which areas unvisited by me can be fillec
Chumik and Rgyari basins are from a plane-table sketch, on the scale of

Published by the Royal Geographical Society.

L A D A K
RIVER
Khartse
Fotu La
Kharding Pass
17500
Leh
76
77
78
Karakoram Pass
Daulat Beg Uldi
Tsaku Chu or Chipchak R.
Depsang Plains
Rimo Glacier
Ford
Yapchan
Choug Kumdan Glacier
Kichik Kumdan Glacier
Aktash Glacier
Depsang Pk
22000
Burtsa Gunma E.G.
Murgisthang Saddle
Sasu Pass
Murgo E.G.
Pangtangsa E.G.
Shyok River
Dongmochu E.G.
Zangmochu E.G.
Thalam
Nubra River
Panamik
Tegar or Kiagar
Deskit
9930
9950
Thirit
11230
21920
25170
24590
24650
16869
35°
78°

ety.

Kashmir territory. A very large portion of the area on the north of that part of the Kashmir was necessarily done in a very superficial way. The trigonometrical stations were very few; the assistants in the survey were expected to bring in very large areas of country mapped during the summer months, and it was impossible to sketch the mountains in anything like accurate detail. In many instances all that could be done was to map in the end of the glaciers; some of the larger ones we were able to go up, but the area brought before you to-night was some way to the east of where I was working myself in 1862. Mr. Ryall did the portion that we have had shown on the screen, and I think that his work was really more difficult than what I had to do. The upper Shayok is a most wonderful mountain system; it is unlike any other portion that I know of in the Himalayas, in the extraordinary structure and altitude of the peaks. I had, from near a peak called Shyok No. 2, which is 21,073 feet, upon the edge of the Changchenmo, a very magnificent view over all the Shyok mountains opposite, and it was one of the most wonderful scenes I think I have ever seen. My work then lay further to the east, so that I was never on the upper Shyok itself. The work that Dr. Longstaff has brought before us has cleared up the true position of that great glacier, the Saichar (Sia-chen), which was first seen by Henry Strachey, the first Englishman who went up into Ladak and began a rough survey of the country. There are many points connected with the lecture this evening, but I think there was one I will touch upon. It appears now, and from what we know of the Saltoro pass, that Vigne made two attempts to cross it; that was in 1835, when Ahmed Shah was the Raja of Skardo. At that time the Saltoro pass was evidently well known, and looking at the map now, and what Dr. Longstaff has done, it appears to me that this pass was in all probability a way by which the people of Baltistan got into Yarkund. They are particularly good mountaineers, and in their own interests they do not mind these glaciers in the least, and from the Shyok valley, where there are very populous villages, it strikes me it was one of the most feasible, probably a more feasible, route then than going by Skardo and the Braldo river, and across the Mustagh pass, the route at present used; and looking at the map and the trend of the Saichar glacier, I think it is very probable that it was really at one time in constant use. There are many other points, of course, connected with the glaciers of this region. They are vast, and a great number of them have yet to be explored. I only hope that at some early date a really scientific expedition will go up into that part of the world to examine the glaciers and their action more thoroughly, like Forbes did the Mer de Glace. There is a very vast amount of work to be done in that direction. Some of the country to the north of the Remo glacier, which you saw shown on the screen, is very doubtful topography indeed, Dr. Longstaff in his paper refers to it, and has been unable to find out who did it. My opinion is that it was done by W. H. Johnson, who at the time he went to Ilchi travelled over the great extent of intervening country very rapidly, and brought back very rough plane-table sketches indeed of the country, which were partly utilized in compiling the final maps.

Sir Francis Younghusband: It was a source of peculiar interest to me that on my last summer in Kashmir two such fine expeditions should have come into the country to explore the northern frontier of Kashmir, in which I had myself twenty years ago been exploring. The first of those expeditions was headed by the Duke of the Abruzzi, and the second was one of which we have heard to-night—Dr. Longstaff's. They were each of them good in its own particular way, and typical of the nationalities to which they belonged. The Duke of the Abruzzi's was magnificently organized, it was soundly equipped, and it did its work thoroughly well, and achieved, I think, its main object. Although the Duke did not actually reach the summit of K_2, he, at any rate, attained a greater height than any other human being has yet reached. The second expedition was what we may call a rough-and-ready pioneer expedition. Dr. Longstaff had with him Dr. Neve, a man thoroughly well known in Kashmir, and one of the most highly respected men in the country. Dr. Longstaff has one qualification to which the President has referred, that is of giving thorough credit to those who have gone before. That is a qualification which is not always met with, and it is most highly appreciated by us unfortunate men who have done our explorations early in life, and have to suffer all the rest of our lives from seeing later explorers criticizing what we ourselves have done under perhaps more trying circumstances. Dr. Longstaff's main object, I understand, was to discover this fabulous Saltoro pass, whose existence had been known for years, but whose exact whereabouts no one had hitherto been able to ascertain. Neither Colonel Godwin Austen, who was exploring in those regions before either Dr. Longstaff or myself were born, nor his collaborators had been able to exactly fix the Saltoro pass. In 1889, when I was sent by the Government of India to explore that northern frontier, and to find any practical routes there might be across it, I was asked, on my way, if I could, to ascertain where this pass was, and to find out if it was at all a practicable route. From the north side I did my best to find where this pass was, and ascended a saddle on the main watershed, but that did not prove to be the actual pass, although at the time I thought it might be. Dr. Longstaff has not only this summer found out the pass and crossed it, but has achieved three other results, of which he made very little himself, but which I think ought to be emphasized because they are of great importance. He has fixed the exact position at that particular part of what is really the greatest watershed in Asia—the watershed which divides the rivers flowing to Central Asia from those which flow down to India. Hitherto it has not been placed accurately on our maps, and it is to Dr. Longstaff's credit that he has now for the first time fixed its true position. That, I think, is one result of great geographical importance. Then, again, on the far side of the Saltoro pass, he found a glacier which he at the time naturally thought must flow north. When crossing a pass like the Saltoro, which has hitherto been supposed to be on the main watershed, and you get on the other side you naturally suppose the glacier there will flow north into Central Asia, but he discovered that it trended south, and came into the Nubra valley, and was, in fact, nothing else but the Siachen glacier. That is a second result of great importance, because it proves that the glacier on the far side of the Saltoro pass and the Siachen glacier are one and the same, and therefore the greatest glacier in Asia. But besides that, on the far side of the glacier, he saw this wonderful mountain of which he modestly puts the height at 27,000 feet. That may prove to be another discovery of the very highest geographical interest, because it is possible that he is erring on the low side; we cannot say for certain that it is merely 27,000 feet, it is quite possible it is 28,000 or 29,000. It had always been expected, as Colonel Burrard said, that there must be a large peak on the far side, and there is no reason why this peak should be not 27,000 feet, but possibly something greater. On all this, we must take into consideration Dr. Longstaff's well-known modesty, and be sure in these matters he has erred on the low side.

There is one final remark I should like to make, and that is regarding a casual observation that he made, that this peak was composed of limestone. We must think to ourselves what that really means. Limestone is a rock which must at one time have been formed beneath the surface of the ocean. You saw that enormous new mountain; you saw those other mountains of scarcely less magnitude, you must recollect that all of them are more than 1000 miles from the sea, and reflect on this, that those great mountains at that immense distance from the sea at one time have lain at the bottom of the ocean. Finally, I should like to congratulate Dr.

Longstaff most sincerely on his magnificent achievement, and to thank him for having caused us in Kashmir so very little trouble and given us such a large amount of pleasure.

Mr. Douglas Freshfield: I have no acquaintance with the region that is the subject of Dr. Longstaff's paper, but as an Himalayan traveller and an old climber I may perhaps venture to comment on some of the points raised by it. In the first place, I would congratulate Dr. Longstaff on his discovery of new peaks of over 27,500 feet, and possibly much more. If the botanist glories in a new lichen, and the entomologist in a new beetle, how much more glorious is it to add to the number of the noblest objects in creation!

No one, I think, who, like myself, has watched and shared in the progress of mountaineering for the last half-century can fail to appreciate the great advance that has been made in extending the limits attainable by human energy and endurance, and, consequently, in exploring the highest regions of the Earth's surface. It is but a few years ago that many persons, otherwise quite rational, thought it ridiculous to pretend that human beings could sleep at 20,000 feet, or climb to 24,000 feet. Now by the feats of Dr. Longstaff, the Duke of the Abruzzi, and their predecessors, Sir M. Conway, the Workmans, the Anglo-Swiss party who camped for seven weeks under K_2, the young Norsemen who climbed Kabru, and others, the "manlevel"—if I may coin a phrase—has been definitely lifted to 25,000 feet. Mountain sickness has been found to be no insuperable obstacle. We know much more about it. It has been ascertained that it is most formidable as a cumulative diminishment of energy, physical and moral, consequent on prolonged stays at high levels, as in sporting language a variety of "slackness." Consequently, the forlorn hopes which will attack the loftiest summits of our globe should, as far as possible, rush their peaks. They should have pioneers to prepare their way to their highest bivouacs. This may seem a contradiction to some of your preconceived ideas; but you will find it prove true—I speak with high medical authority behind me. There is not, in my mind, the smallest doubt that when a reasonably accessible mountain of 28,000 or 29,000 feet can be found in the British dominions, it will be climbed as soon as any one is ready to spend for the purpose a quarter of the money that has been spent on many single expeditions to get near that floating nonentity the North Pole.

Unfortunately, all the highest peaks hitherto discovered have been either excessively arduous, or are in territory barred to British explorers. Their would-be conqueror has either to evade avalanches or to get round Lord Morley, and I know not which is the more awkward obstacle. Till the Chinese Government, which, according to Dr. Stein's account, is sympathetic to research, is ready to grant passports to Tibet we must abandon all hope of Mount Everest.

In physical science Dr. Longstaff has touched on more than one question of interest. His observations tend to support the theory of the conservative, or protective, action of ice, which I ventured to maintain many years ago, in 1888, in our *Journal*. It is held to-day by several most eminent British and Swiss geologists. But it is also contested by Germans, and following the German lead by Americans. For instance, I find in our *Journal* Prof. Hobbs, of Michigan, asserting as axioms views which are, to say the least, no more than doubtful hypotheses—I refer to the supposed excavation of main valleys by glaciers and the production of cirques by snowy *névés* working backwards, to my mind a most fantastic doctrine. But this is not the place to argue on these matters. I desire simply to warn unscientific readers of our *Journal* against being unduly biassed by dogmatic and unqualified statements on moot points.

With regard to two other matters, the rate of advance of glacial snouts and the general periodic oscillations of the glaciers, Dr. Longstaff has some new facts to bring forward which are particularly interesting to me as the English member of the International Society for the Observation of Glacial Movements. He tells us of one glacier which did 6 miles in two months and a half, which, if I have not forgotten my arithmetic, means nearly 6 yards an hour! Mark Twain was, after all, not so very unreasonable when he sat down in the middle of the Gorner glacier in the hope it would take him to Zermett in time for the *table d'hôte!* Again, Dr. Longstaff notes an apparent correspondence in the period of the greatest oscillations of advance and retreat with that observed in Europe. In the Alps the maxima and minima of the glaciers seem to be roughly 50 years apart. I saw the Bernese and Chamonix glaciers at their maximum in 1855, and in 1905 they were, as we all know, deplorably diminished. It might be interesting, did time allow, to compare in detail the physical aspect—the scenery—of the different parts of the Himalaya that have been lately opened up by travellers, and, in particular, to compare the Karakoram and the mountains of Sikhim. Such a comparison is suggested by Signor Sella's magnificent photographs, and by the fine views we have seen to-night. On the one hand, in the Karakoram, we have absolute solitudes, grim towers, and spires and obelisks of naked granite, leading in gigantic avenues 40 miles long to the hidden storehouses of the snow. The valleys are choked by the greatest glaciers outside the polar regions; the ice is hidden under hideous piles and banks of fallen rubbish; there are no trees, and few high pastures—only interminable desolation, the appalling sublimity of a region where man comes as an intruder into a dead, or unborn, world, where the only voices are the groans and creaks of the crawling ice-streams, or the thunder of the avalanche. In Sikhim, on the other hand, the traveller finds himself in an earthly paradise. Deep-cut valleys, whose sides are clothed in the luxuriance of sub-tropical ferns and forests lead up to the broad pastures of the yak, above which elegant, or majestic, snow-peaks group themselves in ever-varying combinations, while over all towers the great white throne of Kangchenjunga, a vision not to be described except by a Shelley. The landscape combines the sublime and the romantic carried to their highest powers. It is as wonderful as a poet's dream, or a child's first pantomime.

I have tried to distinguish between these two regions because, though they are some 900 miles apart, the public does not always do so—nor, I regret to have to add, does our Press assist it in the endeavour. I saw, as I came up, at a railway bookstall, in the last number of an illustrated newspaper called the *Sphere*, the splendid—and to me familiar—plate here exhibited with the superscription in large letters, "The Virgin White Peak of the Himalaya: the Duke of the Abruzzi's Record Climb." Below were the words "taken by Signor V. Sella of the Duke of the Abruzzi's expedition." It is true "this view represents Jannu in the Nepal Himalaya" was added. But how many readers will understand that this picture has nothing to do with the Duke of the Abruzzi's expedition; that it represents a peak 900 miles from the scene of his exploits, as far as Biarritz is from Vienna, and that it is an enlargement from a plate taken by S. Sella when with me in Sikhim ten years ago, and used as an illustration to my book 'Round Kangchenjunga'?

The PRESIDENT: I am sure that every one here present feels we have heard an account of an excellent bit of exploratory work. It is excellent from every point of view. It has increased our knowledge of a very wild and desolate region about which little was known before: it has, as Sir Francis Younghusband has said, solved a number of very important problems; and the author has dealt with the question of glaciation in a most interesting way. No doubt the most interesting bit of news he has given us is as to the possible existence of a mountain, Teram

Kangri, previously unknown, which may make the proud position of Mount Everest no longer tenable. He has told us in his paper how he manipulated his observations in order to make that mountain appear lower than it would otherwise appear, a proceeding probably unique in mountaineering records. The result is, that Mount Everest still occupies her royal position, though her sovereignty must remain doubtful. If I may say so, Dr. Longstaff has been very wise in the attitude he has adopted. If in the end his first calculations are proved to be accurate, and Teram Kangri is, in fact, the highest mountain in the world, he will still have the satisfaction of having his name associated with its discovery. On the other hand, he will have nothing to retract if his more modest figures are substantiated; whilst, in any case, this journey will always be remembered as a most admirable and conscientious bit of work.

Dr. LONGSTAFF: All the gentlemen who have been so kind as to take part in the discussion have been so complimentary that there is hardly any point which calls for an answer. I should, however, like to protect myself from the incredulity of Mr. Freshfield concerning the glacier reported to have advanced at the alarming rate of several yards an hour. Following the example of Herodotus, I sheltered myself behind my authority. I referred, of course, to the Hassanabad glacier in Hunza, which I have never visited, and was quoting from the 'Records of the Geological Survey of India.'

THE GEOGRAPHICAL FACTORS THAT CONTROL THE DEVELOPMENT OF AUSTRALIA.*

By Prof. J. W. GREGORY, F.R.S.

I. THE MAIN FACTORS.

IN those remote times when the primæval forests that produced our coal were growing on the British area, a wide continent extended across two-thirds of the southern hemisphere. It included the highlands of Brazil on the west, the peninsula of India on the north, and probably most of Australia on the east. That vast continent, Gondwanaland, is now represented by some scattered remnants, most of which have been merged in continents of later growth; thus, its most western fragment is part of America; India has become an Asiatic peninsula; and Africa has grown northward and united with an area that is essentially European. Australia, however, although the Malay archipelago, like giant stepping-stones, links it to Southern Asia, has been left isolated in the far Southern seas.

The first fundamental factor in the geography of Australia is then its isolation. It was the last of the inhabited continents, as far as existing evidence goes, to be reached by man, and the last to be discovered and colonized from Europe. It stands apart, almost as distant as any great land-area can be, from the region that contains the chief centres of modern progress. Nevertheless, in spite of its isolation and recent occupation, Australia has already become the greatest White Man's

* Royal Geographical Society, February 7, 1910. Map, p. 744.