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HIMALAYAN RANGE NAMES

THE Editor has pleasure in publishing a group of contributions to the discussion begun in the *Journal* for September last, and will be glad to receive the opinions of other geographers who know the Karakoram, preparatory to a conference on the subject which will, it is hoped, take place early in the coming summer.

The letters from Sir Sidney Burrard discuss two passages of the Editorial Note, and in particular the sentence "These ideas of Godwin Austen dominated the Survey of India for the next forty years" (*G.J.*, 74, 1929, 276).

Major Mason's note is in reply to Sir Sidney Burrard's "Defence of the existing Nomenclature," in the same number of the *Journal;* and Dr. Longstaff's comments were written on receipt of an advance copy of this note.

The Editor has received several letters on the subject which he may be allowed to summarize thus:

Lt.-Colonel Philip Neame, V.C., D.S.O., is strongly in favour of the names used hitherto by the Survey of India, and against the proposed changes, on the ground that the name of the Karakoram Pass is one of the few geographical names known almost universally to the inhabitants of all this mountain region. He would therefore retain the old, historical, and well-known name of Karakoram alone, to be applied to both the mountain region and the Main Range.

Mr. H. S. Montgomerie writes that he is in agreement with Sir Sidney Burrard's article, and maintains that the earlier surveyors described K_2 as essentially a rock peak with bare black surfaces too steep for the snow to lie, as against Major Mason's description, from a different aspect, as "spotlessly white" and the range as the whitest and iciest outside the polar regions. On the early use of the name he quotes from a private letter written by his father, Colonel T. S. Montgomerie, on 22 September 1856: "I took a run into Thibet and have seen the mountains of the Karakorum range that separate the valley of the Indus from Yarkand and those places."

Sir Martin Conway, on the other hand, writes that the Karakoram range "has nothing to do with the pass of that name, still less with the ancient capital of the Mongols. Muztagh is a better name for the K_2 range: but what will you call the range north of the Hispar and that south of the Baltoro?"

THE HIMALAYAN RANGES AND GODWIN AUSTEN'S MAP

Extracts from letters written by Sir Sidney Burrard to the Editor G.J.

From letter of 27 September 1929

There were one or two points in your article on the Indian Border, *G.J.*, September, p. 274, which were not quite fair to the Survey of India.

You are quite mistaken in thinking that the ideas of Godwin Austen have dominated the survey for fifty years or that our maps are dependent on geology. I have never seen that map in any Indian drawing-office, I have never heard it

quoted, and have never used it myself. The reason that the successive maps of Tibet from Walker's downwards all resemble one another is that they are all based on the same topographical data, the later maps having additional data. All our maps of Tibet are purely topographical; geology does not enter; there have been no geological surveys, and if there had been, we never use geology in topographical maps.

In all branches of knowledge generalization is necessary and difficult. Geographers are obliged to generalize, and to produce diagrammatic maps of complicated mountain systems. These diagrams are required as index maps, and for bird's-eye views. If we plot all the known peaks above 16,000 feet, the points on our charts arrange themselves in curvilinear alignments. I am no advocate of "ranges"; as a geologist Hayden was opposed to long ranges, because the eastern part of the Himalayan range was of a different age from the western. But Hayden, like myself, could not but see that the high points of Tibet insisted on grouping themselves in curvilinear arrangements, and a "range" is merely an abbreviation for curvilinear arrangement.

We have to keep quite separate the question of the continuity of ranges from east to west, and the continuity of their names throughout their lengths. As to the continuity of ranges the topographical data lead to the idea that the plateau of Tibet is traversed from west to east by long continuous ranges. If a range does sink into the plateau here and there, it seems to reappear on the same alignment a little farther on. Between the ranges the plateau seems to consist of level strips. There has been no topographical survey; but there have been scattered surveys form east to west and from north to south, and they all confirm the view of parallel ranges.

As to continuity of names across the plateau, every one would like to find Tibetan names. No one wants to extend the name Karakoram east of the Karakoram region: it would be a mistake. The *Map of Tibet*, 1914, which you quote, had a very unfortunate error, which was not noticed by the scrutineer; the drawing-office was short-handed, and this mistake crept in. The draughtsman entered the name Karakoram too far east. This was a mere slip; there was nothing intentional about it. I have never heard any surveyor advocate the extension of the name Karakoram east of the Shyok basin. The name has not been limited in area with the same definite precision as a state boundary. But just as the name of this range is automatically changed to Hindu Kush, as it proceeds westwards into Afghanistan, so we may hope that it will one day take on a Tibetan name as it proceeds eastwards.

With regard to your remark about the Ladakh and Kailas ranges extending eastwards to 92°, there is no doubt that these two ranges are very long alignments of elevated points. The apparent breaks in their continuity are mentioned on pp. 93 and 95, Part II (Burrard and Hayden's sketch). These breaks are probably only dips of the alignment below the high level of the plateau. The difficulties of naming these long ranges, when there are no Tibetan names, were painfully present to Hayden and myself in 1907. Our critics may say, "How absurd to extend the names Ladakh and Kailas through so many degrees of longitude!" The names affixed to these two ranges were given in 1852–53 by Cunningham, a careful, scientific and erudite explorer; we followed Cunningham, and in the absence of Tibetan names we continued

Cunningham's names throughout the eastern prolongations of his range-alignments. In taking this step and in avoiding inventions of new names, we were only actuated by the wish to leave the whole question open for final consideration when the time had become ripe. We thus saved our successors from the complications of having new names started which might prove unsuitable. I may say that in 1907 we consulted every known authority about these ranges, and we received the universal advice: "the time is not ripe; leave the question alone."

The ranges of Tibet seem to open like a fan, and to be squeezed together at the north-western end. But the same elevated alignments seem to persist even when squeezed and pushed north-west.

From letter of 5 October 1929

Thank you very much for sending me Godwin Austen's papers and map. They are forty-six years old, and though they may have marked a step of progress in 1883, they are now out of date, owing to the explorations in recent times of Ryder, Wood, Kishen Singh, and others. When Godwin Austen wrote these papers he had been absent for twenty years from North-Western Tibet, and had become engrossed in the geology of the Eastern Himalayas in Assam. As you kindly invite me to make further remarks upon your paper, I gladly accept.

You say on p. 276 that the geological structure is indicated by long lines in red overprinted on the map. But these lines of red are not geology: they are merely lines of high elevation. Some of these lines are borrowed from Markham and Saunders, who were not geologists. Godwin Austen himself calls these lines "elevation lines." Although he tries in his letterpress to find a relationship between these lines and the known geology, a modern geologist would, I am sure, say he was premature, as so little geology was known. In the sentence you mention on his page 611, he is only referring to the main Himalayan mass, south of Tibet. The geologists had learnt something in 1883 of the Himalayas, but after years of association with Hayden and Holland and Oldham and Middlemiss, I feel sure that they would have repudiated any assumption of a knowledge of geology in Tibet.

On p. 277 you say that the Karakoram range has been carried away east of Mount Everest because geologists identify rocks. The geologists have never explored the Karakoram and its extensions in Tibet; and geographers would never continue a name on geological grounds only. Except for one map, upon which the name Karakoram was misplaced by a draughtsman's slip, this name has never been extended into Tibet.

In Hayden's and my 'Sketch of Himalayan Geography' we drew the ranges by plotting all the high peaks (please see Chart V of Part I, on which all peaks higher than 24,000 feet were plotted). We continued this process down to 19,000 and 18,000 feet. In Tibet, where heights had not been observed, we had to rely upon the reports of explorers concerning the perpetual snow upon peaks.

It is true that the Ladakh range is a long one. The evidence of its length is discussed in Part II, pp. 92, 93, of 'Himalayan Geography.' We stuck to the name Ladakh because it was the only name that had been used by our predecessors, and we disliked inventing new names.

THE PROPOSED NOMENCLATURE OF THE KARAKORAM-HIMALAYA

MAJOR KENNETH MASON, M.C., R.E., Survey of India

SIR SIDNEY BURRARD has written a defence of the existing nomenclature of the Mountains of the Karakoram. I quite agree that it served its purpose in 1880, when little was known of the geography, though I maintain that *Muztagh* would even then have been better than *Karakoram* for the main range. As my report and suggestions have been quoted by Sir Sidney, I feel it desirable to explain in some detail my proposals. His 'Sketch of the Geography and Geology of the Himalayan Mountains and Tibet' has always been my Bible; but it was written over twenty years ago, and it must be to some extent out of date to-day, since our knowledge of the Himalaya has advanced. In it he first sorted order out of chaos, where there were sufficient data to go upon. I have read it over and over again, and in a humble way have tried to carry out his ideas.

My main contention now is that *Karakoram* is definitely unsuitable for the alignment as shown on our pre-war maps, that *Karakoram* has been used far more for the region than for the range, and that it is now definitely inconvenient to use it for both. Sir Sidney says in his Geography: "Colonel Montgomerie . . . named the whole Karakoram region K and its peaks K_1, K_2, K_3," etc. Wood describes his explorations on the Depsang and by the Karakoram pass as in *the Eastern Karakoram;* De Filippi uses 'Karakoram and Western Himalaya' for the title of his book on the Duke of the Abruzzi's explorations in the Baltoro area; for an area between these two, the Workmans use the term *Western Karakoram;* the Vissers include the glaciers west of the Hunza river among their *Karakoram* glaciers. Sir Sidney Burrard himself says: "Are there two Karakoram ranges parallel to one another? . . . No second Karakoram range has been shown upon the frontispiece to Part I; its existence as a separate crustal fold is conjectural. . . . Even the great Karakoram peaks themselves seem to follow two alignments. . . . Of the Karakoram peaks north-east of K_2 we have no knowledge." That was in 1906.

I maintain that the whole area has been called *Karakoram* or *Karakoram-Himalaya*. Burrard hinted at other Karakoram alignments both to the south and to the north of the range of the great peaks. It is Longstaff who says that the southern range, called by Burrard *the Kailas*, is more akin to the main Karakoram range than to the Kailas mountain many miles away to the south-east (*G.J.*, vol. 69, 1927, p. 329). He confirms Burrard's suggestion, and says: "Yes: there is a second alignment of Karakoram peaks south of the northern one." I have merely filled in Burrard's admitted blank in our knowledge about the Karakoram peaks north-east of K_2. Do these not lie on the Aghil–Karakoram range?

Sir Martin Conway's map of the Hispar, Biafo, and Baltoro glaciers, published by the Society in 1894, was headed "The Karakoram Himalayas." A. C. Ferber in the *Geographical Journal*, December 1907, described his "Explorations of the Muztagh pass in the Karakoram Himalayas." The title of Sir F. De Filippi's lecture to the Royal Geographical Society on 21 November 1910 was "The Expedition of H.R.H. the Duke of the Abruzzi to the Karakoram Himalayas."

The title to my own map in the *Geographical Journal*, vol. 69, is "Karakoram Himalaya." Here is a tradition extending over forty years.

It is Sir Sidney Burrard who emphasizes the geological aspect, for what is primary structure but geology? And what does he mean when he says in his Geography: "until geologists prove our assumptions to be wrong" ? (see also *op. cit.*, p. 71). I contend that geographically there are a series of ranges more or less parallel to each other and in a definite geographical regional block, geographical in the sense that an island or a country is a geographical feature. The southern range is unconnected either geographically or geologically with the Kailas. For this regional block, a large part of which has been known rather vaguely as *Karakoram* or *Karakoram-Himalayas* for a number of years, I propose the name *Karakoram-Himalaya*. Many people consider the whole series of ranges of Northern India, and between the Indian plains on the one hand and Tibet or China on the other, as the *Himalaya*, and look on the Karakoram as part of the Himalayan ranges. Is it so much more incongruous to show the source of the Yarkand river in a Himalayan region than to show the source of the Indus in a Tibetan one, or the Hindu Kailas across Buddhist Ladakh or Muhammadan Baltistan? Burrard says it is distressing to see a Sanskrit name applied to a Mongol region. We have become used to the name in Southern Tibet, which is inhabited by Mongolians, while the area where I propose to use it is uninhabited by any one.

I do not think Sir Sidney quarrels with my proposed alignment of the Muztagh-Karakoram. On the frontispiece to Part I of his Geography, he shows the alignment as I propose, having drawn it by joining up the summits of the ice mountains; and here it does not go through the Karakoram pass. It is only on the old maps themselves (through the misapprehension of Moorcroft in the first instance) that the name Karakoram has been bent away along the watershed to the Karakoram pass from the range through the Saser pass; or perhaps it would be more correct to say: The name Karakoram has been bent from the watershed at the Karakoram pass on to the range of the great peaks. In his book Burrard stresses over and over again that a range is not necessarily a watershed, and that the great peaks of the Himalaya do not lie on spurs from the main watershed range. Nor do the great Saser peaks lie on a spur of the insignificant watershed west of the Karakoram pass. The Karakoram pass cannot be considered as the "entrance door" from Yarkand into the Karakoram region as suggested by Sir Sidney Burrard. Hayward was given the name *Karakoram* north of this, not south. The Karakoram pass is excessively easy and essentially an "inside door," rarely closed. If there is an outside door, it is on the Kun Lun on the north, and at the Saser pass on the south. These are the two doors to the true "black," angry, windy, desolate, devil-inhabited region, littered with dead bones.

I used the translation of Karakoram, *Black gravel*, that Sir Sidney Burrard gave in his book, and it is the one generally accepted. Colonel Wood says that *Koram* means a *boulder* or *rock*. I have also been told that the word can mean *boulders* or *scree*. But the actual meaning does not amount to much. "Black ground covered by large blocks of stone fallen from mountains" is surely hardly more appropriate than "Black Gravel" for "the whitest, iciest range of mountains outside Polar regions." It is however suitable for the whole region,

for on both sides of the central ice mountains, the ranges of the Aghil-Karakoram and the Kailas-Karakoram are continually bombarding the valleys with rock.

The theory that *Kara*, "black," may be appropriate as an epithet for an "angry white" mountain is ingenious. But the Turki and the Ladakhi are more material than that. The Sa-Ser is Yellow Ground which is in the Shyok valley; the Kadpa-ngonpo La is the Blue Drift pass, and close to it is a blue scar on the hillside. The Dizma La is the Many-coloured pass because of the variegated

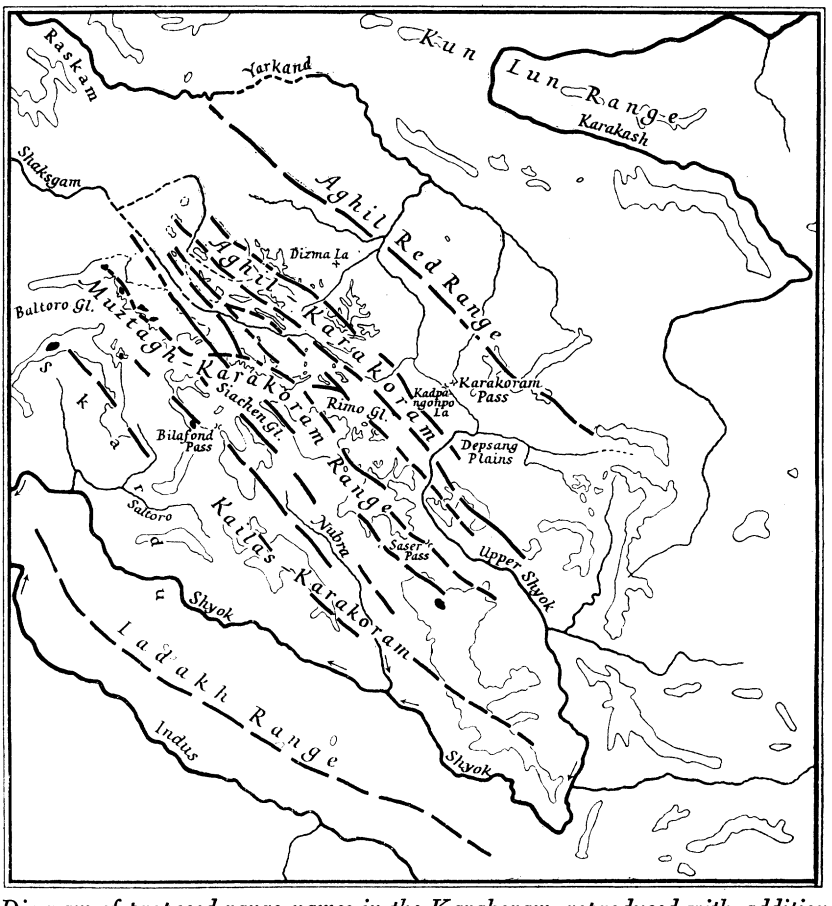


Diagram of proposed range-names in the Karakoram, reproduced with addition of a few pass and glacier names from the original diagram G.J., Sept. 1929, p. 275.

rocks, and the Marpo La is the Red pass because of the red rocks of the Aghil. These names were given us by our men. Aq-su is *white water* from *white snow*. The Muztagh is the abode of divinities, and divinities are white. The ancestor of the Mir of Hunza married a divinity of the peak, Dumani, the Mother of Mist. Nanda Devi and Nanga Parbat are goddesses, not evil spirits. Devils are black, and they live in forests, and deserts, and seas, and oceans.

I base my desire for a revision of the nomenclature on the ineffectiveness, inconvenience, and inaccuracy of the old. I do not suggest that the word Karakoram, which has so many traditions, should be abolished, but rather extended to include the whole area of mountains which all the great travellers of the past have called by that name. Longstaff suggested either the Karakoram, the Karakorams, or the Karakoram-Himalaya for this mountain complex (*G.J.*, vol. 69, p. 330). I have suggested the last, as this seems to me distinctive. It would still include the line of the great peaks. Muztagh, too, has its traditions, and under my proposals, would come back into its own, instead of being banned to obscurity as it was in 1880. The main range would become the Muztagh-Karakoram; it would still be the main Karakoram range, but not the Central Asian watershed. The combination of the two words prevents it being confused with other Muztaghs or other Karakorams which are also numerous; the combination of the two names is unique.

I have said that Muztagh has its own traditions. It was used by Henry Strachey in his 'Physical Geography of Western Tibet'; he saw the distant mountains from the south in 1848. It was shown on the planetable of Godwin Austen in 1861; he first surveyed the range from the south. Hayward, on the north, was given the name for the ice mountains to the south, Sir Francis Younghusband, who first *saw* the range from the north, called it the *Muztagh Mountains*. I have heard the name used in Hunza for the ice mountains to the east, though Turki is not the native tongue of Hunza. The traders of the Karakoram pass have spoken to me of the ice mountains to the west as the Muztagh. Is this not sufficient tradition to sanction its use ?

If we look on the southern range and the northern range as in the Karakoram region, why should we not call them the Kailas-Karakoram, and the Aghil-Karakoram ? With the Kailas range, some such distinction seems necessary. If we mean this southern alignment, and merely call it the Kailas range, we have a vision of the range near the sacred mountain of Kailas, disconnected and far away to the south-east. There is another Kailas, a well-known mountain opposite Chini on the Sutlej, some miles north-east of Simla. This is on the Great Himalaya range, and to distinguish it from the one in Kumaun, it is called either the Lesser Kailas, or more generally the Kanawar Kailas. I have not invented this. To denote the Kailas range of the Karakoram region, is it not natural to call it the Karakoram-Kailas or the Kailas-Karakoram ? Sir Sidney Burrard himself uses regional names for the Great Himalaya. He refers to the Punjab Himalaya; he means the Great Himalaya in the Punjab. He writes of the Nepal Himalaya; he means the Great Himalaya in Nepal. By Kailas-Karakoram or Karakoram-Kailas, I mean that section of the Kailas that lies in the Karakoram region. When we are talking solely of the Karakoram region, we may abbreviate them perhaps as the Kailas, the Muztagh, and the Aghil.

On crossing the Muztagh range, conditions change. It is cumbersome to speak of "the conditions of the country on the far side of the main range of the Karakoram." Nor would it be accurate to say "Trans-Karakoram conditions," for that would exclude the typical Karakoram country between the main range and the Yarkand river in Raskam, since it is uncertain whether we refer to the region or the range. But if we say "Trans-Muztagh conditions," it is obvious

that we mean the conditions beyond the main axis of the ice mountains. I have explained these changed conditions on page 74 of my report.

Sir Sidney Burrard seems to me to argue the question from General Walker's point of view in 1880. He gives the dates "of the principal events in the history of Karakoram Maps" as follows: Before 1820, 1853–1854, 1855–1865, 1866–1869, 1868–1872, 1876–1878 and 1879. I am not belittling these years, nor the great men who made these years great. But what about the years after 1880? What about 1887 and 1889 (Younghusband); 1891 (Cockerill and Conway); 1909 (Abruzzi, De Filippi and Longstaff); 1913 (the Workmans and Grant Peterkin); 1914 (De Filippi and Wood)? Surely it is the detailed exploration of these years that really counts to-day. Sir Sidney's dates stop short of the discovery of the Aghil range, of the Shaksgam river, and of the correct alignment of the range north of the great glaciers, the Baltoro, the Hispar, and the Siachen. Hayward's map shows the tributaries of the Yarkand river flowing north from the main range of "hairy caterpillars," and shows them on a very small scale. Godwin Austen's planetable of 1861 showed a dotted line from east to west with the inscription, "supposed course of the Hunza river, but which may have a long branch farther north." Hayward was given the name Karakoram north of the Karakoram pass, and the name Mustagh for the ice mountains. Godwin Austen has himself told me that his instructions were that he was not to "waste time in surveying barren country above 15,000 feet." One has only to read Colonel Wood's postscript at the end of his 'Explorations in the Eastern Karakoram and the Upper Yarkand Valley,' to realize the effects of this instruction and to get some idea of the roughness of the material that the old geographers had to go upon. Consider Johnson's topography of the upper Karakash and of the vicinity of the Karakoram pass, together with the comments of Colonel Wood. Look at the old Rimo Glacier and compare it with the one surveyed by De Filippi. Are they the same? See the glacier tributaries of the Siachen and of the Siachen itself, and compare them with Longstaff's exploration and his prophecies, so admirably fulfilled this year by the discoveries of the Vissers. Look at the geographical insignificance of the Nubra-Shyok watershed on the old atlas map, and compare it with what we know now from the explorations of Neve, Longstaff, Gompertz, and the Vissers. To-day I have received a letter from Khan Sahib Afraz Gul Khan, in which he details the exploration of the Shyok side of the Nubra–Shyok watershed. The old map was little more than guess-work, sketched from a long distance on a small scale. Remember that when Longstaff crossed the Bilafond pass as late as 1909, he thought at first that he had crossed the Central Asian watershed! This was after the publication of Sir Sidney Burrard's book. I am not casting discredit on the old surveyors: they did all that they were asked to do; but the accumulation of geographical knowledge is a gradual process, and early ideas must surely be modified when later facts are known.

Sir Sidney Burrard quotes me as saying: "It is first of all Moorcroft's misapprehension and then a misunderstanding of Hayward's intention, and of the observations of Montgomerie, that led European geographers to use the term *Karakoram range* as it is at present applied." I meant to stress the word *geographers* as opposed to active surveyors rather than the word *European*. Is it heresy to suspect that General Walker and consequently Sir Clements Mark-

ham, those great geographers, may conceivably have been mistaken in interpreting the views of Moorcroft, Hayward, and Montgomerie, all of whom were dead before the name Karakoram first appeared as a single range upon the map? Surely in view of this scanty knowledge of their time they must not be considered infallible. Neither had seen the country to which they were allotting the name Karakoram. I must risk being further misunderstood to substantiate the remark that has been quoted. Moorcroft's misapprehension was that *the watershed* between the Indus and the Tarim basins lay on a great range. It does not. But the map drawn in the drawing-office showed it to be a great range. Burrard says: "On almost all maps the water-partings are made the most conspicuous ranges." This watershed range, which passed through the Karakoram pass, was the primary cause of the name Karakoram being given to the water-parting, and afterwards adopted for the range. Hayward explored part of the Yarkand valley, but did not reach the source, nor discover that there were two ranges (the Aghil and Muztagh). He heard the name Muztagh for the ice mountains and called the only range he knew of, *Muztagh or Karakoram*, his first preference being Muztagh. Montgomerie, who only saw the summits of the peaks from the distant south, called the whole region "K" (=Karakoram). But he either accepted Hayward's nomenclature, *Muztagh or Karakoram*, or preferred that order himself. Godwin Austen, who first surveyed part of the main range, always alluded to the range as the *Muztagh*. As late as 1924 he corrected me when I referred to it as the Karakoram.

Sir Sidney Burrard remarks: "But while Montgomerie and General Walker at Dehra Dun were rejecting Muztagh, they were hesitating to adopt Karakoram." There is no question that Montgomerie and Walker were closely associated in many enterprises and were the closest friends. But is there any evidence that Montgomerie was rejecting Muztagh? Is it not possible that there was a little friendly obstinacy on the part of both? General Walker alone had the power to select either name for the map. As his subordinate, Montgomerie may have gone to the extent of conceding the Karakoram alternative, but he did not reject Muztagh. Is it only a coincidence that Hayward died in 1870, and that no name was given to the range in 1872, though parts of it were surveyed by Godwin Austen in 1861? Is it a coincidence that the name Karakoram appears first on a triangulation chart, covering all the area enclosed by the "K" peaks of Montgomerie? Is it a coincidence that it appears first for the Muztagh range alone on the maps of 1880, two years after the death of Montgomerie? I firmly believe that Hayward, Montgomerie, and Godwin Austen, the surveyors, were in favour of *Muztagh;* while General Walker and consequently Sir Clements Markham, the geographers, accepted *Karakoram.*

Sir Sidney Burrard writes throughout his criticism as though the *inhabitants* use the name Karakoram. There are no inhabitants. On both sides of the main ice-range there are traditions of two passes, both the Muztagh. Colonel Wood writes: "The name (Karakoram) is applied by the traders to the pass alone and not to the mountains. Dr. Thompson, who in 1848 was the first European to reach the pass, found the same in his day, and Hayward, in 1869, repeats the same information." Wood found the same in 1914, and I the same in 1926. It is we Britishers who have applied the name both to a region and to a watershed range, which is not a primary structure. There is no question of the Mongols

having applied the name Karakoram to the range, though they may have done so to the pass.

I have tried to make my position clear, that I criticized our sagacity, not that of our great predecessors. Would they be impressed with our sagacity if we retained a faulty nomenclature merely on principles of conservatism? Did they retain the elephants and dragons shown by their predecessors on the maps of Asia? Sir Sidney Burrard concludes that the growth of traditions "has been due to the continued co-operation of successive generations of men." Surely the succeeding generations are entitled to build on the foundations of the past.

HIMALAYAN NOMENCLATURE

DR. T. G. LONGSTAFF

IN approaching this most difficult subject we must be clear as to the precise context in which the nomenclature is to be used. Burrard and Hayden's standard work adopts a system which appears to me admirable for what I would call a large-scale description essentially physical and geological in outlook; and I should be very sorry to see any of this nomenclature changed. But the traveller, the mountaineer, the mere topographer, must use smaller units than we find dealt with in the classical 'Sketch of the Geography and Geology of the Himalaya Mountains and Tibet.'

Any system must be arbitrary: for example, when standing on any height between Gilgit and Hunza I have found it extremely difficult to visualize where the Karakoram ends and the Hindu Kush begins! Yet it is definitely convenient to use two different names, though we recognize that our system is a purely artificial one. Another example which is also familiar to me is the exceedingly well-defined group of peaks bounded on the north by the Saser Pass and on all other sides by the upper Shyok and Nubra rivers; I have only penetrated it once, but I have been completely round it; it forms a topographical unit if ever there was one, and yet it fits in schematically with both the Karakoram and the Kailas systems of Burrard and Hayden: I mean that this north-to-south topographical unit fits in with two immense east-to-west geological or geophysical units. The latter system is excellent for the purpose of systematic description, but most unpractical for the explorer or topographer studying the actual mountain complex on the ground. He can only speak of the "Nubra-Shyok Group" or of the "Nubra Peaks" because their approach is only feasible from the Nubra Valley, just as in the Alps we speak of "the Zermatt Peaks," or of the "Bergamasque Alps." With much diffidence I ask for the removal of the label "Kailas Range" from the peaks along the north bank of the Indus about Skardu, for to the onlooker they are indivisibly only the southern axis of the Karakoram. They may be tectonically a continuation of that axis of elevation marked by holy Kailas of Tibet, but both ranges I know, and each is so different from the other, and Kailas is so far from Skardu!

I see no alternative but to make use of two systems of names; what I would

call the "schematic" and the "topographical." Let us stick to Karakoram, rejecting Muztagh altogether for the reasons adduced by Sir Sidney Burrard, and particularize by using well-known topographical labels for splitting up the main axes of elevation. The "Saltoro group," the "Baltoro Peaks," the "Western Karakoram," the " Eastern Karakoram," are all ready to our hands for the differentiation of units of this great system, which is already so extensive that I would deprecate adding the Aghil range to the complex and would preserve its separate designation on historic grounds: at the same time registering my belief that the Karakoram Pass belongs physically to the Aghils rather than to the Karakoram system. But we cannot change the name of the Karakoram Pass.

Burrard's names "Ladakh Range" and "Zaskar Range" are good examples of the sort of topographical compromises I advocate. The Himalaya itself is better known than the northern systems and its nomenclature is less open to argument. We use the title as we use "the Alps," and distinguish the Himalaya "of Garhwal," or "of Bhutan," or the "Nanda Devi group" as the case may be. But the case of the Karakoram is admittedly more difficult. We might agree for convenience to make use of river valleys, which are hereabouts generally important lines of human communication, and define its western boundary as the Gilgit River, separating Karakoram from Hindu Kush; its southern boundary as the Indus-Shyok, instead of labelling the southernmost range as a continuation of Tibetan Kailas; the northern limit as the Shaksgam and Shingshal rivers, separating Karakoram from Aghil, for surely the face of the country is very different on the two sides of this great river trench. On the east the most *natural* limit seems to me to be the upper Shyok Valley, though having route-hunted east of this with Captain D. G. Oliver in 1909 I must admit that our knowledge is so defective that on this side we cannot speak with any certainty and our decision must be merely an arbitrary one and, worse than that, perhaps only temporary! But there is a very obvious change in the character of the ranges on the two sides of the upper Shyok, and as we penetrated eastwards conditions became definitely Tibetan in character and completely different from the Eastern Karakoram, in which I had travelled for the previous three months.

THE APPLICATION OF STEREOSCOPIC PHOTOGRAPHY TO MAPPING: *A paper read at the Afternoon Meeting of the Society, 11 November 1929, by*

CAPTAIN M. HOTINE, R.E., Geographical Section, General Staff

THE surveying camera is really an instantaneous, yet fairly accurate, theodolite. A single photograph exposed in it will do no more than provide a rapid record of angles which could be measured from the camera station. If the photograph is exposed in a vertical plane, then it becomes an easy matter to derive horizontal and vertical angles from it by measurements on the plate or by simple graphical constructions. This, then, constitutes the first and most direct method of photographic survey which is still used with advantage for small-scale work in the mountains of British Columbia. Photographs are exposed at 1 and 2 (Fig. 1) from the ends of a long base and are

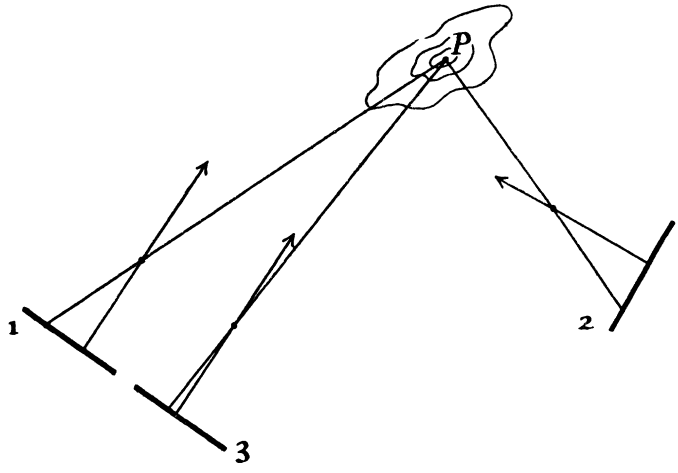


Fig. 1. Direct method of photographic survey

used to intersect the position, and determine the height, of detail appearing on both photographs.

The main trouble in this class of work is that the same object P may have an entirely different appearance on each of the widely dissimilar views, and it becomes easy to intersect the wrong point or to provide an inaccurate fixation of the right point. The difficulty may be overcome by exposing photographs at 1 and 3, from the ends of a short base, but in that case we should obtain a narrow angle intersection which is the bane of all good graphical surveyors. To overcome this further difficulty, graphical methods were given up in favour of precise micrometric measurements on the photographic plates, coupled with the stereoscopic examination of the photographs in order that corresponding images might be identified with certainty. The stereoscope is in this case merely a convenient means of seeing two things at once, and has no particular magic of its own.

If we continue to expose the photographs in vertical planes, then we shall

retain that facility for the simple determination of horizontal and vertical directions from either camera station. If we go farther and expose the two photographs in the same vertical plane, then it becomes a simple matter to convert stereoscopic measurements on the photographs into horizontal distances from the base line, and thus provide a complete fixation. Full details of this system have been printed from time to time—for example, in an article by Lieutenant (later Brigadier-General) F. V. Thompson on "Stereo-photo Surveying" in the *Geographical Journal* (31, 534, May 1908)—and it is not proposed to repeat them here. The general principle on which the measurement rests is illustrated by Fig. 2. Any natural object will give rise at exposure to corresponding images o and o' on photographs P and P' taken from the ends of the base EE'. During stereoscopic examination, the photographs may be viewed from E and E' in such a manner that only one picture is presented to each eye. The stereoscopically fused image of the original natural object will then appear to lie at O. A pair of artificial "floating marks" ff', in optical contact with the photographs, will similarly give rise to a stereoscopically fused image at F. By moving o or f in the plane of the diagram the relative distances of O and F from the eyes can be varied. The amount of this motion to produce apparent equality in distance between O and F—which occurs when $oo'=ff'$—is measured micrometrically and is used in a simple formula to determine the corresponding distance in Nature. This simple discussion is open to several more or less academic objections, but it will suffice for a condensed practical explanation. A full account of the subject will be found in Professional Paper No. 4 of the Air Survey Committee, although even that is not entirely free from academic objection. This system was first applied practically in Fourcade's Stereocomparator (Pl. 1) about 1900. The widespread belief that Pulfrich of Zeiss was first in the field is entirely due to the fact that Mr. Fourcade was and still is modest about his achievement. Reference should be made to Mr. Fourcade's own description of the construction and use of this instrument in the *Transactions of the Royal Society of South Africa* (vol. 14, 1926, p. 83). It might still be used with advantage for small-scale surveys of mountainous country, where the main requirement is a framework of point fixings on which to hang intermediate sketching, and which could not pay the overhead costs of modern automatic machines.

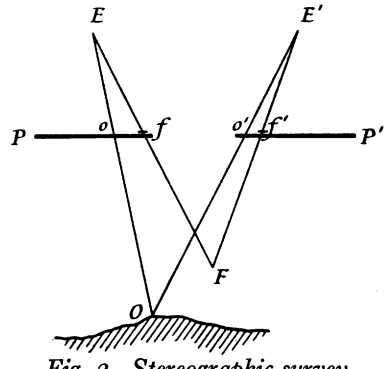


Fig. 2. Stereographic survey

In order to secure as much ground as possible on a pair of photographs, it was later found desirable to give up the restriction to exposure in the same vertical plane and to expose the photographs on tilted and converging orientations. At the same time, attempts were made to avoid the labour and possible mistakes involved in any system of point-by-point plotting and to substitute some means of automatically plotting plans and contours from the perspective stereoscopic view. These attempts have led to the evolution of such machines

as the Thompson Stereoplotter, the Von Orel Stereoautograph, the Hugershoff Autocartograph, the Wild Autograph, which have been described from time to time in the Society's *Journal*. The first machine of this type (Fig. 3) is due to Deville, the late Surveyor-General of Canada. The photographs were viewed by reflection at the surfaces of two half-silvered mirrors under such conditions of distance and position relative to the eyes as would serve to re-establish the internal perspective of the field camera. The photographs and mirrors were further adjusted to reproduce the external orientation of the two views, when a virtual true-to-scale stereoscopic image of the landscape could be seen, apparently behind the mirrors. A "floating mark" consisting of an adjustable target carried on a movable vertical column could be moved about in this virtual image in apparent coincidence with various natural features. A pencil at the base of the column plotted the position of such a natural feature, while the height of the target above the plotting board furnished a measure of relative altitude. For pure simplicity this arrangement has never been surpassed, but unfortunately it has certain optical and mechanical disadvantages

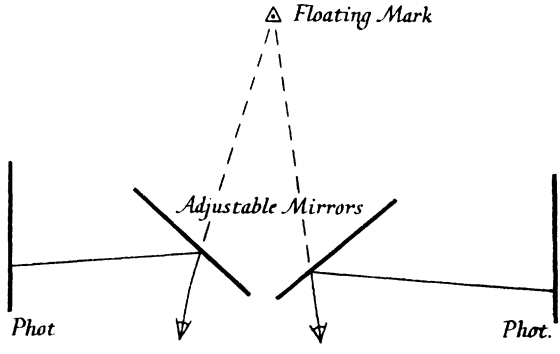


Fig. 3. Deville's Stereoscopic Plotter

which decided the inventor against its full development. It is interesting to note that the same principle of a real "floating mark" has been used in at least two modern machines.

The last machine of this type is that finished piece of intricate workmanship known as the Wild Autograph (see *G.J.*, 70, 358, October 1927), which provides a complete, if complicated, answer to any orientation or tilt whatsoever of the camera during exposure, provided such exposure conditions are measured on the ground or can be subsequently determined. It is used extensively for ground surveys in mountainous regions, and is probably an economic proposition on medium or large scales. There is little doubt about the excellence of the maps produced under these conditions. Even in mountainous country consisting of well-defined steep ridges, as opposed to broken country, certain areas of dead ground appear on the ground views, but no difficulty is experienced in filling these by the plane-table.

This stage of development has by no means been neglected in this country. Messrs. Barr & Stroud have produced a Photogrammetric Plotter which is superior in general conception and practical simplicity to any Continental

model. Like all first models, it contains certain mechanical defects which can easily be remedied in subsequent instruments.

The introduction of photography from the air has considerably extended the possible applications of photographic surveys by providing suitable views of flat or undulating country, with the further advantage that longer bases are usually possible than in the case of ground stereographic surveys. It has, however, introduced the problem of unknown exposure conditions, for whereas the position, tilt, and orientation of a photograph exposed deliberately on the ground can easily be measured directly, none of these quantities has so far been obtained directly in the case of air photographs. The aeroplane travels so fast that its position cannot be established to any useful degree of approximation, while random accelerations preclude a determination of level closer than a few degrees. Most of the machines mentioned above were designed on the assumption that the exposure conditions were obtainable by direct measurement, and they consequently depended on this facility for rapid and economic setting of the photographs, in their correct positions for plotting. Wholehearted, if perhaps misguided, efforts have subsequently been made to adapt them to the case of unknown exposure conditions. The conditions are however so entirely different from those obtaining in the case of ground photographs that it is safe to say, in the light of after knowledge, that the whole question should have been tackled afresh.

An individual air photograph, or an individual stereoscopic pair of air photographs, requires some form of surveyed ground control in order to establish these exposure conditions. Failing direct measurement in the air, which is not likely to be realized with sufficient accuracy for many purposes, there is no alternative. Originally attempts were made, notably by Professor Hugershoff, to establish the exposure conditions of single photographs from ground control by calculation. Such methods have been considerably shortened in this country by Captain McCaw, but even so, no economically practicable system of computation has been evolved. Linear and angular dimensions are so hopelessly intermingled in this problem that a simple solution is never likely to be discovered. The difficulty has been overcome in an instrument invented by Lieut.-Colonel (now Colonel) MacLeod known as the "Tilt Finder" and constructed by Messrs. Barr & Stroud, as a means of providing the setting data for their Photogrammetric Plotter. The experimental model of this instrument contains certain optical defects which limit its accuracy to about 15 minutes of tilt, but it is reasonable to suppose that these could be eliminated in subsequent design. A more promising field than the treatment of single photographs has however opened recently, and further development of the instrument is consequently in abeyance.

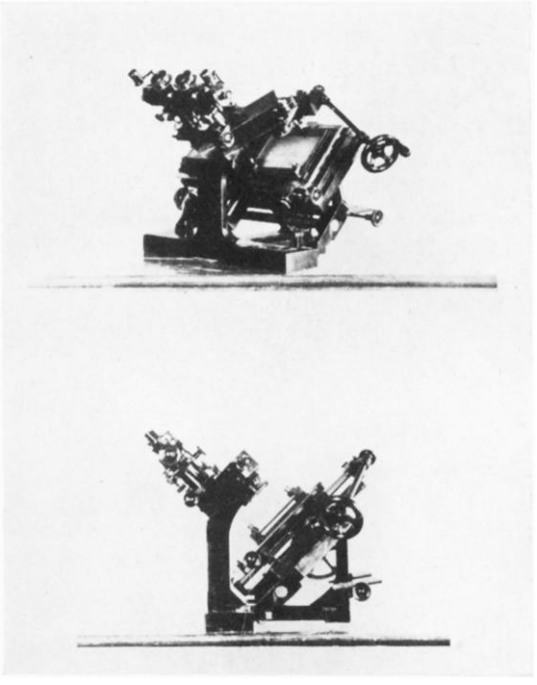
The usual system of setting now practised is to set a stereoscopic pair simultaneously, using the principle of "correspondence setting" originally devised by Mr. Fourcade about 1925. The photographs are first set relatively "in correspondence," which simply implies that the visual directions to corresponding points of photographic detail shall intersect in single image points to produce a true stereoscopic image of the landscape. This operation requires no ground control. Secondly, both photographs are moved together in order to establish the scale and level of the stereoscopic image from ground control.

We shall see later how Mr. Fourcade himself applies this principle. For the moment it will suffice to say that the movements of all Continental machines are not suited to the application of this new method of setting. The first operation of correspondence setting can usually be performed reasonably quickly and accurately, but the subsequent settings for scale and level destroy the initial correspondence setting, with the result that the whole operation has to be repeated by trial and error. A good final result can undoubtedly be obtained, but hardly at an economic speed.

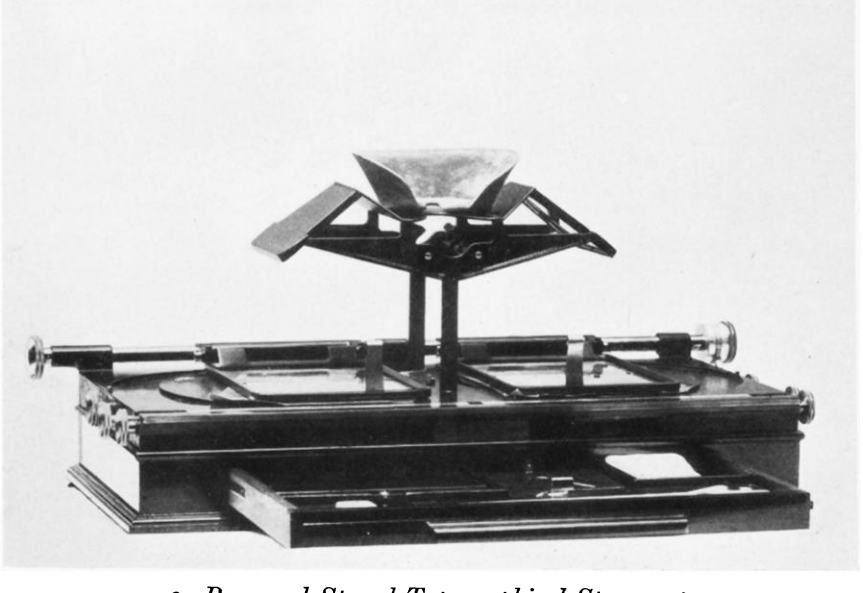
The modification of Continental machines to deal with the setting of air photographs has led to a good deal of instrumental "patchwork." The most notable example is the Wild Autograph, in which an additional movement is now employed. This machine produces excellent 6-inch maps from air photographs, at the rate of 1 sq. mile in 16 hours. Using a somewhat different principle, Mr. Brock, of the firm of Brock & Weymouth, Philadelphia, has devised a modified method of using the original stereocomparator with vertical air photographs. Here again excellent maps are produced, but four hours are consumed in the tilt correction of one pair of plates. The complexity of these modified ground machines, and the time required for setting air photographs in them, mean that they cannot economically be used for air surveys on topographic scales. In addition they mostly require a dense ground control, which adds very considerably to the cost.

Concurrently with such instrumental methods, various simple and wilfully approximate methods of dealing with vertical air photographs have been evolved in order to solve the problem of topographic scales. We have, for instance, the "mosaic" or composite photograph obtained by sticking individual prints together on a common base. In the hands of enthusiasts this "mosaic" idea has from time to time been the subject of gross exaggeration and over-statement, with the result that it is looked on by many surveyors with far more distrust than it actually deserves. The truth is that it furnishes a rapid means of obtaining a very detailed picture of an area of flat country, which may often be used as material for topographic mapping not requiring a greater degree of accuracy in the measurement of short distances than 2 or 3 per cent. In undulating country it is less valuable—on account of the differences in scale occurring at different levels—while in hilly country it cannot be compiled at all. I have, indeed, recently seen a "precise mosaic" of part of the American Rockies, obtained by cutting out portions of the photographs at the same contour level, subjecting these portions to an individual degree of enlargement, and assembling in much the same manner as a relief map. Apart from the prohibitive amount of time required to compile such a mosaic, a knowledge of the relief has to be acquired which in that type of country amounts almost to complete mapping. It is interesting, but can hardly be considered a serious contribution to economic mapping.

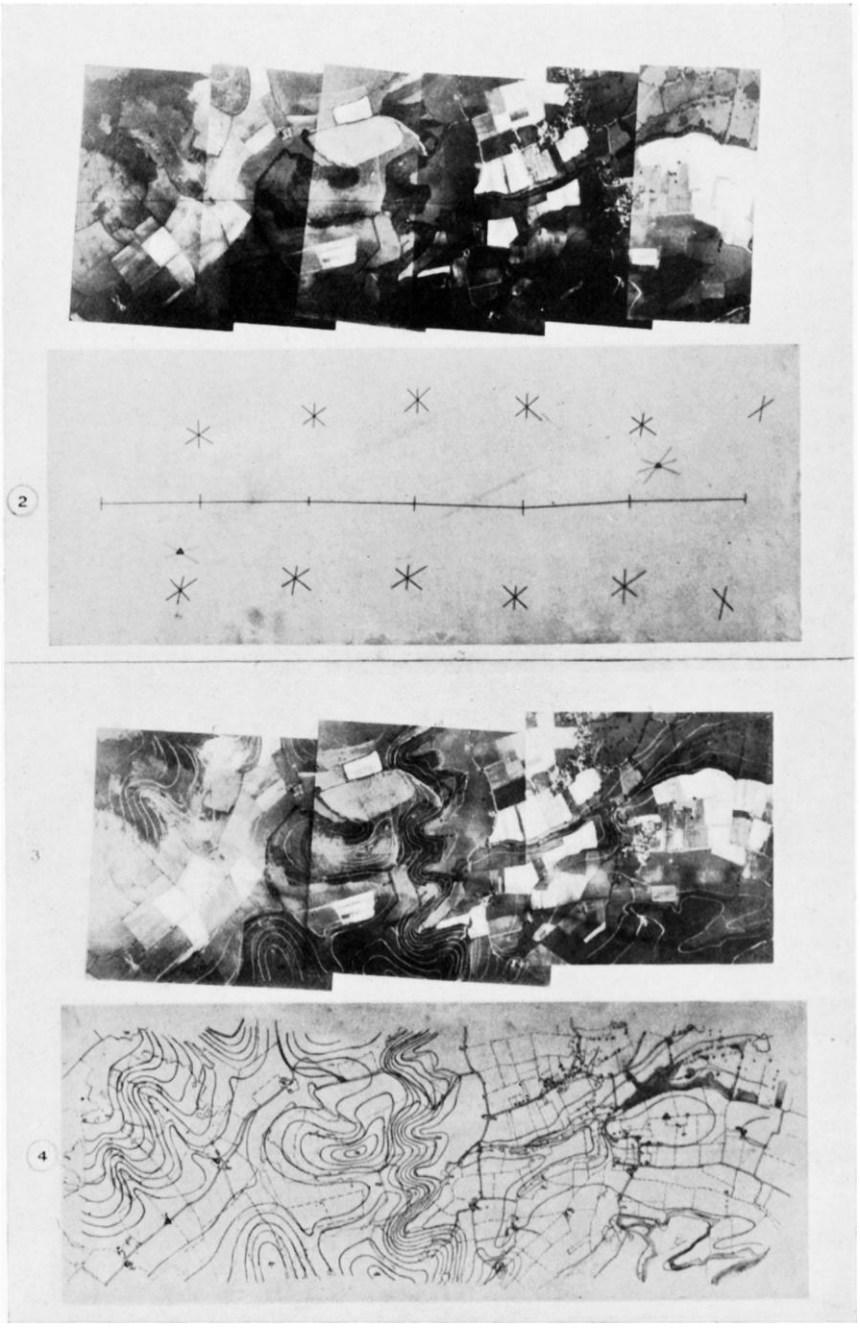
While still retaining the merit of simplicity, we can improve very considerably on the mosaic by graphical plotting and by simple stereoscopic interpolation of heights and contours between a network of control heights fixed on the ground. Such a method has perhaps been developed in greater detail in this country than in any other, although the principles on which it rests are age-old. There is, indeed, some doubt as to whether the credit should be given to the



1. Fourcade's Stereocomparator



2. Barr and Stroud Topographical Stereoscope



3. Experimental Survey: Arundel Method

inventor of the plane-table, whoever that was, or to a gentleman in the United States who dealt in photographs taken from balloons about 1898. We call this the "Arundel" method because it was first put into practice in this country in an experimental area near Arundel. Part of this experimental survey is illustrated in Pl. 3 in the various stages of blank photographs, control plotting, contoured photographs and finished map. The only instrument used in present practice is the Topographical Stereoscope constructed by Messrs. Barr & Stroud and illustrated in Pl. 2.

The Arundel method produces excellent topographical maps rapidly and cheaply, but in its simplest form its application is restricted to country varying in relief by not more than 10 per cent. of the altitude of flight. It also requires a network of ground heights—something like 4 or 5 per square mile—and fixed positions every 5 to 10 miles. Good draughtsmanship is essential for the purely graphical plotting, although this can be replaced by a simple extension employing a little computation. Under these conditions, the method will continue to be used in spite of any foreseen future development. The burning questions of time and money will always ensure that no more complicated method is used than the scale and purpose of the survey warrant.

An attempt has recently been made to avoid the restriction imposed on permissible relief of the ground by obtaining the tilt of each photograph from a form of computation based on Fourcade's correspondence principle. No additional ground control is required, but the time of plotting is increased by half an hour to an hour per photograph. This method also takes its name from the location of the experimental survey near Clova in the Eastern Highlands of Scotland. So far as results are concerned this experimental survey was entirely successful. Unfortunately, the method is rather too complicated for routine work in large areas. The same process will probably be simplified and quickened by using the Fourcade Stereogoniometer (described below) or by developments in air navigation tending to more stabilized flying. Gyroscopically controlled aircraft may, for instance, make it possible to limit the determination of tilt to, say, every tenth picture.

Full details of the Arundel and Clova methods will be found in Professional Papers Nos. 3, 4 and 6 of the Air Survey Committee.

To overcome the limitations of the Arundel method on topographic scales, as regards relief and close height control, as well as to provide a ready means of tackling larger scales, the tendency is to employ a machine, but a machine designed expressly for the unknown exposure conditions obtaining in the case of air photographs. I refer to the Fourcade Stereogoniometer, which is shown diagrammatically in Fig. 4. Essentially, the machine consists of a pair of cameras CC' in whose focal planes are placed the photographs under examination. The position of the photographs, and the lenses of the two cameras, can be adjusted to correspond with the camera in which the photographs were originally exposed. The photographs are observed through a fixed binocular telescope system T provided with floating marks, the sighting rays being reflected into the camera objectives by two plane mirrors M and M'.

In order that different parts of the photographic field in a vertical direction may be brought under examination, both cameras may be swung *together* about a horizontal axis PP', which represents the base line joining the two camera

stations. To bring different parts of the field in a horizontal direction under examination the mirror carriers are movable together in a direction parallel to *PP'*. At the same time the mirrors themselves are automatically rotated about vertical axes by the amount necessary to ensure that the perspective ray to the point sighted is reflected along the fixed line of collimation of the telescope (see the dotted position of the mirrors in Fig. 4). To vary the convergence of the sighting rays, and thus alter the apparent stereoscopic depth of the photographic image in relation to the floating marks, provision is made for a similar movement of the right-hand mirror only.

In addition to these three observation movements, five setting movements are provided in order to bring the two photographs into correspondence, as defined above, and thus into their correct positions relative to one another and to the base line. These movements are indicated on Fig. 4 by arrows. The first model of the instrument is shown in Pl. 4. A new model is now being designed by Mr. Fourcade with an automatic plotting mechanism which is coupled to the observation movements.

There are four main points about this instrument to which I should like to

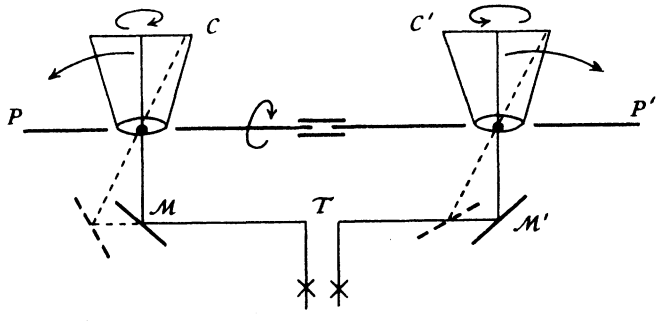


Fig. 4. Principle of the Fourcade Stereogoniometer

call your particular attention. The first is that the correspondence setting movements are made in respect to the base line, to which they are properly related, and not, as in all Continental machines, to the horizontal. The result is a quicker and more accurate relative setting in cases where the base line is inclined to the horizontal. The second is that the observation, or plotting, movements are entirely distinct from the setting movements and have no effect on the previously established correspondence of the photographs. The result is that both trial and error are reduced to a minimum. The third is that no hard-and-fast type of ground control is required. Depending on the scale and purpose of the survey, the control may vary from a base length and two angles of elevation or depression on each pair of photographs, to a similar amount of control at each end of a strip of photographs; from an ordinary triangulation, to a simple record of altitudes measured in the air. The fourth is that the use of the instrument may vary from the determination of tilts and spot heights for rapid detail plotting by the Arundel method to automatic plotting for more deliberate or larger scale surveys. These considerations would appear to indicate a wider field of practical application than has hitherto been possible with the Continental machines.

THE BARR AND STROUD PHOTOGRAMMETRIC PLOTTER

In the course of the preceding paper I remarked that the Barr and Stroud Photogrammetric Plotter was "superior in conception and practical simplicity" to any Continental machine designed for the same purpose. During the subsequent discussion this statement was received with some scepticism, due perhaps to an undue British reticence. The Barr and Stroud machine has not yet been described, but if silence is being taken as a sign of failure, then it is

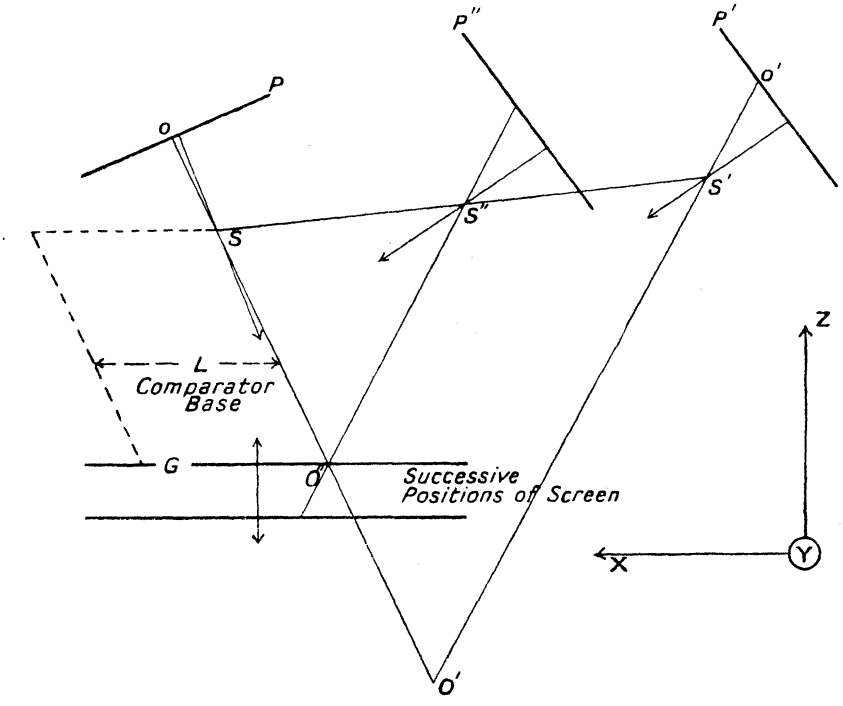


Fig. 5. Geometry of the Photogrammetric Plotter

indeed time for this defect to be remedied. Professor Barr, the designer of the machine, could have written a far better description, and I asked him if he would consent to do so. In a way I am glad that he refused. My own efforts will be less hampered by the modesty pertaining to and becoming the designer himself.

Geometrical Principles and Plotting Movements

Imagine a pair of air photographs P, P' (Fig. 5) exposed at the ends of a base SS' and covering, in whole or in part, the same area of country. If the plates were taken out, developed and put back in their original positions in the cameras—which for the moment are assumed not to have been moved—then it is clear that light-rays originating in corresponding image points o, o' on the photographs and passing through the camera lenses would intersect in the position of the natural object O' which gave rise originally to such corresponding

images. Theoretically, at any rate, this would provide a means of "reconstructing" the original landscape to its natural scale.

Instead of keeping the cameras immovable between exposure and reconstruction, suppose that we move $S'P'$ always parallel to itself and in the direction of the base-line SS' until it takes up a position $S''P''$. The reconstructed landscape (of which O'' is one point) will now be similar in all respects to the original landscape, but reduced in all linear dimensions in the ratio SS''/SS'. A little consideration will show that this must be so, without the necessity for a mathematical proof.

Suppose that we take a screen G to represent a horizontal plane in Nature and arrange to give it a single movement perpendicular to its plane, that is, in the vertical direction in Nature. When the two corresponding images caught on this screen coincide in a single point O'', then the position of O'' on the screen will provide its plan position in relation to the position of the base-line SS''. If the rays originally came from a point at a higher level than O', the screen G would have to be moved higher in order that the two rays might meet on the plane of the screen. Movements of the screen for various points on the ground therefore give a measure of the relative levels of these points.

Equally well, we may keep the screen fixed and bring the two corresponding images into coincidence at O'' by moving both cameras together in a direction at right angles to the screen. The amount of this movement of the cameras (known as the Z-motion) will now furnish a measure of vertical heights. It will be evident that all points on the ground at the same level as O' will have their two projected images coincident on the screen, and the plan positions on the screen of these images will correspond to the plan positions of the original points on the ground. When the level of the screen, or the distance from it of the cameras, is altered to bring a fresh set of points into coincidence, the plan positions of these other images will as before correspond to the plan positions of the original points on the ground. A pencil moving over a drawing-board in such a manner that its movements are always equal and parallel to corresponding distances between coincident screen images will plot the plan positions of these screen images.

As a further possibility, we may provide two more movements for the cameras and thereby bring corresponding screen images into coincidence with a particular point on the fixed screen. These movements, which are both parallel to the plane of the screen and, for convenience, are arranged in directions at right angles to one another, provide a means of establishing the relative plan co-ordinates of such points as O''. If these movements, known as the X- and Y-motions, are imported by direct gearing to the drawing-board, then the pencil, which is now considered fixed, will automatically plot plan positions.

Either of the methods described in the last two paragraphs may be employed for plotting plan positions. Actually, both methods are used in a manner which will appear later.

Before plotting, we have seen that the photographs have first to be replaced in projection cameras geometrically similar to the field cameras. These projection cameras are provided with certain setting movements in order that they may occupy the same positions relative to the machine base-line (SS'' in Fig. 5) and to the plane of the screen as the original field cameras occupied relative to

the field base (SS' in Fig. 5) and to the horizontal plane in Nature. By means of the plotting movements described above we are then able to derive a correct plan of the landscape and also a measure of relative heights. The scale of the resulting map, in all three dimensions, will be SS''/SS'.

If the photographs had been exposed on the ground instead of in the air, in such a manner that they occupied planes more nearly vertical than horizontal, then we consider the plane of the screen to represent a vertical plane in Nature. In that case, the Z-motion of the machine affords a measure of horizontal distances, and the Y-motion affords a measure of heights. If the X- and Z-motions are now coupled to the drawing-board—instead of the X- and Y-motions—we are still able to draw direct plans. By this means the machine is made capable of dealing with photographs at any inclination whatsoever.

In one respect only does the geometry of the actual machine depart from the foregoing simple description. The two projectors are separated in the X-direction by an arbitrary amount L from the theoretical positions SS'' of Fig. 5. The two screen images are then no longer observed in actual coincidence but are considered as coincident—for the purpose of plotting—when they fall at the same distance (L) apart as the projectors have been separated. The increased separation L is known as the "comparator base." This device is employed also in most Continental machines. Mechanically it provides more room for the projectors, and optically it enables the two views to be examined stereoscopically without the necessity for first disentangling the images of the two pictures.

Optical Principles

For the internal perspectives of the two photographs to be correctly re-established, we have seen that each photograph must be placed in the focal plane of a projector equipped with a lens similar to that of the field camera. The emergent beam from the projector lens will thus consist of parallel light which would only form a sharp image at infinity. To bring this beam to a focus on the screen a system of auxiliary lenses is employed (see Fig. 6, which represents a side elevation).

In order that the geometry of the machine shall be unaffected by the introduction of this auxiliary lens system, it is necessary for the axis of the latter to coincide in all positions with the line joining the screen image O'', of the point under observation, to the front nodal point S'' of the projector lens. (O'' and S'' have been lettered to correspond in Figs. 5 and 6.) It will be seen later that an approximation is made in this respect when plotting is carried out over limited areas without moving the projectors in X and Y. It remains true, however, to say that the axis of the auxiliary lens system passes through the mean point of observation and through the front nodal point of the projector lens. This condition is ensured in the following manner (see Fig. 6). The auxiliary lens system is given three motions of translation similar to the three co-ordinate motions of the corresponding projector; the girder *1* carrying the auxiliary lenses moves bodily in the Y and Z directions, while the lens system moves along this girder in the X direction. The auxiliary lens system is carried on two gimbal axes *2–3* and *4*, intersecting in the point *4* on the axis of the auxiliary lens system. By initial adjustment of the X, Y and Z motions of the auxiliary lens

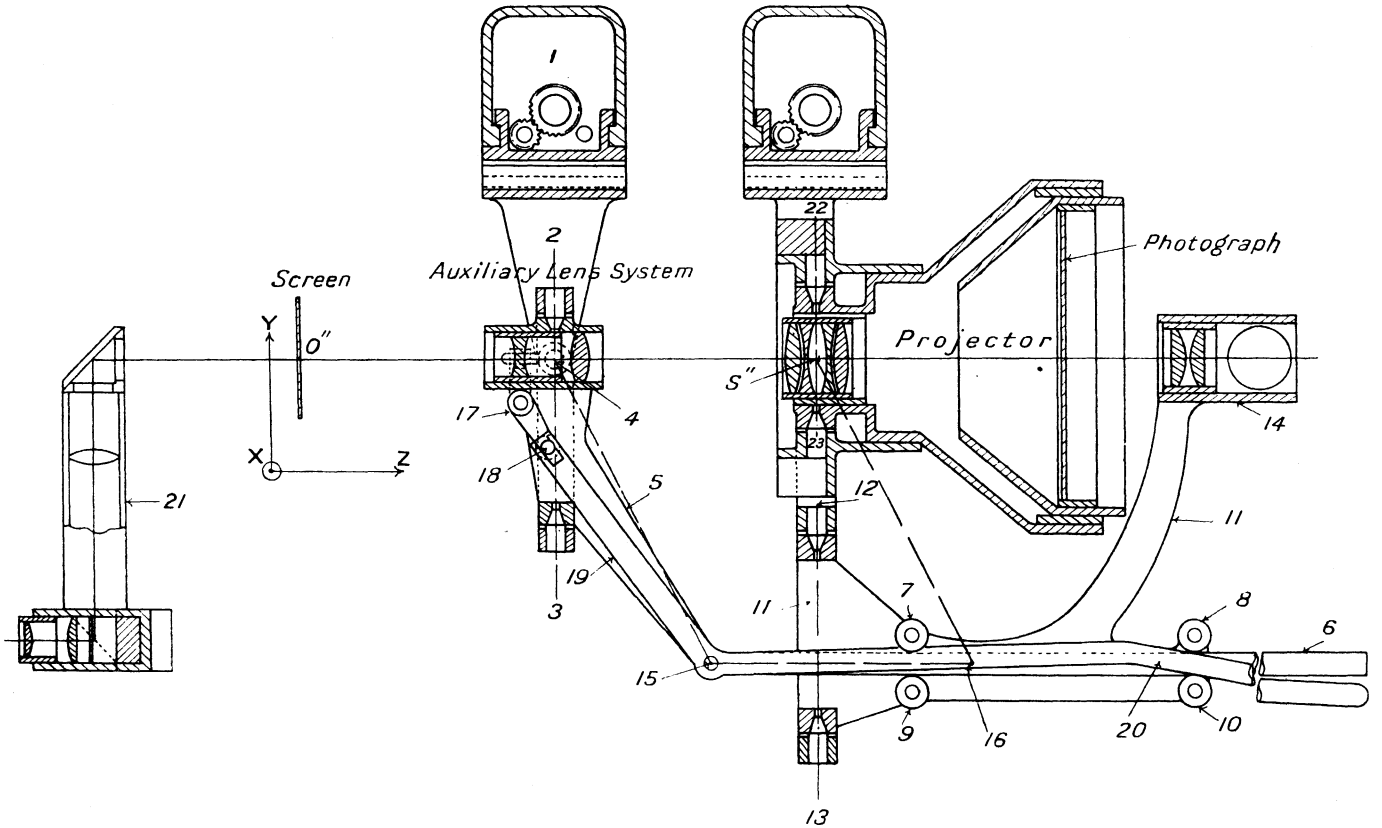


Fig. 6. Construction of the Barr and Stroud Photogrammetric Plotter

system the point *4* is brought on to the line *S''O''* at a point midway between *S''* and *O''*. Thereafter this relative position is maintained by imparting half the X, Y and Z motions of the projector to the corresponding movements of the auxiliary lens system. These movements of the auxiliary lens system are provided automatically through reduction gearing from the X, Y and Z controls of the projector movements.

This arrangement ensures that one particular point on the axis of the auxiliary lens system always falls on the geometrical line of sight *O''S''*. It remains necessary to rotate the axis of the auxiliary lens system about this point until it passes through the front nodal point of the projector lens, and thereafter to preserve this condition automatically for all movements of the latter. This is done by means of the arm *5*, which is rigidly coupled to the auxiliary lens system and is continued as the rod *6*. The latter slides between rollers *7*, *8*, *9* and *10*, which are fixed to the bracket *11*, carrying gimbal axes—of which *12–13* is one —intersecting in the front nodal point (*S''*) of the projector lens. Initially the centre line of the rod *6* is arranged parallel to *O''S''*.

Mechanically, this linkage is equivalent to a single rod rigidly connected to the auxiliary lens system and sliding in a sleeve universally jointed to S''. Its action may be explained alternatively as follows: Suppose that *15* is a point on the centre line of the rod *6* at its junction with the arm *5*. Imagine a point *16* on the centre line of *6* and rigidly associated with the frame *11* in such a manner that *S''–16* is equal and parallel to *4–15*. These two lengths clearly remain equal after any movement whatsoever of the projector or the auxiliary lens system. Moreover, since the angles *S''–16–15* and *4–15–16* always remain fixed in magnitude, *S''–16* and *4–15* are always parallel. Consequently, *15–16* is always equal and parallel to *4–S''*. Any rotation of the line of sight *4–S''* is thus equal to the resulting rotation of the rod *6*, which is imparted through the rigid joint *15* to the axis of the auxiliary lens system.

The bracket *11* carries a condenser and lamp *14*, whose centres are initially adjusted on a continuation of the sighting ray *O''S''*. By means of the mechanism described, the centres of the condenser and lamp remain on the sighting ray *O''S''* for all related movements of the projector and auxiliary lens system, and thus constantly illuminate the photographs in the areas under examination.

It may be admitted here and now that the mechanism described above and illustrated in Fig. 6 introduces errors, particularly in the Y direction, owing to faulty balancing. These errors do not seriously affect plan positions, as plotted, but they are too great to allow the machine to be used for setting the photographs in the machine itself on the Fourcade correspondence principle. Such an application was not, however, considered in the initial design, and the defect could easily be eliminated in subsequent models. Photographs are set in the first model from data acquired in a separate instrument—either from individual photographs in the MacLeod Tilt-Finder or from stereoscopic pairs in the Fourcade Stereogoniometer. These data are provided in both cases by marking the actual plumb points on the photographs and by recording the length and inclination of the base. But for this (avoidable) source of error in the Y-direction, the machine itself could be used for correspondence setting quite as well as any Continental machine.

It remains desirable to vary the focal length of the auxiliary lens system in

order that focus on the screen may be preserved for all variations in the distance $O''S''$ (or O''–*4*) consequent on the X, Y and Z motions of the projector. This is done by mounting the double convex component in a separate barrel provided with pins engaging in a slotted lever pivoted at *17*. The lower end of this slotted lever is provided with a pin *18* moving in a slot at the end of the lever *19*. The latter is pivoted at *15*, whence it is continued as the curved arm *20* passing over a fixed roller in front of *10*. The under side of *20* is given a definite shape which regulates its rise and fall as the distance between the projector and auxiliary lens system is varied. By means of the lever system described above, the rise and fall of *20* is transformed into an alteration of the separation between the two components of the auxiliary lens system, with an attendant variation in the focal length of the combination.

The two screen images are observed by means of a stereoscopic comparator *21*, provided with floating marks. The apparent separation of the floating marks on the screen is made equal to the "comparator base" as described above. Alternatively, the stereoscopic comparator may be replaced by a coincidence comparator in which comparison between halved images is made on the principle of the ordinary Barr and Stroud coincidence rangefinder.

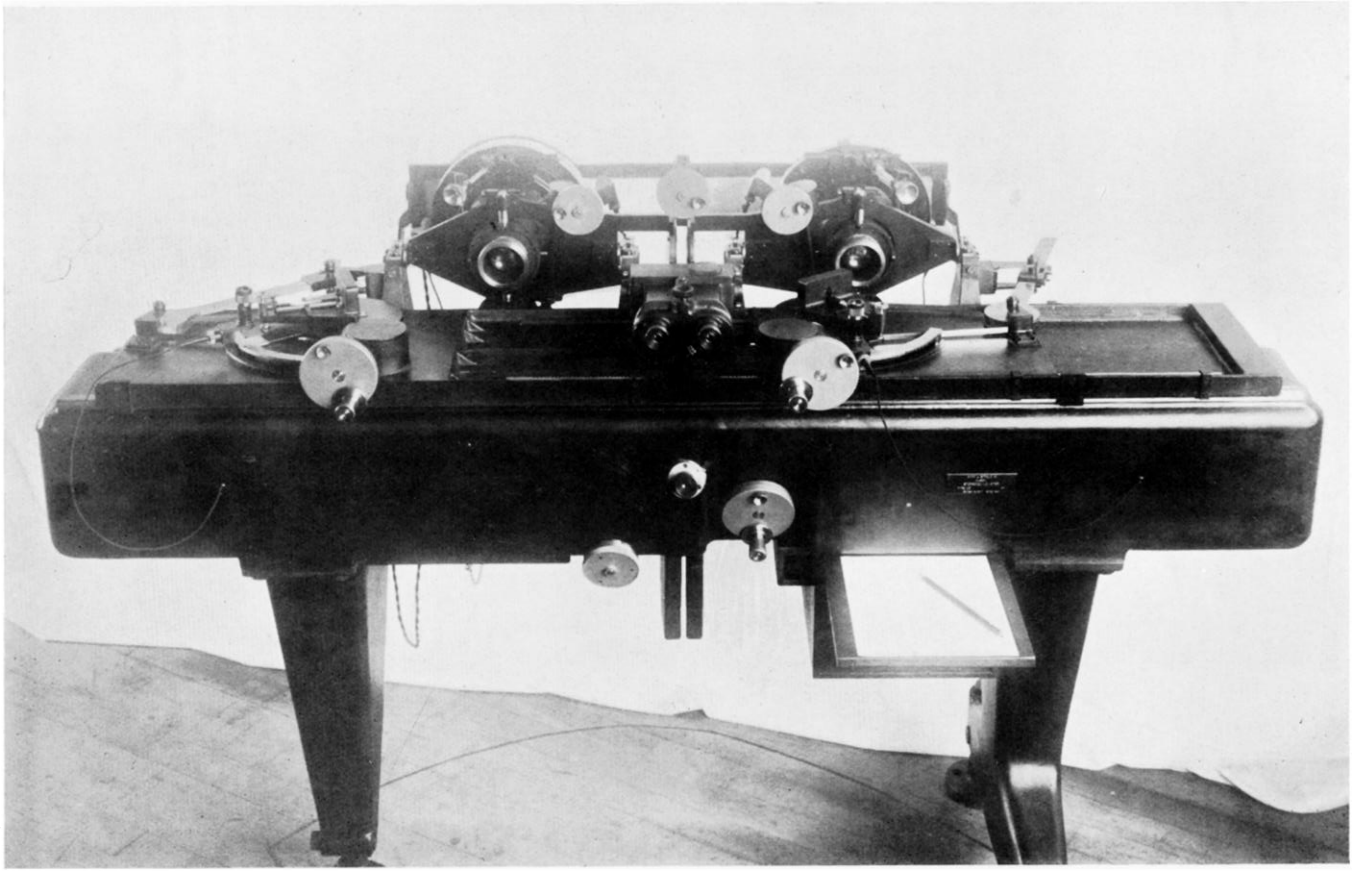
So far, the description of the machine rests on the replacement in the projectors of the original photographic negatives, in which case the landscape is reconstructed true to scale and form, from the point of view of an observer looking at the screen from the position of the projectors. The effect of observation on the other side of the screen is to reverse the apparent relief of the landscape, without modifying the truth of its geometrical reconstruction, and thus to provide the unnaturally flat impression usually associated with pseudoscopic vision. This difficulty is overcome, and the natural appearance of the landscape is also increased, by using glass positives printed from the original negatives. There is no need to introduce any complicated system of optical inversion so dear to the hearts of Continental designers.

Setting Movements

To re-establish the photographs in their correct relative positions, the following movements are provided:

To re-establish the internal perspective of each photograph in relation to the projector lens, the photograph is given two motions of translation in its own plane and one motion at right angles to its own plane. The extent of these motions is determined by calibration of the field camera, and the corresponding adjustments in the machine remain fixed for use with a particular camera.

To obtain the external perspective the photograph may be rotated in its own plane, and the projector as a whole may be tilted about an axis passing through the front nodal point of the projector lens (*22–23* in Fig. 6). These two motions enable the marked plumb point of an air photograph to be brought on to the counterpart in the machine of the plumb line in Nature (that is, the perpendicular on the screen from the front nodal point of the projector lens). A further rotation of the whole projector about this plumb line allows for the external orientation of the photographic perspective. In dealing with air photographs, these latter motions of the projectors are worked until correspondence of photographic detail is secured in the vicinity of the plumb points.



4. The Fourcade Stereogoniometer

5. The Barr and Stroud Photogrammetric Plotter

In future models it will probably be advisable to replace these movements of each projector by one rotation of the photograph—in its own plane—and one tilt in each of the fixed X and Y directions. This would enable the principle of correspondence setting to be applied almost as well as in the Fourcade machine itself and far more rapidly than is possible with the involved geometry of the Continental machines. The method of setting would be approximate, but would probably attain sufficient accuracy without prolonged successive approximation—especially in the case of vertical air photographs.

One projector may be moved independently of the other in the X direction. The amount of this motion is determined by a final separation of the two projectors equal to the length of the base—to the required scale of plotting—plus the length of the "comparator base."

One projector is given an offset movement in the Z direction equal to the difference in altitude of the two air photographs—also to the required scale of plotting. A similar offset movement in the Y direction is provided for setting an inclined base in the case of ground photographs.

Similar movements, equal to half the corresponding projector movements, are imparted to the auxiliary lens systems.

X, Y and Z scales are provided to enable the relative co-ordinates of any point in observed coincidence with the comparator floating marks to be read off direct.

Mechanical Details

Such details of operation as have not been described above may best be gathered from the photograph of the actual machine reproduced in Pl. 5.

The X, Y and Z control wheels are placed on either side of the observer. Clutches are provided which enable the drawing board to be moved independently of the projectors (to set for the origin of the plot) or coupled to the X and Y (or Z) projector movements. During the plotting of air photographs the main controls are moved until a fresh patch of detail is thrown on the screen. The comparator, to which the drawing pencil is attached through an extension arm, is then moved over the screen image with the floating mark in successive contact with photographic detail which it is desired to plot. An occasional turn of the Z control is required during this process to bring the floating mark to equality in depth with the stereoscopic image, though no great accuracy is required in this respect. To trace contours, the Z control is fixed—at the required height—and the floating mark is moved in apparent stereoscopic coincidence with the ground, either by the X and Y projector controls, or—locally—by moving the comparator.

By means of two suspension wires led over pulleys and attached to the same balance weight, the comparator is prevented from rotating but is otherwise free to move in two dimensions. This motion is so well balanced that no difficulty is experienced in tracing continuous detail in two dimensions, especially as the movement of the comparator is parallel to the shape of the detail. The comparator may be moved by one hand or two, and forearm rests are provided for steadiness.

The drawing pencil can be raised out of contact with the paper, either temporarily or permanently, by means of a lever and catch placed convenient to the observer's left hand.

The screen may be moved bodily up and down by means of the screen control, and at the same time the comparator may be swung round through 180° to observe on the screen in its lower position. This device allows the whole machine to be reduced in size and yet deal with photographs considerably tilted (up to 45°) in the Y direction. Air photographs tilted more than 45° in the Y direction may be dealt with by an interchange of the Y and Z plotting movements as in the case of ground photographs.

The British soldier is in the habit of describing his tools by affectionate, if frivolous, nicknames, and as the name Big Bertha was mentioned in the discussion, it becomes necessary to add a word of explanation as to size. The actual space occupied by the machine may be gauged from Pl. 5, and admittedly exceeds that required for some Continental machines. The first model was designed according to specification for a whole range in permissible size of photographs up to $9\frac{1}{2}$ in. $\times 7$ in., and for a range in focal length up to 12 in. A 20-in. focal length, in use by the French at the time, was given up only after the main structure of the machine had been completed. The machine, moreover, was designed for every conceivable combination of tilts and base lengths, and for a wide range in plotting scales. At the time the machine was designed, no practical experience was available regarding possible limitations in these respects—the design of air cameras was, for instance, fluctuating from month to month—and there was no alternative but to make provision for every probable, or even possible, case. The penalty of increased size had accordingly to be paid, but for an experimental first model this was not considered a serious disadvantage. The conditions are very different now. Air cameras for instrumental surveys are rapidly crystallizing into a standard size of 5 in. $\times$ 5 in. $\times$ 5 in. (focal length) as a just compromise between aircraft space, weight, angular field, and the interpretable scales of photographs exposed from economic altitudes. The types of air photographs for which it is necessary to legislate could, for all foreseen practical purposes, be restricted now to verticals and pairs of lateral obliques equally tilted to $20° \pm 5°$. The range in plotting scales could also be considerably restricted. In these circumstances, a very much more compact and accurate machine could without the slightest doubt be constructed on this principle. There is no justification for an unfavourable comparison in this respect between other machines and the first Barr and Stroud model, with its wide range of application.

Characteristics

The chief advantages which may fairly be claimed for the Barr and Stroud machine are simplicity and ease in plotting.

The greater ease of plotting in the Barr and Stroud machine is at once apparent to any one who has worked with it and with other machines. All the observer has to do is to follow the course of detail as he sees it by a single movement which directly copies the apparent shape of that detail. If the observer sees a square or a circle he traces a square or a circle with the comparator by moving the floating marks along the outlines of the detail which it is required to plot. It is true that a certain amount of theoretical error is introduced in the process, owing to aberrations of the auxiliary lens system, but the extent of this error may be controlled at will by limiting the area traced at one setting of the pro-

jectors—thus using a principle with which all practical surveyors are fully acquainted. The projectors can at any time be moved to bring in a new area, and no accurate adjustment is needed of the amount of such motion. Contrast this with the "one-man-band" operation of other machines, in which the observer has to follow the course of detail running in any direction by compounding the independent effects of turning two handwheels, at the same time turning a wheel with his foot. I am well aware that good continuous plotting can be carried out under these latter conditions, but only as the result of prolonged training.

The drawing-board of the Barr and Stroud Plotter is placed close to the observer, who can consequently see exactly what he is doing during the process of plotting.

As regards simplicity, there are no redundant movements involving complicated cam mechanisms, and no reversals or changes in geometrical direction which oblige the observer to imagine himself turned inside out or standing on his head to obtain a clear picture of what he is doing in setting the machine. The principles and operation of the machine can be learnt in a few hours' actual work, the makers' adjustments and calibration are simple and direct, and the user's adjustments are simple and few.

It may be argued that complexity in machine construction is a matter for the designer and is no concern of the user, who does not need to understand its working thoroughly. With that view I most heartily disagree, and I base my opinion on an intensive experience of this type of machinery. Sooner or later the rule of thumb operator makes a mistake and may spend days locating it. If the machine goes out of adjustment or has to be moved, he is helpless and has to call in the maker. From the day of its delivery, the Barr and Stroud machine has been under intermittent test—much of the work being done by a draughtsman—and not once have we been compelled to call in the advice or explanation of the makers. I have yet to learn of a Continental machine being put to work at a considerable distance from the factory and without the assistance of the makers or without personnel specially trained by the makers.

DISCUSSION

Before the paper the PRESIDENT (Colonel Sir CHARLES CLOSE) said: Captain Hotine has very kindly consented to give us a paper on "The Application of Stereoscopic Photography to Mapping." We are all, in a general way, acquainted with what is going on in the direction of stereoscopic mapping, but it is not everybody who has had actual practice in the matter. All these new methods, which are extraordinarily fascinating in themselves, will ultimately depend upon their value in cheapening surveys. I think, of course, there are some instances in which stereophotogrammetric methods will be used whether they are cheap or not, because they may be the only methods available for that particular problem, but in general we expect that these methods will have to justify themselves financially. I will not say any more about that point now, but ask Captain Hotine to begin his lecture.

Captain Hotine then delivered the lecture printed above, and a discussion followed.

The PRESIDENT: Captain Hotine is serving with the Geographical Section of the General Staff under Colonel MacLeod. We shall be glad if Colonel MacLeod will say a few words.

Colonel MACLEOD: Before making any comments on the paper I would like to pay a tribute to the work which Captain Hotine has done on this subject. I think I can claim to be as well qualified to do that as anybody, because now I am the only member of the Air Survey Committee, which deals with this matter, who has served on that Committee since its inception, and I can recall our ideas on this subject when Captain Hotine joined the Committee. We had talked a good deal and we had made a number of suggestions and discussed them, but when it came to actually doing a job of work, we were, as the story goes, all of a-tremble; we did not seem to be able to get on at all. I would not have you think that we achieved nothing: that would be doing us an injustice. After the war we on that Committee not only had to get our theoretical ideas in order but we also had to devise and get constructed apparatus with which to carry them out. That naturally took time and cost a good deal of money, but for the most part it did eventually materialize.

The first thing we wanted in order to progress with this subject was a properly calibrated camera. That we had not got, to start with, but ultimately we did get it, thanks largely to Wing-Commander Laws, who is with us this evening. After that we had to get plotting machines of various kinds, and the production of these instruments was the first task the Committee had to tackle. Though we got these things made, I think we must now admit that we really did not do very much more than "clear the ground"; indeed, the uncharitable might say that we left a good deal of junk lying about on it. However, I think much of it was useful junk, and when Captain Hotine came along he was able to pick out the useful bits, cement them together with ideas of his own, and produce the working system which he has described to us and the products of which are on the screens in this room. It is a working system which has, on the occasions we have tried it, given surprisingly good results.

Looking back, I cannot help thinking that one of the reasons why we made such poor progress was that our experience in France actually misled us. As you know, in France we were engaged in producing maps from air photographs, but we hardly realized that we were dealing with a special case. We dealt there with the individual photograph, and after the war when we had to solve a more generalized problem we tried to do so by methods which had served us in France: in other words, by working on the individual photograph. It was Captain Hotine who brought home to us that the " unit " as regards air photographic mapping is the overlap—the stereoscopic pair—not the single photo.

I have to plead guilty to having, at a meeting of this Society, belittled the stereoscopic principle on the ground of the restriction thereby imposed on the length of the base; I thought that it was not taking the fullest advantage of the mobility of the aeroplane. Mr. Fourcade and Captain Hotine have shown us how to get over that difficulty, and though after my former failure it may be a little rash for me to venture another prophecy, I am now satisfied that it is on the stereoscopic principle that the future of air surveys will rest.

A word about the stereoscope. I do not expect many of you have used it. Some people are, I think, at first inclined to distrust the stereoscope as an instrument of precise measurement. There seems to be altogether too much scope for judgment in using it; in fact, one is apt to think that with an instrument of that sort in the hands of a man who is not thoroughly trustworthy, judgment may very easily degenerate into "fudgment," and that, as you know, is the surveyor's most heinous crime. Actually I think that is not so. Captain Hotine will bear me out when I say that with practice soon comes a confidence in the stereoscope which is amply justified by results.

Before sitting down I would like to add, with reference to the President's

remarks on the economic aspect of this matter, that of course there is another aspect which I in my official capacity am concerned with, namely, the military aspect. I personally regard the perfection of air photographic survey methods as a scientific development whose military importance can hardly be exaggerated. I think that when it is well understood and properly exploited it will put into the hands of the civilized and educated man a weapon—or rather, a method of fighting—which will prove perhaps more effective even than the armoured vehicles that now loom so large in the public eye. It would require a good deal of explanation to say why that is so, and there is no opportunity for me to go into that here, but I believe that statement will prove correct, and, what is more, I believe that this method of fighting will be particularly valuable because it is one which the illiterate and the savage cannot use.

Brigadier E. M. JACK: I would like to ask one question. How long did the setting of the photographs recorded take?

Captain HOTINE: The first pair took a whole day; the second pair three-quarters of an hour. We have not tried the third pair yet, but I think we shall be able to cut down.

Brigadier JACK: The only other thing I would like to do is to express the very great interest with which I have heard Captain Hotine's paper and to congratulate him on the lucidity and clearness with which he delivered it. It really was delightful.

The PRESIDENT: I will ask Mr. Hinks if he will kindly say a few words on the subject, which he has studied a good deal.

Mr. HINKS: I should like to express my great pleasure at having heard this paper, and equally my great gratification that we shall be able to publish in the *Geographical Journal*, in the course of two or three months, some description of methods that many of us have wanted to know about for a long time and now, for the first time, have the opportunity of judging. There has been, we have heard, a mysterious creature which has been kept somewhere in the War Office, which is known, I believe, by the name of "Big Bertha," and I am interested, first, to note that Captain Hotine speaks of her—the Barr & Stroud machine—as "superior in conception and vastly simpler than any Continental model." That, of course, is a very strong compliment to Big Bertha, but it clearly necessitates that we should be able to have her portrait and, I hope, a description of her constitution published in order to judge of the merits of the statement. I think I am right in saying that at present nobody, except one or two in the War Office, knows anything about the optical design of Big Bertha or the geometry of the method. I feel that now we have been told it is "superior in conception and vastly simpler than any Continental model" we are justified in expecting this secret to be at any rate partially revealed. We have heard first in this Society of the Stereoautograph and the Hugershoff machine, and more recently, after Major Kenneth Mason had made that very successful photographic survey in the Shaksgam, we had some account of the Wild machine. While Major Mason was actually measuring the plates I was trying to write out the geometry of the thing, and we had a joint paper on the subject. Captain Hotine spoke rather scornfully of the modification by which Wild has made a patchwork of a machine originally designed to work upon the ground. I venture, with all deference to Captain Hotine, to maintain that that is not quite fair. The machine of Wild was originally designed to work either upon the ground or from air photographs. It is perfectly true that Wild found that as soon as he had given an additional motion to the machine he could make it easier to work on air photographs, but I do not think it is just to him to call it a " patchwork system in a machine originally designed to work upon the ground." I am interested to know that Captain Hotine considers, even when

that system has been patched up, its geometry is not as successful as that of the Fourcade machine. I asked Captain Hotine—I hope he will accede to my request—to write a page or so in the *Journal* explaining exactly what the geometry of Wild's modification is and how it is that it breaks down. My own account of the machine was written before the latest modification, and although I saw the machine in July at the Aircraft Exhibition at Olympia I am bound to say I did not in the least understand the modification.

The second point that I should like to emphasize is that, if I understood correctly—and I shall be glad to be assured on this point—the Fourcade machine, which was also built by Barr & Stroud, is a very fine solution of the problem of the duplex tilt-finder, and its duplicity—in the good sense—enables one to put together pairs alternately and so step along a long traverse. Colonel MacLeod developed several forms of tilt-finder in the early days of the Air Survey Committee. It is, of course, as Captain Hotine says, possible to add a plotter—that is possible with any machine, though rather a heavy job sometimes—and it will be interesting when he has been able to realize it.

There are many things one might say in discussing this fascinating subject, but I will say only one more. Captain Hotine warned us—I do not know whether he was referring to me in particular—off academic optical objections to his theory. In spite of that warning I would like to remark that at present all the diagrams I have ever seen explaining the optics of this machine show optical rays converging from a pair of eyes towards a plate. I do not say that that way of drawing the thing is necessary to the explanation, but it certainly seems to be involved in the explanation, and it also seems to me to be plainly false, because there is no question whatever that in any of these stereoplotting machines the axes of the eyes are governed by lines between the optical centres of the eyepieces and the floating marks, and in order to keep those floating marks fused the eyes must remain parallel. There is no doubt about it that the idea that the eyes converge to get these optical effects is totally wrong. I do not say that is the explanation always given, but it is too often given. There is something very much more occult and mysterious about it than mere convergence of the eye. I think Captain Hotine will agree.

Captain HOTINE: I will answer the question, but I do not promise to agree.

Wing-Commander LAWS: I am not sure that I can contribute anything useful to the discussion. I have only dealt with the air side of the problem. It might be of interest, however, for me to say that any air work called for in connection with the making of these various maps has not presented any problem which could not be overcome by any reasonably well-trained pilot. That seems to me to be important from both the Service and commercial points of view. I would say that any scheme produced which necessitated the employment of a pilot highly skilled in surveying would be a failure from a Service point of view. I can assure you that the method described by Captain Hotine does not require any special knowledge. We are satisfied that under normal conditions we can meet the requirements.

Captain KEMP: I am afraid I have nothing very useful to add, but I would like to congratulate Captain Hotine on his very clear and interesting paper, and to say that I hope Colonel MacLeod's views can be forced upon the authorities so that the Committee may have better funds in future.

Major COCHRAN-PATRICK: The President has stressed the point of economy in air surveys and Colonel MacLeod has shown the importance of the military side, but there is one aspect which is really even more important and which has not been touched upon, and that is the question of speed. By using air surveys we have enormously hastened the whole operation of mapping. To digress for a

second from the topographical scales mentioned in the paper, I might cite a point that has come up in a recent survey of Rio. We have only one equivalent survey with which we can compare it, and that is the survey of Berlin. We have heard from our manager in Rio that he has completed in one and a half years a job equivalent to one which took twenty-two years in Berlin. That is on the scale of 1/1000. We were definitely using ground methods supplemented by air photography; there was no question of stereoplotting instruments. Where we gained, of course, was on account of the fact that we did not have to force our way into backyards and get access to private property. We find that actually the amount of checking on the ground which has to be done in the detail work is surprisingly small.

Captain Hotine has said a great deal about the various instruments which were produced in the early stages, but he has really said very little of the instruments which he has been mainly responsible for producing and which, of course, are applicable to the smaller topographical scales. I should like to pay a tribute to his ingenuity in originating the idea of the parallactic grid and in producing in this practical manner a two-dimensional instrument instead of the three-dimensional machines with which we had been trying to compete. We in our company have used those topographical stereoscopes of his a great deal and have had much practice with them; we find everything he claims works out absolutely exactly. In fact, the only alterations which we have had to make are in detail operations. For instance, in the drawing on of contours we find that the average draughtsman is not particularly good at lifting a grid and drawing a contour on the photograph underneath, so that it is simpler, in spite of the extra expense, for us to make glass positives, put the grids under them and draw the contours directly on to the positive without interfering with the grid at all and, in fact, while looking at the grid. I should like to thank Captain Hotine very much for his paper.

Mr. G. T. McCaw: I should like to follow up the preliminary remarks with which you, sir, opened the meeting. Omitting military and some special requirements, I would refer to-night to the economic adaptation of air photography to civil ends. Of the numerous inquiries which have come before the Air Survey Committee, none has been more insistent in peace than the question of cost. In this matter there has been a gradual evolution of thought and method—as indeed Colonel MacLeod has already hinted. Starting with the individual photograph, we began by thinking of the means of bringing it into terms of ground controls. The process was not simple. Faced with this difficulty, we were forced to the conclusion that the application of such methods would damn for ever the employment of air photography in an economic sphere.

There was in existence, however, though in rather crude form, the graphical method of radial-line plotting. In the hands of Captain Hotine the method was developed, chiefly by the adaptation of a simple stereoscope to the improvement of the orientation and spacing of photographs taken throughout a strip flight, and by the invention of a transparent grid to gain sufficient knowledge of relative heights. This "Arundel" method in skilled hands proved rapid and inexpensive, while giving the accuracy required for topographical maps on common scales. For more accurate work on large scales and for mechanical plotting, the difficulty remained practically unsolved until Mr. H. G. Fourcade—one of the earliest workers in photogrammetry—came forward with the Correspondence Machine which we have named the Stereogoniometer.

In both the graphical and mechanical methods mentioned there is a common fundamental principle—that of utilizing the correspondence between overlapping photographs of a strip to set up their own control. This process is, of course, not continued indefinitely, but it is continued far enough to remove air survey

from the academic to the economic sphere. Mapping from aloft would never have made headway had the fundamental principle not been accepted that, since it is economically impossible to fix ground controls for every photograph, air survey, to be economical, must be to a certain extent, as it were, self-supporting. That it can be so has been the text of the lecture to-night.

Mr. M. A. SPENDER: I wonder whether there would be any chance of bringing this method down to earth again. It has always struck me that the trouble with the Wild instrument is that you have to know far too much. You have to know enough about the base conditions to tell you everything, and then you have to have the three controls to set the instrument. Is it possible to have a method of control whereby the photographs are their own control—to simplify the whole thing and bring the ground pairs together mechanically into line with the air pairs?

Captain HOTINE: As regards bringing the whole system down to earth again, that is, I assume, the question of making photographs produce their own control, that is what we are hoping to do with the new Fourcade machine. Major Cochran-Patrick has remarked that a glass positive might be used in the Topographical Stereoscope so as to avoid having to lift up the grid plates to draw contours. That instrument was designed primarily for military purposes, and whereas we can always get hold of a paper print and be relied upon not to break it, the same does not apply to a glass positive. I think he may be right in adapting the instrument to the use of glass positives for his own purposes. I do not think we ourselves would be justified in doing so. The draughtsmen in the Geographical Section of the War Office have little or no difficulty in this respect. They get quite used to lifting the grid with one hand and working with the pencil in the other. There is no reason why a draughtsman should not occasionally remember that he has two hands and that both are available.

Major Cochran-Patrick also spoke of speed. On that question I agree with him as regards the speed of plotting on larger scales, but I disagree when it is a question of small scales and open country. If you are out, for instance, to produce a $\frac{1}{4}$-inch map of open country, and assuming you are able to spend the large amount of money required for air photography in hiring a correspondingly large number of plane-tablers, then I have not the least doubt that this army of plane-tablers would beat the aeroplane every time. But, of course, the crucial point is that there is no army of plane-tablers available, not even a British army.

As to Mr. Hinks' objection to my criticism of the modification of the Wild instrument, Wild had originally arranged that photographs exposed in any way, even horizontally or vertically, *could* be set in the instrument, but he had omitted to consider *how* he was going to set them. It was the setting of the instrument which necessitated the patchwork arrangement—an expression to which I still adhere. In fact, if Mr. Hinks will agree that it is necessary to set photographs before one can plot them, I think he will agree that the original criticism holds.

Mr. HINKS: Of course Wild originally intended to make a separate tilt-finder.

Captain HOTINE: Yes, but he did not do so.

Mr. HINKS: No, but he did the other thing instead.

Captain HOTINE: Yes, by patchwork—an afterthought. I think I can promise a description of that elusive lady, "Big Bertha." When I say that the instrument is superior in general conception I really mean it. It is the only instrument of its kind in which you can see clearly what you are doing in setting and what you are plotting. I think those are two very considerable advantages which justify its superiority in conception. That other merit of simplicity can only be justified by a full description of the machine.

I think the only other point I have to answer is Mr. Hinks' question as to a large convergence of the eyes. I should like, first, to say that it is quite true that when you are examining any objects stereoscopically you do not wilfully converge the eyes to the extent shown in the diagram. It would be uncomfortable to do so. But we have to keep such diagrams within the compass of a lantern slide or a piece of paper, and consequently we cannot make the diagram disproportionately large in order to make it look more natural. That, I feel, is not exactly Mr. Hinks' objection; he rather claims that in most stereoscopic machines the actual condition is that the axes of the eyes are not converged at all but are parallel. That, I think, is wrong; certainly in every stereoscopic machine I have examined. The two floating marks are usually fixed in most stereoscopic machines, and they are designed for a certain convergence of the eyes, either by decentring the floating marks or by increasing the interocular distance setting. Otherwise, in cases where two corresponding points of photographic detail are at a greater separation than the floating marks and tend to form an image at a farther distance, the eyes would necessarily have to diverge in order to fuse them.

Mr. HINKS: If you had the eyes directed on those objects. I think you keep the axes of the eyes upon the marks and, by some peculiar process you do not understand, do the fusing; you get the impression of the stereoscopic views round about the floating marks, keeping the axes of the eyes fixed on the marks.

Captain HOTINE: I think you first of all fix the marks and then fix the ground in rapid succession.

Mr. HINKS: I do not think so.

Captain HOTINE: It is perhaps a matter of opinion. The movement is too rapid for one to be conscious of, but I imagine I have given the explanation. In any case it is usual in stereoscopic machines to allow a certain convergence on the floating marks so as not to have any uncomfortable feeling of divergence.

Mr. HINKS: Perhaps I should have said the axes of the eyes remain fixed rather than parallel. The floating marks are fixed and you keep the axes of the eyes fixed—not perhaps strictly parallel, but fixed. It is not a question of altering the convergence of the eyes to get the stereoscopic effect.

Captain HOTINE: I agree that it is *possible* to compare the stereoscopic depths of objects lying within the field of distinct vision without altering the convergence of the axes of the eyes. Experiments made under the instantaneous illumination of an electric spark, when the eyes have no time to alter their state of convergence, have proved this. I do not, however, believe that a sufficiently acute observation can be made under such conditions. In comparing two objects, is it not reasonable actually to look at each in turn? If the two objects are at different depths, looking at them entails an alteration in convergence. In training stereoscopic observers, we find that a common fault is to concentrate too much on the marks, as you are suggesting, and too little on the ground. We get them out of that habit as soon as possible by telling them to concentrate on the ground and ignore the marks. The latter have a strong enough stereoscopic character to force attention, and in the result the observer arrives at the correct state of balance between the two. To concentrate on the marks and ignore the ground, thereby retaining a fixed state of convergence, is roughly equivalent, to use a monocular parallel, to concentrating on the foresight and neglecting the target.

Mr. HINKS: The explanation, I think, lies far deeper than one can go with geometrical optics. We cannot explain by what process in the brain the separate and slightly different images formed by the two eyes in ordinary use are fused into one picture with the sense of solidity; but there is much more in

it than any simple question of variable convergence, and I would maintain that we should accept it as a mysterious physiological fact and not attempt to explain it by geometry.

The PRESIDENT: Captain Hotine at the commencement of his admirable paper described how in the early days one was apt to mistake a hill on two photographs. I am afraid that even the plane-tabler does that sometimes. I remember in 1890 in Burma I was given a reconnaissance map made by a staff officer in which appeared a magnificent 5000-feet hill. When I came near the ground I found the hill non-existent; he had his two rays and had identified them wrongly. That might happen to anybody, even to a photographer. I was struck by the progress that has been made in the stereoscopic method. I remember when Mr. McCaw was in Fiji he took some stereoscopic photographs and sent them to Southampton, and we had the pleasure of trying to make a map from them. It was excessively difficult. In those days we used Major F. V. Thompson's machine, and it was difficult to get any sort of coincidence.

Mr. MCCAW: Of course there were special difficulties in Fiji.

The PRESIDENT: But the progress has been very great. In reading up this subject I am struck with the difficulty of remembering the names given to these various machines. We have stereocartograph, autocartograph, photocartograph, and stereoplanigraph. It is hard to remember which machine you are dealing with. I wish some simpler form of nomenclature could be devised.

We are glad to hear from Captain Hotine that the British machine has the merit of simplicity. The general outcome of this sort of work is that we shall tend to employ, in future, a few skilled men as opposed to a large number of relatively unskilled men. We congratulate Captain Hotine on the development of the parallactic grid, and are very grateful to him for the paper he has given us. I know you will show your appreciation in the usual way.

HIMALAYAN NOTES

I. *Identification of Karakoram peaks by the stereoscope*

MAJOR Kenneth Mason sends us tracings of two panoramas, F and I in Dr. De Filippi's 'Karakoram and Western Himalaya,' taken respectively from the ridge east of the Sella Pass, and from the southern ridge of Staircase Peak, and looking eastward over the Shaksgam valley to the country which he surveyed with the photo-theodolite in 1926. By a study of his pairs of photographs in the stereoscope he has been able to identify with certainty a large number of features in the panoramas taken on the Abruzzi expedition, and he remarks that without the stereoscope these identifications were not possible, while with it they were fairly obvious.

II. *An unpublished report on Hunza glaciers*

We are indebted also to Major Mason for a copy of a report on Hunza glaciers, made by Captain F. H. Bridges in 1908, which has remained unregarded in the records of the Political Officer at Gilgit for some twenty years. It

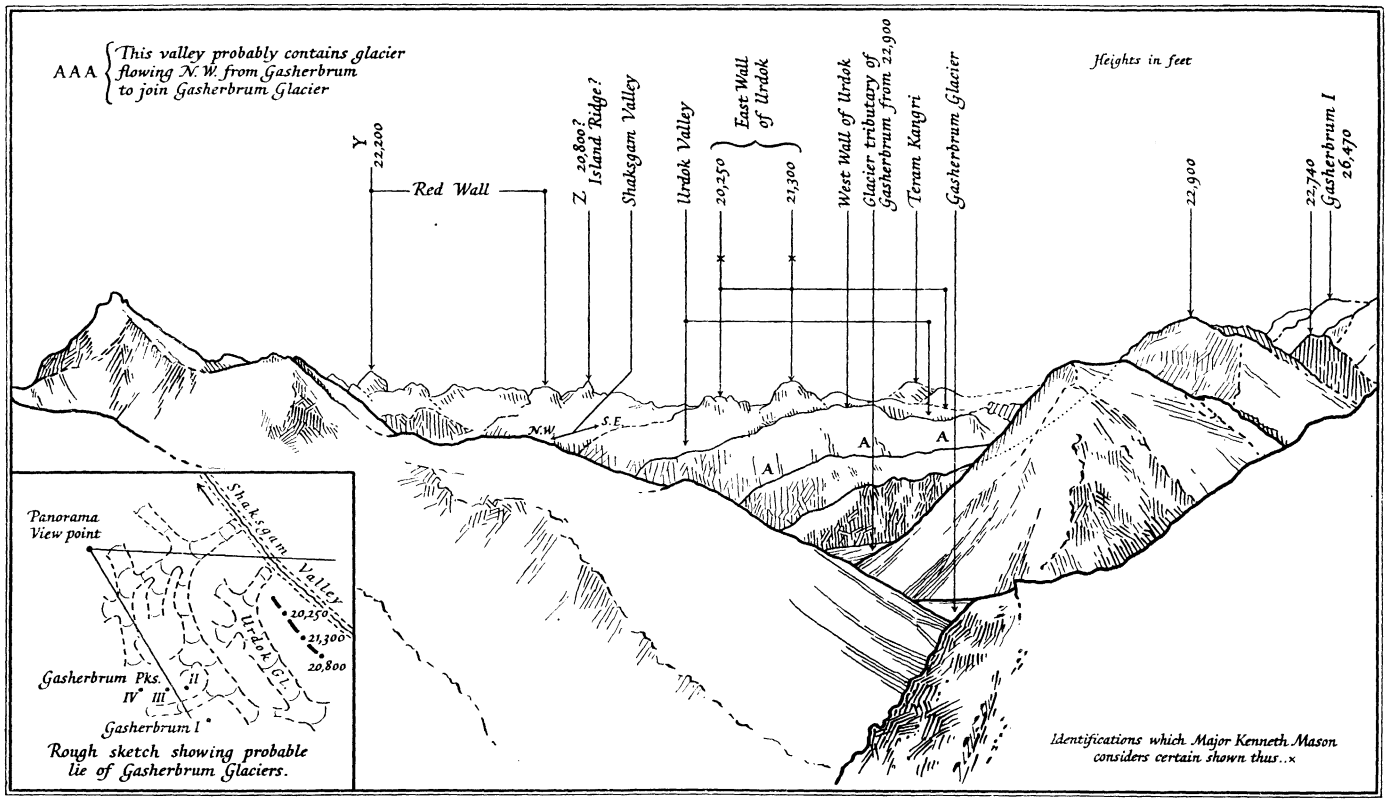
will be remembered that in 1892 Brig.-Gen. Sir George (then Lieutenant) Cockerill made a reconnaissance of the Shingshal Valley, with the particular object of reaching the Shingshal Pass from the west and joining up with the reconnaissance to this pass from the east made by Lieut. Younghusband in 1897. Four miles above the village of Shingshal he reported a large glacier which is the Yazghil, but for which he obtained the name Verigerab, and just below its snout he turned north-eastward up the nullah which comes down from the pass, leaving the upper part of the main valley unexplored. His report on this journey remained in the confidential records of the Political Department for thirty years, until in 1922 he obtained permission to publish the paper in the *Journal*, vol. 60, p. 97, Aug. 1922, calling attention to a most interesting region which had, it seemed, never been visited by any European since 1892.

When Mr. and Mrs. Visser planned their Karakoram expedition of 1925 they resolved to follow up this pioneer work of Lieut. Cockerill, and two marches beyond the village of Shingshal they "made the exciting discovery of an immense glacier region which was quite unknown." Three immense glaciers, the Virjerab, Khurdopin, and Yukshin-Gardan, were explored by them and mapped by Afraz Ghul Khan (*G.J.*, 68, 457, Dec. 1926); and Mr. Visser came to the conclusion that the floods which from time to time devastate the valley are caused by the Khurdopin advancing and blocking the valley.

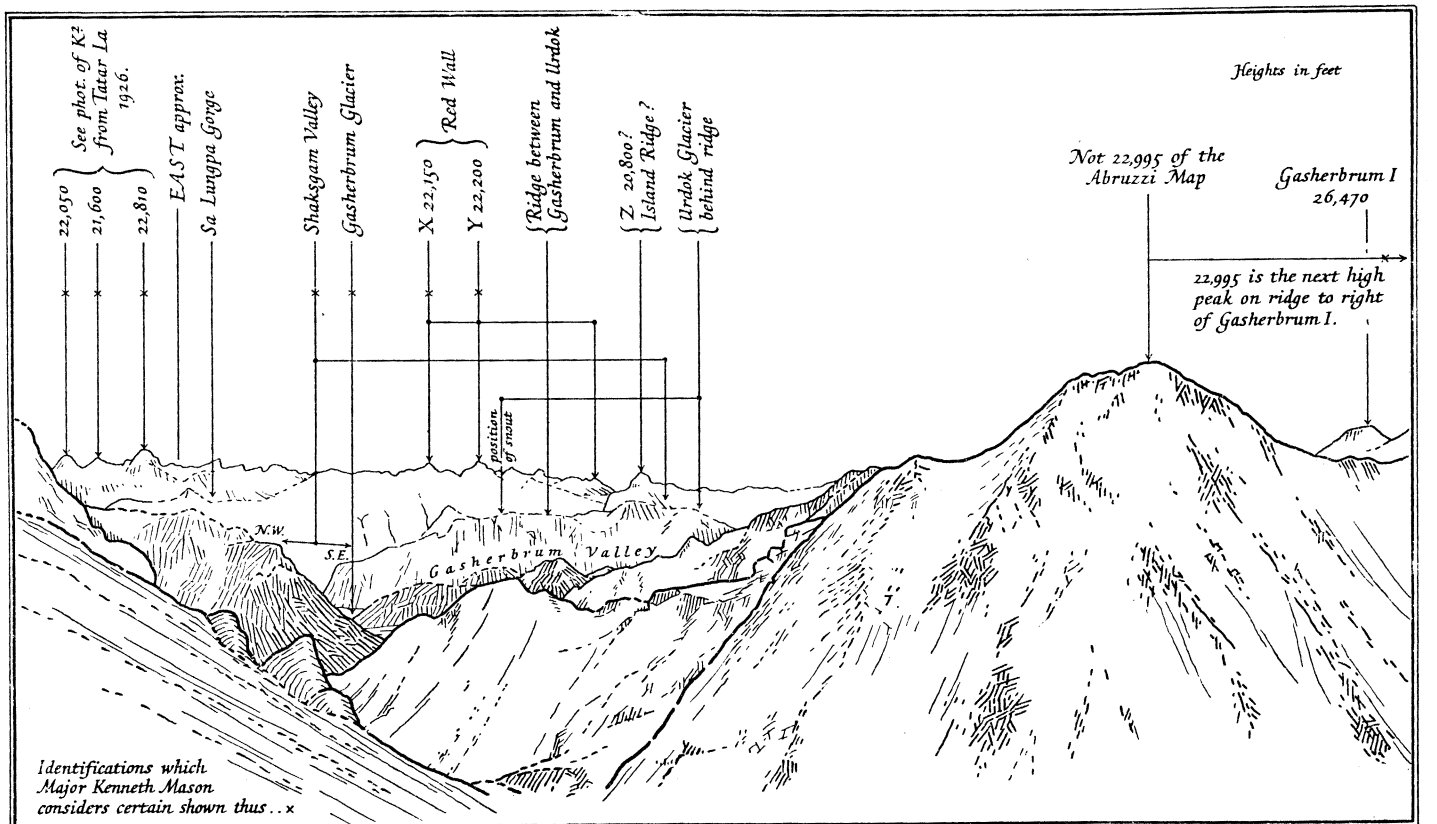
It now appears that this question had been investigated in 1908 by Captain F. H. Bridges and a little later by a surveyor detailed by the District Engineer. Thanks to the stimulus of the Himalayan Club the report has now been disinterred from the Gilgit records, and the greater part is printed below. The three glaciers which we first learned of from the Visser expedition are laid down on the sketch-map accompanying the report, and four sketches of the glaciers accompany it, of which copies are now in the Society's collection. Captain Bridges made no attempt to ascend the glaciers; his business was to study the cause of the occasional floods, and to provide for better future observation he established marks to serve as flood gauges, for the use of the watchers sent each summer by the Mir of Hunza. One may hope that some results came of this enterprise, and that further search in the Gilgit records, or inquiry of the Mir, may produce details of floods and heights of the temporary lakes.

Captain Bridges writes Yarsghil for Yazghil, Kurdarpin for Khurdopin, Vergerap for Virjerab, and Shungdickt (or Shungdiekt on the sketch-map) for Yukshin-Gardan of the surveys of Afraz Ghul Khan. His report for the region above Shingshal village is as follows:

On the 24th [April 1908] we moved camp up to the big glacier, which is about 8 miles from Shingshal. About 2 miles beyond the mouth of the Shugerab nullah is the Yarsghil Glacier, shown in error on the map as the Vergerap. This glacier is said to be about 8 miles long. It divides into two before reaching the river-bed, being split up by a hill in the mouth of the nullah. The two snouts of the glacier are about $\frac{3}{4}$ mile apart. The nullah-bed opposite the glacier is narrow, varying from about 10 yards to about 80 yards. Opposite the upper snout of the glacier is rock, from 100 feet to 200 feet high, and above that conglomerate pari. This snout is 48 yards from the opposite cliff. The snout of the lower half of the glacier is now only about 10



Panorama looking south and south-east from ridge east of Sella Pass, 20,000 ft. (De Filippi's Panorama F)



Panorama from southern ridge of Staircase Peak, 21,627 ft. (De Fillippi's Panorama I)

yards from the hill opposite, which is conglomerate pari. The stream from the glacier is at present issuing from the upper snout.

It is difficult to gauge the amount of water now issuing from the glacier, as it issues in several streams; but the local men tell me all these streams are unfordable in the summer, so the amount of water must be considerable. The upper half of the glacier must be about 1000 yards wide, and the lower half about 500 yards; but in both cases the greater part is curved well back and has not advanced parallel with the snout. I placed three pillars at 50-feet interval in height opposite both snouts, and told the surveyor to put up a fourth both here and at Malunguti, so as to be able to register 200 feet. The lower snout of the glacier closed into the opposite bank last year; but the water ran all the time underneath. When the big glacier burst, it cut away the Yarsghil bund also. If the upper snout moves forward and piles up against the rocks opposite, a very serious bund will be formed and the nullah-bed between Yarsghil and the big glacier will be enclosed. The nullah-bed is about $1\frac{1}{4}$ miles long and 1 mile wide. It is dry at present, as the water from the nullahs above is running into the lake formed by the big glacier.

Above the Yarsghil glacier the valley opens out, and is about 1 mile broad for the next $1\frac{1}{2}$ miles, and then widens out to $1\frac{1}{2}$ to 2 miles across. About 5 miles above Yarsghil the valley divides into three nullahs: Vergerap, Khurdarpin, and Shungdickt.

Of these, Shungdickt is a small short nullah about a mile or two in length, while the other two extend for an unknown distance. At various times men have been sent by the Mir of Hunza to try and penetrate to their head; but have always returned unsuccessful. One levy, by name Murad Beg, who accompanied me, had been four marches into both of them during the time of Rajah Ghazan Khan. He said he could see no signs of the heads of the nullahs, and returned, as he had finished his rations.

The Khurdarpin and Shungdickt glaciers have swept down through their own nullah-beds, and meeting in the main nullah, have gradually moved on down till they now extend in one huge glacier, filling the entire main nullah-bed for a distance of about 2 miles below the mouth of the Vergerap nullah, and within about 16 miles of the upper snout of Yarsghil. The Vergerap Glacier, on the other hand, has remained stationary, and is still about 3 miles [1·6 miles according to the surveyor] away from the mouth of the Vergerap nullah. The united glaciers of Khurdarpin and Shungdickt, sweeping past the mouth of Vergerap, and impinging along the whole cliff face below Vergerap for about $1\frac{1}{2}$ miles, have enclosed a large open space at the mouth of the Vergerap nullah, and it is in this space that the lake gradually collects.

I went to the edge of the dam, overlooking the above space. It is difficult to estimate its size accurately, looking down on it like this; but, I should say roughly, it extends for 3 or 4 miles in length, and varies in width from 100 to 300 yards at its base, and would, of course, increase in width as the water rose. [The area enclosed extends from the dam up to the snout of the Vergerap Glacier (Survey Sheet, No. 3), length 2 miles, mean width 1 mile.—*Surveyor.*] At present there is water in it for about a mile in length; but it is impossible to make any accurate estimate of its depth. The local men estimate its present depth at the lower end at about 20 or 30 feet. Some of the Hunza men got

down by ropes to the lake to try and measure the depth; but had to abandon the attempt, owing to falling rocks and debris. [The depth measured at the upper end of the lake (see Survey Sheet, No. 3) was 25 feet. The ground has a fall of 2·6 feet per cent. The depth at the lower end of the lake would therefore be about 150 feet.—*Surveyor.*]

I could see the water-line of last year's flood on the rocks, and should say that the water did not reach a greater height than 200 feet, though this is a rough guess, as, without proper surveying instruments, it is impossible to make an accurate estimate. The surveyor, however, sent up by the D.E., will be able to do this. [According to mark pointed out by the local people, the water rose 140 feet above present water-level in the lake.] The water in the lake, I am told by the local men, stretched as far back as the snout of the Vergerap Glacier last year, and I could see the water-line on the rocks in the Vergerap nullah. The water, according to the reports of the men told off to watch it, rose last year till it overflowed the top of the glacier, where it impinges on the right bank, and then cuts its way clean through the glacier. This is undoubtedly true. There is an enormous channel, about 150 feet deep and 80 to 100 feet wide [mean width, 50 feet], cut clean through the ice, like a huge canal, at the lower end of the lake. This has water in it now. I went to the edge of it and looked down into it, and have told the surveyor to go to the same place and measure the depth of the water with a plumb line. This canal is closed by an ice-dam now, lower down. This dam is, I should say, roughly about $\frac{1}{2}$ a mile, or perhaps a little less, from the outlet from the lake. It is impossible to find out what is the nature of the glacier between this dam and the snout along the right bank. Last year's flood has broken up the glacier a good deal, and left enormous crevasses all along its right bank, and, consequently, it is impossible to reach this part. One of the Hunza men managed with difficulty to reach a spot from which he could see the dam blocking the canal, but could get no farther. From questioning him, I should say it was about 100 feet above the present water-level. The water breaking through last year has caused the whole of the glacier on the right bank to sink a good deal. The centre has remained much higher, but both on the right and left banks of the nullah the glacier is at a much lower level. I examined the snout of the glacier where it impinges on the right bank, and found no sign of an outlet. There was a perpendicular wall of ice with no apparent fissures about 100 or 150 feet from the nullah-bed across last year's outlet, which is now closed. The distance between the snout near the right bank and the ice-dam in the canal is, I should think, roughly about $\frac{3}{4}$ of a mile. My camp was in the nullah within 200 yards of the snout of the glacier. My aneroid showed a rise of 800 feet from my camp to the highest point in the centre of the glacier between my camp and the lake. The distance from my camp to the lake was, I should say, about 2 miles.

Unless the glacier moves forward again and, piling up against the hill, closes last year's channel, I should say that the lake will not rise as high as it did last year, as all the local men agree that last year's bund was a good deal higher. There is, on the other hand, the danger of the bund this year suddenly bursting, when the lake is full, instead of the water gradually cutting a way as it did last year. The water last year from the lake took eleven days to empty; hence the small rise of water. I placed three pillars of stones in a line, close to the present

canal, so that the surveyor, while working there, can watch them, and see if the glacier is closing in on the canal. The local men tell me that the channel is narrower now than it was after the flood last year. Water from all three nullahs frequently empties into the lake, according to the local men. At present there is water from both the Vergerap and Khurdarpin nullahs running into the lake. Water from these nullahs runs all the year round; but in the winter the streams are small. In the summer the Vergerap stream, I am told, is bigger than the Shingshal River between Passu and Dikat, which means a considerable volume of water, as the latter is unfordable in summer and even now is $3\frac{1}{2}$ feet deep in places, and about 8 yards wide. In the big flood three years ago, the flood took much the same course as it did last year; but the bund was higher then.

In the flood that took place about four years ago, which destroyed a great deal of the Shingshal cultivation, the flood came down the left bank of the nullah, having worked its way under the glacier. The second flood which came down last year in September was caused by the Malunguti Glacier blocking the stream, and not by the Khurdarpin lake at all, which at that time was empty.

At present there is no water issuing from the glacier, except a few small streams caused by thawing on the surface. I think the lake ought certainly to be watched again this year. Information should also be sent at once to the D.E. if either the Yarsghil or Malunguti Glaciers block the nullah, and a lake forms behind them.

I was accompanied the whole way by Wazir Humayun of Hunza, who made the most excellent arrangements for me. I was shown all the arrangements which were made last year to give information to Baltit when the flood was coming. Great trouble appears to have been taken over this by Wazir Humayun and the Shingshal people. There were thirty-one different posts of three men each out on the hilltops, day and night, for twenty-three days. The arrangements were that, if the flood came at night, beacon-fires were to be lit, and if it came by day, shots were to be fired.

In case the D.E. wishes to ask any questions at any time from local men, I would recommend Levy Murad Beg of Shingshal being sent for, who has watched the glacier for years. The arrangements last year were made by Trungfa Kalandari of Hyderabad, who was specially deputed for this work.

On the march back, a good deal of difficulty was experienced at two of the fords, between Dikat and Passu, on April 29, as the river had risen and was $3\frac{1}{2}$ feet deep, with a very strong current. The coolies, however, managed to get across with the aid of ropes, and there were no accidents, though a certain amount of the baggage got very wet.

I did not have any difficult work climbing, the fords being the only difficulty on the road. Wazir Humayan tells me that once the river between Passu and Dikat has become unfordable there is no possible way down this part of the valley, even for the local men, and they have to go round over the Karan Pir to Gircha.

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COLONEL SIR THOMAS HUNGERFORD HOLDICH,
K.C.M.G., K.C.I.E., C.B.

THE death of Sir Thomas Holdich at the age of eighty-six has removed one who, at the beginning of the century, had a greater experience and a more profound knowledge of the geography and inhabitants of the North-West Frontier of India than any other living man. That knowledge and experience were founded on personal contact with almost every tribe and race that inhabit Afghanistan, Baluchistan, Turkistan, and Persia, during twenty years of service, crowded with incident military and political, on the borderland of India. When he left India he was the supreme authority on all matters connected with frontier delimitation and demarcation.

Sir Thomas was born at Dingley, Northamptonshire, on 13 February 1843, the son of the Rev. Thomas Peach Holdich, and was educated at Godolphin Grammar School. Passing high out of the Royal Military Academy at Woolwich, he was commissioned in the Corps of Royal Engineers on 17 December 1862, and after completing his instructional courses at the School of Military Engineering at Chatham, he came out to India early in 1865. His choice of career in India had probably been made before sailing for the East, for in less than a year he received a temporary appointment in the Survey of India, and accompanied the Bhutan Field Force as assistant surveyor in the cold weather of 1865–66. At the close of that expedition he was made permanent in the Department, and remained in it until his retirement in 1898 at the age of fifty-five.

Holdich was soon on active service again. After little more than a year in Rajputana he was selected as one of the survey officers for the Abyssinian campaign in December 1867. Eighteen months later he returned to India and joined a survey party in Central India. It was here, I believe, that he had the narrow escape in company with Edward Leach out tiger shooting, the story of which he used to tell right up to his death as one of the most exciting moments of his long career. But this was an incident that did not compensate one whose yearning was already for a life of active service on the frontier, and soon after he was given charge of the Vizagapatam Survey in 1877, he took furlough to England, after having been continuously abroad, it appears, for twelve years.

From this furlough he was recalled to join the Southern Afghanistan Field Force in December 1878, thus beginning his long unbroken connection with the frontiers of India, which lasted for twenty years.

When Holdich first set foot in Quetta, in the early days of Robert Sandeman, very little was known of Baluchistan, beyond parts of Kalat and the Pishin plain; even the present line of the railway was unexplored, and, to quote his own words, "only a thin line of information was marked on the maps linking up Jacobabad with Quetta and Kandahar." The Afghan War changed all this, and in many ways changed also the policy of the Army towards geographical and topographical exploration. This change in policy was due mainly to two men, Sir Donald Stewart and Michael Biddulph, the two generals who commanded the South Afghanistan Field Force. For the first time, apparently, trained staffs of sapper surveyors, both triangulators and topographers, with Indian assistants, accompanied the advanced forces in the field to carry out scientific survey, as distinct from rapid military sketches. An accurate system of triangulation was carried up to Kandahar by Maxwell-Campbell, Heaviside, and Rogers, and when that place was taken in January 1879, Holdich, who had been in charge of the topography, following close on the heels of the triangulators, employed his men in detailed surveys towards the Helmand, Girishk, and Kalat-i-Ghilzai.

On the conclusion of peace in the spring Holdich accompanied the Thal-Chotiali Field Force, which returned to India by the previously unexplored Khojak route. The peace was, however, of very short duration. The fate of Cavagnari's mission at Kabul restarted the war in the autumn, and Holdich was ordered to join the force operating on the Khyber line. The survey officers who had been in the Kurram during the first phase of the war were almost all out of action. Samuells and Charles Strahan were down with typhoid; Edward Leach (who had won the V.C.), Tanner, and Woodthorpe had all been wounded; only Scott, who first surveyed the middle course of the Kabul river, was whole. Woodthorpe, however, was able to join the Kurram column under General Roberts, while Holdich, with Bright's force, carried his triangulation along the Khyber. The junction of the two surveys was made on the hill overlooking Bala Hissar. Surveys and rapid reconnaissances were now carried out in all directions from Kabul, until they were interrupted by the siege of Sherpur, in the defence of which Holdich and his surveyors took an active part. Subsequently he accompanied Roberts on his memorable march to Kandahar, but, as might be expected, the pace was too hot for much survey work. For his services during the two Afghan campaigns, Holdich was mentioned in despatches and promoted brevet-major.

Early in 1881 the Wazirs raided Tank, and a force was called into being at Dera Ismail Khan to punish the offenders. It was divided into two columns, with the northern of which, under General John Gordon, Holdich was attached as surveyor and triangulator. While Gerald Martin, with the column under General Kennedy, ascended Pre-Ghal, the highest mountain in Waziristan, and triangulated to the south, Holdich, with an escort from the northern column, was the first white man to ascend Shuidar, the second highest, whence a fine view was obtained as far as the Safed Koh to the north, dividing the Khyber from the Kurram. It is of interest in these days, when Shuidar and

Razmak are so easily accessible, to remember that Holdich accompanied the first British force to reach both places.

The results of this little and almost forgotten campaign—so forgotten that it was asserted in 1927 that neither Pre-Ghal nor Shuidar had been climbed—were most important from a survey point of view, and Holdich was quick to seize the opportunity. The policy of sending explorers into forbidden country was revived. Surveyors, both British and Indian, were trained by Holdich as explorers, and, often without the knowledge of our own political officers, were encouraged to cross the border. Their rapid and surreptitious reconnaissances —in these days we rather look on them as "tip-and-run" surveys—based on the points fixed by Martin and Holdich, afterwards proved most valuable. Unfortunately, no history has ever been written of the exploits of these men, and but for scattered references to such as McNair, Abdul Subhan, the Bozdar, and a few others, it is almost impossible to ascertain details.

We find Holdich next in charge of the Kohat survey, but not for long. In 1883 he was placed in charge of the Baluchistan Survey Party, and he was officially, according to the Survey of India records, in command of this party until his retirement.

In the very year he took over charge, an opportunity came for another useful extension of frontier survey and geographical knowledge. The Shiranis had been blockaded for some two years without any effect, and it was decided to send a small "survey promenade" into their country, more with the object of showing them that they were not beyond the reach of punishment than for any other reason. It is, I think, admissible to assume, though there is no official record of the fact, that it was Holdich himself, with his burning desire to turn every faint opportunity of gathering knowledge to full advantage, who proposed and argued this little expedition into being. Only the Khiddarzai clan were recalcitrant: and they lived in the neighbourhood of the Takht-i-Sulaiman. The Takht is a high hill, commanding a fine view to the west and south; the way to it leads through the Dabarrah defile. The combination of circumstances led the Khiddarzai to shout defiance, and Holdich to accept the challenge. The actual capture of the enemy's position on the Takht-i-Sulaiman was due to Holdich, who, while out with a plane-table, discovered an unguarded but difficult route by which an ascent could be made to the summit. Guided by Holdich in the night, the position was turned and captured without a single casualty.

The highest point of the range was climbed and rapid triangulation executed from it and a neighbouring peak. Forty thousand square miles of new country were within view, and points scattered over this area were fixed by which the "tip-and-run" process could be continued.

By 1884 Holdich was already a very experienced and efficient frontier surveyor, desperately anxious to leave no blank space unfilled upon the map. And like all frontiersmen of the day, he viewed with intense suspicion the steady advance of the Russian across Central Asia. The "Russian Menace" was on every one's lips. In February of that year, while England was occupied in the Sudan, the way was apparently being prepared for an advance from Merv across Afghanistan. The Amir, jealous of his eastern and southern frontiers, appeared negligent of his Herat border, and it became imperative for the

British to call a halt to Russian designs. The outcome of diplomacy at St. Petersburg and London was the formation of the unwieldy Russo-Afghan Boundary Commission, to assemble on 13 October 1884 at Sarrakhs, the point where Russia, Persia, and Afghanistan met. Holdich was placed in charge of the survey party and marched up from Quetta via Kandahar and the Helmand. The old boundary between Turkistan and Afghanistan was extremely vague, and though the Russians had pushed reconnaissances forward and had a good idea of the geography, our own maps were a complete blank. The survey work accomplished by the inadequate staff under Holdich was amazing. By various "technical expedients," as he himself called them, triangulation was taken from the neighbourhood of Kandahar to the Helmand, and thence through Western Afghanistan as far as the Hindu Kush near Herat. It was carried along the frontier, and on it was based not only the British but also the Russian topographical surveys: and from the eastern end it was connected across the Hindu Kush again with the previous work near Kabul. The work of this Commission, undertaken by Holdich, Gore, and Talbot, with only three native assistants, is still reproduced in text-books, as an example of how such survey should be carried out. At the end of it Holdich had some hard words to say about the political organization of the Commission; but it speaks much for his own tact and capability that, in spite of the scientific rivalry between the two survey camps, the Russian and British surveyors worked throughout in the utmost harmony, even when people at home had begun to rattle their sabres.

The frontier laid down by this Commission has been respected to this day.

For his services on the Commission Holdich was promoted brevet-lieutenant-colonel in 1887, and was awarded the Gold Medal of the Royal Geographical Society "in consideration of the services he has rendered to Geographical Science by his surveys in Afghanistan."

On the conclusion of the Russo-Afghan Boundary Commission, Holdich found himself back in Baluchistan at the time when Sir Robert Sandeman was carrying out his policy of peaceful penetration and settlement. At the end of 1889 he accompanied Sir Robert on the political promenade known as the Zhob–Gomal expedition, which closed the back door to the Sulaiman tribes. The whole of the Zhob valley and much of the Kundar were surveyed and the site of Fort Sandeman was selected. For the next year or two Holdich, now promoted brevet-colonel, was engaged in organizing the surveys of Southern Baluchistan and Makran, the triangulation of which was undertaken by his assistants, Talbot and Wahab. Holdich himself gained an extensive knowledge of Makran and the Persian coast, and surveys were extended as far as Jask and Bandar Abbas.

In 1892 he was appointed Superintendent of Frontier Surveys, and it was in this capacity that he was called upon to organize the various survey parties for delimiting and where necessary demarcating, the line laid down in the Durand Agreement of November 1893. The actual work in the field in connection with this agreement was not completed till 1896.

Holdich was an opponent of the Durand Line policy from the start. He always maintained that the presence of a surveyor or topographer, who knew the ground from personal observation, among the advisers of Government, would have prevented some of the errors that were made owing to lack of geo-

graphical knowledge, and the consequent political troubles on the border, both during and after demarcation. He never agreed with the policy of defining an easily penetrable frontier-line behind the independent tribesmen. As long as there was no boundary west of the tribes, we could, if necessary, follow up raiders and punish them: the boundary line did not prevent intercourse between the Amir and the tribes, but merely formed the frontier of a sanctuary, which we bound ourselves not to violate. Holdich, an ardent admirer of Sandeman's methods, maintained that to do any real good, military posts connected by good communications should be maintained at the " back door" of the tribal tracts, and so prevent the escape of marauders into the Afghan asylum. That was long before the advent of motor cars and aeroplanes, but it is interesting now to see those early ideas of Holdich in force to-day, though modified by modern conditions.

South of the Khyber the work of demarcating the line was divided into three sections. Holdich placed the Kurram party under Captain Macaulay, the Waziristan party under Major Wahab, and the long Baluchistan section, stretching westwards to the last pillar on Kuh-i-Malik Siah, the tri-junction of Persia, Afghanistan and Baluchistan, under Captain Ranald Mackenzie, with Tate as his assistant.

Holdich himself, who had been awarded both the C.I.E. and C.B. in the early part of the year, accompanied Mr. Udny on the Kunar Valley Delimitation Commission in December 1894. Once more he took the Khyber route towards Kabul, and crossing the Kabul river at Jalalabad ascended the Kunar river to Arnawai, the disputed point. It was here that they were to await the arrival of Captain Gurdon, the political officer in Chitral, who was to represent the interests of that state during the demarcation of the frontier between it and Kafiristan. The trouble which broke out in Chitral and the siege of that place hardly concern us here, for in spite of the attitude of the Afghans, Udny and Holdich carried on the work of demarcation and survey and completed it up to the Dorah pass by the following April.

The actual survey work was disappointingly meagre, in spite of the efforts of Holdich himself and his assistant, Lieut. Coldstream, simply for the reason that the Afghans obstinately refused to allow any work to take place that was not absolutely necessary for the delimitation. It is not till 1929 that any error has been found in this frontier, and that error lies in the section of it beyond the Dorah pass which was accepted as correct by both the Afghan and British Commissions.

Hardly was Holdich back from these duties when he found himself appointed as chief survey officer on the Pamir Boundary Commission, with Major Wahab, whose work in Waziristan was finished, once more his assistant. Unlike the other boundary settlements included in the Durand Agreement, the demarcation of a boundary on the Pamirs was necessitated by the principle that at no point on the Earth's surface should the land frontiers of England and Russia meet. The Amir was therefore given the small strip of Wakhan, a "long attenuated arm of Afghanistan reaching out to touch China with the tips of its fingers." This narrow springless buffer, a bare 8 miles wide at one spot, is all that separates Russia and Britain in the East; and it was the northern edge of this buffer that was demarcated. The work proceeded without a hitch; the

Great and the Little Pamirs were surveyed in detail; and the surveys and reconnaissances of Holdich were connected by triangulation carried out by Wahab, based on resection to the distant peaks already fixed from the south. When the geodetic link was forged between India and Russia eighteen years afterwards the difference between the common points of the two triangulations averaged only 5 seconds of arc in latitude and 3 seconds in longitude.

The Russians and British parted on the Pamirs on 12 September 1895. On his return Holdich was immediately appointed Chief Commissioner of the Perso-Baluch Boundary Commission, to demarcate the frontier west of Baluchistan and Makran, with Colonel Wahab as his chief survey officer. Holdich was now able to put into practice the lessons he had learnt during the many boundary commissions he had been on. He already knew much of the ground, surveys had already been carried up to and along much of the frontier, and he had himself studied the characters of the men with whom he had to negotiate. These factors were of enormous advantage to him and enabled him to complete the demarcation most expeditiously before the hot weather set in. For his services to India on this commission Holdich was made a K.C.I.E.

The year 1897 saw the frontier ablaze from Waziristan in the south to Swat on the north. Once more Holdich had to find officers and surveyors to accompany each column that penetrated the tribal areas. With his intimate knowledge, he was able to direct the efforts of his best assistants to the regions where the maps were "blankest"; and in 1898, while he was personally engaged on the Tirah campaign and reached the fatal age of fifty-five, decreed by the Government of India to be the age of inutility for Survey officers, he handed over his command in the field to his old friend Colonel Wahab.

When Holdich left the frontier there was hardly a corner of accessible ground on it that he had not seen. His strict scientific training, his capacity to endure the extremes of heat of baking deserts and the cold of Himalayan heights, his adventurous enjoyment of tight corners, all combined to make him an example to his successors on the frontier. His many frontier experiences rendered him most valuable at headquarters, where his push and tact and influence ensured that no opportunity of acquiring topographical information was missed. His view was that, when not actually required in the field, it was his job to see that his subordinates had every chance to do their job efficiently. The fact that surveys still continue on the frontier is due to the ever-increasing needs of peaceful development. Maps of larger scale, of greater exactness and detail, contoured for the alignment of roads and railways, and not merely for the punishment of marauding tribes, are required to-day, and our frontier surveyors are still hard at work. We find little blunders, necessitated by the "tip-and-run" circumstances of Holdich's time. To-day the frontier is at peace, and the back doors are connected by roads. The motor, the aeroplane, and the survey camera are there to assist us. The tribesman, at any rate in bulk, rarely scampers to his *bast* behind the Durand Line.

It must not be supposed that Holdich at the age of fifty-five closed his interest in frontier matters. Though his talents were employed in various fields for many years to come, those of us in the Survey of India who had the honour of meeting him long after he had left us always found him well up in all that concerned the Indian frontiers. It was not till then that he had time to put

his experiences in print for the benefit of his successors. 'The Indian Borderland' appeared in 1901; 'India' and 'Tibet' in 1904 and 1906; 'The Gates of India' in 1909; and 'Political Frontiers and Boundary Making,' a summary of all his accumulated wisdom on the subject, in 1918. Many of these are delightfully illustrated by his own sketches. That his interest never waned till the very end may be instanced by the fact that on 5 October last, less than a month before he died, he wrote me a letter asking me to find out what had become of a certain explorer, and of the report that he had taken down from the explorer's lips in 1884. A nephew of the man was traced and the manuscript found a few days after November 2. Sir Thomas Holdich was a Founder Member of the recently formed Himalayan Club and a generous donor to its foundation fund and library. The last words in his letter expressed a wish for the prosperity of the Club.

KENNETH MASON.

Perhaps the most important of all Holdich's work was his connection, after retirement, with the Chile–Argentine Boundary. The protracted dispute between these two countries over their common frontier in Patagonia, which on more than one occasion nearly led to war, arose from the ambiguity of their Boundary Treaty of 1881, which defined the frontier as following the highest crests of the Andes along the line that divides the waters which flow into the Atlantic from the waters which flow into the Pacific.

For a distance of some 900 miles in the northern portion of the boundary, a lofty unbroken mountain chain also traces the continental water-divide, but this unbroken ridge ends at Mount Lanin (about lat. 40° S.), and from that point southward, for another 900 miles, the mountain system is a jumble of detached massifs, often separated by great lakes lying transversely to the main axis, and sometimes cut through by deep gorges through which flow westward to the Pacific considerable rivers which have their sources far out in the Patagonia pampas to the east. It will be seen, therefore, that the actual geographical conditions did not by any means conform with the terms of the Treaty so far as the southern half of the frontier was concerned.

The Chileans claimed as a frontier the continental water-parting in its entirety, in accordance with their interpretation of the Treaty of 1881. The Argentine case, on the other hand, was a closely reasoned argument in favour of a boundary following a series of high detached peaks as constituting the main range and equivalent to the line of the highest crests mentioned in the Treaty.

After many years of discussion, which at times nearly led to open rupture between the two countries, the governments concerned, with great good sense, decided to submit the whole matter to arbitration, and invited the British Government to undertake the task. This led to the appointment of an Arbitration Tribunal, in 1900, composed of Lord Macnaghten, a Lord of Appeal, as President, Major-General Sir John Ardagh, the distinguished head of the Military Intelligence Department, and Col. Sir Thomas Holdich, as members, with Major E. H. Hills, R.E., as secretary. In view of the divergence of the claims, and the conflicting and often contradictory evidence adduced, the Tribunal felt that an examination *in situ* of the region in dispute was the only means of arriving at a decision on the numerous points submitted to it. This

mission fell to Holdich. He embarked for Buenos Aires with four officers as assistants on 31 January 1902.

The examination of various portions of the frontier which the Tribunal had found difficult to decide upon was carried out by the different officers of the mission, while Sir Thomas himself crossed to Valparaiso, where he embarked on a Chilean cruiser. Eventually he arrived at Puerto Montt and, in company with the Chilean Boundary Commissioner, Dr. Hans Steffen, crossed the Andes by the low pass at Perez Rosales to Lake Mahuel Huapi, where he met the Argentine Commissioner, Dr. Francisco P. Moreno, the well-known Patagonian explorer. Thence he started southwards, making long marches by the easiest available routes, eager to get into touch with his southern parties before the winter set in. He soon established cordial relations with his mixed following, his impartiality, his friendly demeanour, his keen interest in the work of the surveyors, his determination to complete his task in spite of natural obstacles and vile weather, all combining to make an unqualified success of the journey. He concerned himself with the physical aspects of the line of the continental water-divide as an international boundary, which he found, as he expected, to be an absolute negation, in many parts, of the principle that such a frontier should be easy to see and difficult to cross. Thus it remained for him to select for the consideration of the Tribunal a line that should possess, as far as posible, the requisite physical characteristics and one that should not create any inaccessible enclave, mere occupation, in his opinion, offering no basis for arbitral consideration. The parties then assembled in the neighbourhood of Lake Buenos Aires and marched across the Pampas to Comodoro Rivadavia, where the mission embarked for Buenos Aires, just escaping the on-coming winter, which in these latitudes is very severe.

On Sir Thomas's return to England his recommendations were considered by the Tribunal and their definition of an agreed boundary line was embodied in an award signed by H.M. King Edward VII in November 1902.

The frontier as awarded followed a series of lofty mountain ranges, crossed rivers at gorges and avoided giving to either country any useless, because inaccessible, area. The award was received with the greatest satisfaction by both governments concerned, who have observed it scrupulously ever since. The immediate result was a Treaty of Peace and Disarmament between Chile and Argentine which still exerts a beneficent influence over their mutual relations.

The award met with but little criticism in the popular press, for both countries very soon realized that each had received all it could reasonably hope to make use of. Their appreciation has greatly increased with the passage of time.

On the successful conclusion of the arbitration Sir Thomas was awarded the K.C.M.G. For him, however, the conclusion of the matter had not yet been reached. There still remained the actual demarcation on the ground of the boundary so awarded. Here and there, especially in the south, in the otherwise unmistakable line there were a few points, certain mountain passes, and river and lake crossings, and the portion of the line at the southern extremity, where the governments of Chile and Argentine felt that friction might arise if the boundary marks were not set up by independent authority. They accordingly

invited Sir Thomas to return to South America for this purpose in the ensuing summer. This he did, again accompanied by a party of officers.

For purposes of demarcation the frontier, where it did not actually follow the crest of the Andes, was divided up into sections and allotted to the various officers of the Commission who actually superintended the erection of the boundary pillars in the presence of representatives of the two governments.

The writer, who was present with Sir Thomas in South America, can testify to the fact that the success of this undertaking was very largely due to the power he possessed of conciliating divergent elements where difficulties had to be smoothed over. He was endowed with a personal magnetism not often met with.

It is not too much to say that at the present date, twenty-seven years after the arbitration, the name of Holdich is held in high esteem in both Chile and Argentine, while certainly few things gave him more pleasure in his later years than the thought of the enduring peace that has prevailed ever since, due, in no small measure, to his labours. H. L. CROSTHWAIT.

It remains to speak very briefly of Sir Thomas Holdich's work for the Society. On his return from India he was immediately elected on the Council, and in the following year was made a Vice-President. He reverted to the Council in 1906 and was elected a Vice-President again in 1910, succeeding Mr. Freshfield as President on 21 May 1917. He presided at the Anniversary Dinner on its revival in 1919 after four years intermission during the War, but did not serve the customary third year as President, owing to increasing deafness. After four more years as Vice-President he retired from the Council at the Annual Meeting of 28 May 1923, having then completed twenty-five years of continuous service on the Council. He died at Merrow near Guildford on 2 November 1929.

THE ICE-AGE ON THE TIBETAN PLATEAU AND IN THE ADJACENT REGIONS

DR. EMIL TRINKLER

THE main aim of this paper is to give a general idea of the extension of the glaciers during the Ice-Age in Tibet and in the mountain ranges bordering that great plateau. I shall endeavour to give a comprehensive study, based upon numerous reports as well as upon my own explorations. In September 1929 I had the opportunity of examining the large collection of photographs stored in the map-room of the R.G.S. Amongst this collection there are many which, from a morphological point of view, are extremely interesting, and I shall have occasion to refer to a number of them later on.*

The territory to be considered in this paper includes the high mountain ranges of the Kunlun and the Karakoram, the big plateau of Tibet proper, and the Himalaya and Sino-Tibetan ranges. Before dealing with the special investigation of ancient glacial troughs and valleys, of moraine walls, striated boulders, trough-shoulders, and so on, I will summarize the main data at our disposal about the above-mentioned regions, beginning with the mountain ranges bordering the Tibetan plateau in the north.

1. *The Kunlun Ranges*

The geological and geomorphological exploration of this big system of mountain ranges has been much neglected. With the exception of Stoliczka† and Bogdanovich‡ no trained geologist had ever done any remarkable work there until my companion, Dr. de Terra, started with his geological work in the Western Kunlun in 1927–28.§ Collections of rock-specimens had been made by Zugmayer‖ in the upper Keriya Darya district, and by Hedin¶ in the Kunlun ranges rising between the Lop Depression and the high plateaux of Tibet proper. But we need not be astonished if we do not get much information from these explorers about the extension of the glaciers during the Ice-Age in these regions. We find a hint about the former more extensive glaciation of the Arqa Tagh in Hedin's 'Scientific Results of a Journey in Central Asia,' vol. iii, p. 83, where he says, "The glacial mass that now survives rises therefore like an *insula-relicta*, a fragment of an immense ice-sheet that has now all but entirely disappeared."

Schlagintweit** had already mentioned that formerly the end of the Elchi glacier (on the northern side of the Hindutash Davan) was nearly 1700 feet lower than the spot where it ended when he saw it in 1856. But the best infor-

*I am very much obliged to Lt.-Col. Wood, Major Mason, and Dr. De Filippi for allowing me to reproduce here several of their photographs.

†'Scientific Results of the Second Yarkand Mission' (Calcutta, 1878), vol. i.

‡' Geological observations in Eastern Turkestan' (Russian). St. Petersburg, 1892.

§'*Geologische Rundschau* (Berlin, 1929), Bd. XIX, pp. 41–51, Bd. XX, pp. 120–136.

‖*Ztschr. d. Deutschen Geologischen Gesellschaft*, 1913, pp. 173 *et seq.*

¶*Petermanns Mitt. Ergh.* 131.

**Schlagintweit-Sakülünski, 'Reisen in Indien und Hochasien' (Jena, 1880), Bd. 4, p. 140.

mation about the former glaciation of the Kunlun we owe to Sir Aurel Stein,* G. Sobolevski,† and to G. Prinz.‡

Sir Aurel Stein, who visited the high alpine valleys of the Kunlun south of Khotan, refers to the big loess-covered moraine walls in the Nissa and Qaranghu Tagh district (10,000 feet). Sobolevski, who made his explorations in the westernmost Kunlun in 1913, calls special attention to terminal moraine deposits in the following valleys of the western Kunlun: in the Qaratash valley at 3500 m.; the Yeisa valley at 3500 m.; the Tarlung valley at 3300 m.; the Leisa valley at 3500 m.; the Paspu valley at 3000 m.; the Chong Karaz valley at 3700 m.; the Kilian valley at 3450 m.; and the Kichik Karaz valley at 3500 m.; the Tegerek valley at 4000 m.; G. Prinz, who also paid a visit to the western Kunlun, gives lower heights for old moraine deposits: in the Qaratash valley, 3100 m.; and in the Pittik, 3250 m.

He also paid special attention to the configuration of the valleys. Judging from the prevalence of the U-shaped sections of formerly glaciated valleys, he states that the glaciers ended in the Jainage-Korumdu valley at 2800 m.; the Ordolon valley at 3245 m.; the Chimgen Su valley at 3300 m.; the Pittik valley at 3250 m.; and the Otrake valley at 3400 m.

Sobolevski believes that during the Ice-Age the snow-line on the northern slopes of the Kunlun was at 4100–4150 m., on the southern slopes at 4500 m.; while the corresponding heights of the present snow-line may be taken as 4800 m. and 5160–5200 m. according to Sobolevski's and to my own observations. But as to the height of the Pleistocene snow-line, Prinz as well as I myself get lower values. My observations in the Kilian valley tend to show that during the biggest glaciation the glaciers in this valley also ended as low as 2800 m. There are two moraine deposits in the Kilian valley; the upper, also mentioned by Sobolevski, consists of big boulder deposits, while the lower is more difficult to trace, being covered by loess. But if the badly preserved lower deposits should give rise to any doubt as to their origin, the beautiful trough-shaped valley and the old trough shoulders prove the bigger extension of the glaciers down to this spot (Pl. 1). So I believe that Prinz is right in assuming a depression of the snow-line during the later glacial periods by at least 600 to 800 metres. As the main aim of this paper is to examine which parts of Central Asia were once buried under glaciers, I shall not discuss here the question of the existence of the different glacial periods, the more so as this question is still unsettled, although we can fairly safely assume that there were at least three greater glacial periods.

The data about the former glaciation of the Kunlun Ranges east of the meridian of Khotan are very scanty. As the present snow-line is, according to Pyevtsov,§ much higher there than in the west (northern slope 5400 m., southern slope 5700 m.), we can fairly safely assume that the same also applies to the snow-line during the glacial period.

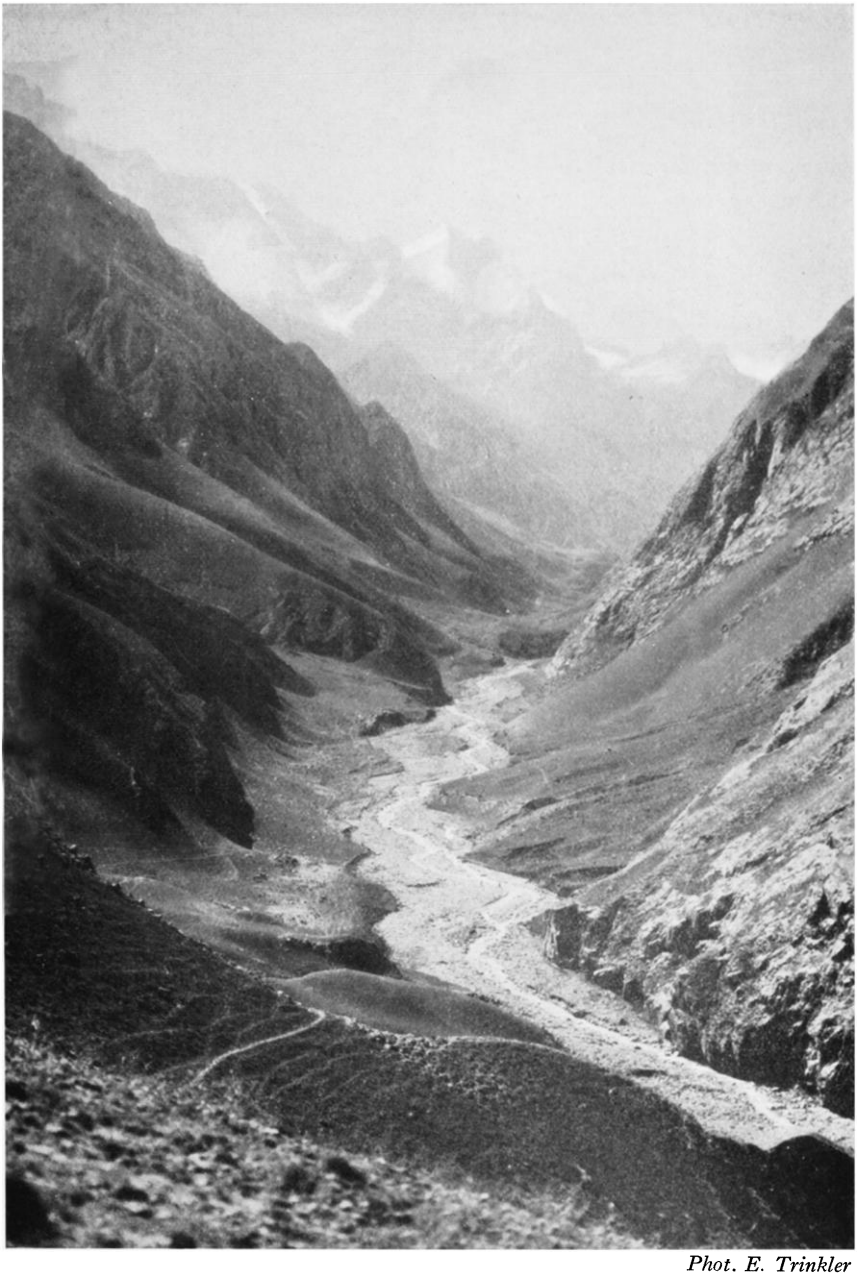
Some noteworthy observations about a former larger glaciation of some

*A. Stein, 'Ruins of Desert Cathay' (London, 1912), vol. i, pp. 182, 199.

†G. Sobolevski, 'The present and past glaciation of the western Kunlun,' *Bulletin* Russian Geographical Society (Petrograd, 1919), Bd. 54, p. 97.

‡'Ergebnisse der Forschungsreisen durch Innerasien,' v. G. Prinz (Pécz, 1928).

§'Results of the Expedition to Tibet' (Russian), Petersburg, 1895, vol. i.



Phot. E. Trinkler

1. The glacial-troughed valley of the Upper Kilian Darya

Phot. K. Mason

2. Looking up the Nubra valley from near its junction with the Shyok

ranges in the eastern Kunlun were made by Albert Tafel.* He mentions cwms on the northern side of the Burkhan Buddha Range and erratic boulders. He also found moraine deposits in the Bayen-khara Mountains, where the valleys are often trough-shaped.

2. *The Karakoram*

Observations as to the former greater extension of glaciers are as numerous in the Karakoram Mountains as they are scanty in the Kunlun. G. Dainelli, who accompanied Dr. Filippo De Filippi's expedition to the Karakoram Mountains in 1913–14, has given us an excellent general review of all earlier notes on former glaciation in those regions, and he has corroborated these data with his own observations.† In his opinion there were four great glacial periods in this part of Central Asia, corresponding with the Mindel, Riss, Würm, and Post-Würm stages in the Alps. Unfortunately, the terminal moraines of the first two glaciations are so poor and so much obliterated that it is impossible to give an approximate height for the snow-line during those periods. But it is absolutely certain that big glacial-troughed valleys had already been modelled and excavated by more ancient and bigger glaciers, before the terminal moraines of the third glaciation were deposited. Dainelli believes that during the earlier glacial periods the big Indus Glacier ended with its snout in the lake formerly covering the Punjab between the foot of the Western Himalaya and the Salt Range. We now have fairly abundant material at our disposal in order to get an idea of the extension of the glaciers during the later glacial periods. Nearly everywhere in the region of the Karakoram–Himalaya, terminal moraine walls near the debouchure of tributary valleys into main valleys (Shyok–Indus–Nubra–Hunza valley) prove that the glaciers advanced considerably, often into the main valleys which had received their trough form during the earlier glacial periods. Dainelli has given a complete list of the moraine deposits of his third and fourth glacial periods, and he also discusses the elevation of the snow-line. His investigations show that during his third glacial period the height of the snow-line in the region of the Shyok valley must have been something like 5100 m., while during the fourth glacial period it was 5950 m. On p. 609 of his work he gives a sketch-map showing the height of the snow-line during the third period in the north-western Karakoram-Himalaya.

In 1926 Major Kenneth Mason passed the Nubra Valley on his way to the Shaksgam, and in his report he‡ points out: "The whole valley at one time must have been filled by a huge glacier nearly 100 miles long which pushed its snout across the valley of the Shyok, damming back that great river and causing an immense lake to form behind it. Longstaff, who in 1909 passed up the Nubra by the right bank, remarks that the solid rock near the junction is for hundreds of feet above the river-level polished, rounded and scratched by the ancient glacier. For my mind there is no doubt about the existence of this glacier, for I could still observe the remains of old lateral moraines first noted by Drew high up the mountain sides though they have been much eroded since his day."

Amongst the photographs taken by Mason there is one panoramic view of

Ztschr. Ges. Erdkunde (Berlin, 1908), p. 389.

†G. Dainelli, 'Studi sul Glaciale' (Bologna), 2 vols.

‡'Records of the Survey of India' (Dehra Dun, 1928), vol. xxii, p. 14.

the Nubra valley showing its glaciated form quite well (Pl. 2). I myself paid a visit to the Nubra valley in autumn 1928. I studied the beautifully striated rocks and boulders between Panamik and Sumur, and I found terminal moraines near Thirit and Khalsar in the Upper Shyok valley. A photograph taken by F. O. Cave on Mason's expedition to the Shaksgam shows the trough-form of the valley called B. Another very remarkable valley of this kind is Wood's valley I, called Lungmo-che by Mason. This valley is a typical broad trough with big névé reservoirs or cwms hanging over the valley* (Pl. 3).

Big glaciers pushed their snouts into the Qarakash valley from the great range in which the Suget Davan is situated. The moraine deposits between Suget-Qaraul and the Suget Pass prove that a glacier once ended there. There are two valleys uniting at approximately 4200 m.: both are broad U-shaped valleys, filled with detritus and gravels. If the big moraine deposits at the lower end of this valley were not proof that once a glacier really came down through it, it would hardly be possible for any one to prove this fact by the morphological configuration of the upper part of the valley (Pl. 5). We shall see later on that the same applies to the valleys and plateaux of Tibet proper. There are valleys which were glaciated during the Glacial Period, but which have not the form of a glacial trough at all. But careful investigation will nearly always prove that along the slopes of the mountains bordering these valleys there are small rounded shoulders and remnants of old valley-bottoms, though generally so much worn and eroded that only a very careful observer can recognize them. Furthermore, in the more continental regions the valleys are buried under gravels and detritus, often hiding the lower part of the glacial-troughed valleys.

Another valley which once contained a big glacier is that of the Upper Yarkand near Khufelang. Two photos taken by Wood prove this (see Pl. 4). Unfortunately, the material I have at my disposal concerning the Yarkand valley from Khufelang via Kulanuldi into the Raskam Valley is so poor that I am unable to estimate the former glaciation of that part of the valley. The big broad trough-like valley bordering the range in which the Karakoram Pass is situated in the south was formerly also glaciated, as prove its rounded and smoothed step-like shoulders (Pl. 6).

We have now to consider the regions lying farther west. The best idea of the former greater glaciation can be obtained from the region of the Hunza river. Conway in 1892 had already seen the "roches moutonnées" near Tashot.† The beautiful trough of the Hunza valley shows the action of the glaciers of the Ice-Age remarkably well. The eastern end of the Oprang Pass seems to be a broad U-shaped valley like the valley leading to the Mintaka Pass from the Chinese side. Arved Schultz states that once a big glacier coming from the Oprang and Hunserab region and uniting with the upper Taghdumbash Glacier pushed its snout into the Taghdumbash valley.‡ A photograph taken near Khaibar in the Upper Hunza Valley shows evidence of former glacial action, as does a photograph taken by W. R. Read from the Batura

*Wood, 'Explorations in the Eastern Karakoram and the Upper Yarkand valley.' Published by Survey of India (Dehra Dun, 1922), with photographs and map.

†Martin Conway, 'Climbing in the Himalayas' (London, 1894), p. 236.

‡Arved Schultz, 'Landeskundliche Forschungen im Pamir' (Hamburg, 1917).

Phot. H. Wood

3. View north-east and east from peak 18,508 in valley I, Karakoram

Phot. H. Wood

4. Valley near Khufelang (Upper Yarkand valley)

5. Formerly glaciated valley leading north from Suget Pass

Phot. F. De Filippi

Glacier looking up the Kanjut valley, and one by C. J. Morris at the junction of the Khunjerab and Ghujerab.* Nearly every photograph taken in the neighbourhood of the Rakaposhi gives an idea of the great effect of glacial action in these regions.

Farther west we come to the tributaries of the Hunza river, the Ashkuman-Karambar, with its right-hand tributary the Yasin. There are several very remarkable photographs in Stein's 'Innermost Asia.' I refer here only to figs. 38 and 41 (Head of the Yasin valley), and fig. 50 (Karambar valley). In 'Serindia,' vol. i, by the same author, there are two photographs giving a fine idea of the former extension of the glaciers in this region. No. 17 shows the Defile of Darband, with a view down to Jhopu in the Yarkhun valley, while No. 20 gives an idea of the Darkot Glacier from the foot of Raukang Spur, looking south. I have not succeeded in finding much material about the Yarkhun valley. A large photograph in the R.G.S. collection, taken by Captain J. Sulley, represents a view of Lower Kala Drosh in winter. The old rounded shoulders on the slopes of the mountains bordering the broad U-shaped valley are probably due to former glacial action.

We turn now to the region round Nanga Parbat. The only definite proofs of ancient moraines were found near Astor. Dainelli refers to these deposits† and points out that the end moraines near Astor, at 1300 m., belong to the third glacial period, while those near Rattu Spur in Astor Valley, at 2500 m., belong to the fourth. But during the older glacial periods the whole region must have been buried under ice. The valleys in the Darel and Chilas District have probably been modelled by former glacial action (see A. Stein, 'Innermost Asia,' vol. i, phot. 3, 16, 17, 18). Data about the difficult tracts east and west of the Indus Gorge below Bunji, however, are so poor that we cannot get any idea at all about the former extension of the glaciers there. The same applies to the lower Chitral–Kunar River running into the Kabul near Jalalabad, but that the upper Swat Valley once contained a glacier is evident from a photograph taken by Sir Aurel Stein.‡

3. *Tibet*

Before entering into the discussion of my own explorations, I will summarize the views of different explorers who have been in Tibet. Although Sven Hedin discussed in his older reports§ the probable glacial origin of several of the Tibetan lakes he says in his 'Southern Tibet,' vol. ii, p. 178: "On the highland Plateau of Tibet the temperature must have been sufficiently low to allow the entrance of an ice-age but even then and on account of the protection of the southern mountain systems the precipitation has not been sufficient to cover the highland with a cap of ice. There are glaciers, although sporadic, rare, and small, all over Tibet, and they advanced considerably at the same time as those of Himalaya and Kara-korum. But otherwise I have in vain searched for any traces of an ice-age in the country."

In his 'Transhimalaya' Hedin pointed out that the depressions of the Holy

*G.J., vol. 71, 1928, Plate facing p. 525.

†G. Dainelli, 'Studi sul Glaziale' (Bologna), vol. i, pp. 600, 604.

‡'On Alexander's track to the Indus' (London, 1929), Phot. 60: View down the Swat River from Peshmal.

§Sven Hedin, 'Scientific results of a Journey in Central Asia, 1899–1902' (Stockholm, 1904–1907).

Lakes (Manasarowar and Rakas Lake) were excavated by glaciers advancing from the range in the south.* Formerly he mentioned that probably the Naktsang Tso and the basin of the Ziling Tso were affected by glacial action. A study of the photographs published by Hedin leads us to the conclusion that the glaciers of the "Transhimalaya" also must have been longer; e.g. the photographs of the beautiful hanging valley in which nestles the monastery of Linga Gompa, and the Targo Kangri Range (south of Tangra Tso) wherein fine cwms can be recognized.† Hayden discovered ancient moraines on the shores of the Kyaring Tso; they can only have been deposited by glaciers coming down from the Transhimalaya in the south.‡ Huntington has published a special study of the glacial origin of Pangong Tso,§ and Dainelli also refers to the glacial origin of its basin. I think there can be no question about the basin of Pangong Tso having once contained a big glacier. The whole fjord-like valley containing the lake is a typical submerged broad trough (Pl. 7).

In 1846 Henry and Richard Strachey travelled in the district of the Holy Lakes, and Richard Strachey discovered unmistakable moraines in the Darma Yankti and in the Gunda Yankti valley.‖

Hugh Ruttledge has published a remarkable paper on a visit to Western Tibet in 1926.¶ Amongst the photographs reproduced there is a view of the Darma Gorge from near Nangling. The cross-section of the valley shows a trough-like form, indicating that glacial action has been active here. Amongst the collection of photographs at the R.G.S. there is another taken by Ruttledge showing the view from the Lipu Lelch Pass towards the north. The valley down is trough-shaped. In the distance Gurla Mandhata with its big snow reservoirs can be recognized.

Very important observations about the former glaciation on the northern side of the Himalaya were made by members of the Mount Everest Expeditions. Heron, the geologist of the first Everest Expedition, says:** "I am able to add my testimony to that of Hooker, Blanford, Hayden, Garwood, and others concerning the former much greater extension of glaciation. The present glaciers are but tiny representatives of their former might as shown by the huge moraines which encumber all the northern valleys."

Also N. E. Odell, in his final report on the rocks and glaciers of Mount Everest,†† refers to the former greater extension of the glaciers. About the former glaciation of the northern side of the Himalayas he says: "Now, if we consider, in the light of such morainic evidence as remains, what effect on the country of the maximum phase of the Cycle must have meant, we must conclude that the ice completely blocked most of the valleys, and in fact that in many instances the ice streams were linked up on this north side of the main chain." Odell even

*Sven Hedin, 'Transhimalaya' (German Ed.), vol. ii, p. 107.

†Sven Hedin, 'Southern Tibet' (Stockholm), vol. iii, third plate after pp. 274, 280.

‡H. H. Hayden and Cosson, 'Sport and travel on the Highlands of Tibet' (London, 1927), p. 135.

§Ellsworth Huntington, "Pangong, a glacial lake in the Tibetan Plateau," *Journal of Geology* (Chicago, 1906), vol. xiv.

‖*G.J.*, vol. 15, pp. 150 *et seq.*

¶*G.J.*, vol. 71, May 1928.

**'Records Geological Survey of India' (Calcutta, 1922–23), Part 2, LIV.

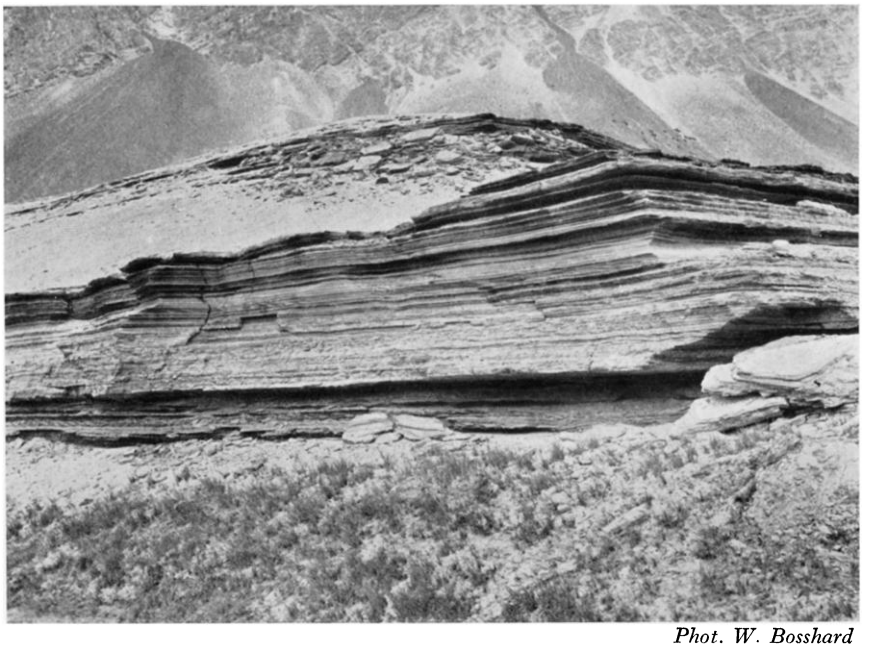
††*G.J.*, vol. 66, October 1925.

Phot. F. De Filippi

6. Glacial-troughed valley south of Karakoram Pass

Phot. W. Bosshard

7. Snow reservoirs in range south of Pangong lake



Phot. W. Bosshard

8. Stratified clay deposits of Pangong lake

refers to the possibility that many other parts of the Tibetan Plateau were engulfed by ice. For my part I even venture to say that very probably the Tsangpo valley also once contained a glacier, like the Upper Indus valley in the west. The basin of the Yamdrok Tso was deeply affected by glacial action; the bays and arms of this lake can easily be interpreted as submerged troughs.* Very similar cross-sections showing preserved valley bottoms and trough shoulders can be recognized in photographs taken in the Tsangpo valley. But here the greatest part of the broad trough is submerged and buried beneath fans of sediment and gravel deposits.

As to the former glaciation of the northern side of the Himalaya, the late Sir H. H. Hayden pointed out that the glaciers of Pauhunri and Kangchenjau once extended to the north into the Yaru plain and he also calls attention to the big moraine deposits of the Phari and Tuna plain. He says:† "The small glaciers on the northern sides of these mountains are but the shrunken relics of what must once have been a great ice sheet almost completely covering the slopes of the culminating range of the Himalaya and extending far into the neighbouring plains and valleys."

Before entering into the discussion of the former glaciation of Central Tibet I have to point out here some features in the configuration of the valleys and plains on the Tibetan Plateau. An expert trained in glacial-morphological studies might be surprised to learn that the valley reproduced on Pl. 5 once contained a big glacier entering the Qarakash valley from the south. The same expert would probably deny the existence of a glacier when studying the photographs published in Hedin's 'Southern Tibet,' vol. iv, pp. 6 *et seq.*, showing the scenery round Marsimik Pass. But the extensive and well-preserved moraine deposits near Suget Qaraul as well as those near Pobrang, the hanging valleys on both sides of the valley leading to the Marsimik and Suget passes, and the small badly preserved shoulders on the slopes of the mountains, are proofs of the former glaciation. Several explorers have studied the Deosai plateau in Kashmir, and they have proved that during the Glacial Period this plateau was glaciated. The rocks are denuded and rounded, and the type of landscape is very similar to that in the mountains of Central Tibet and of the Transhimalaya, only that in these regions the rock is much more disintegrated (compare fig. i, Pl. 33, 34, Oestreich, "Die Täler des nordwestlichen Himalaya," *Petermanns Mitt.*, Ergh. 155, with plates following p. 278, Hedin, 'Southern Tibet,' iii).

In the continental regions of Central Tibet we scarcely ever find any striated boulders or polished rocks because the disintegration is too great owing to the strong insolation. We do not find any typical trough-like valleys because the pre-glacial erosion and dissection did not affect the Central Tibetan landscape so much as that of the bordering regions and because the valleys are now more or less filled up with younger deposits. The valleys are broad plains filled with detritus, sands and gravels. Like a big mantle the sheets of ice engulf the mountains.‡ Often the broad snouts of the glaciers enter the main valley

*See Phot. of Yamdrok Tso in 'Tibet,' by W. F. Ottley.

†'Memoir Geological Survey India,' vol. 36 (1907), Part 2, p. 15.

‡See *G.J.*, April 1927, Pl. 13, "Aghil-Depsang and Tatar-la"; Hedin, 'Scientific Results,' etc., vol. iii, Pl. 83; vol. iv, Pl. 73; H. H. P. Deasy, 'In Tibet and Chinese Turkestan' (London, 1901), plate on p. 85; and *G.J.*, vol. 16, 1900, p. 509.

plain. During the Glacial Period these glaciers must have united and they must have more or less filled the broad valley-plains. They did not wend their way through deeply eroded valleys and model them into steep-sided troughs, but the glaciers probably covered the plain-like valleys as well as the big plateaux in the shape of broad sheets of ice. Prinz has recently pointed out (p. 298) that during the Ice Age the ice covering the Eastern Pamirs was developed in the form of "Highland Ice" (Tafeleis), which does not leave any traces after melting. In my opinion the same may apply to the ice-masses which formerly covered the big valley-plains of North-Western Tibet. Recently Foster Flint has contributed remarkable observations and views about the stagnation and dissipation of the last ice-sheet of New England, in a well-illustrated article.* Considering the morphology of New England he describes the dissipation of the ice as a dead or stagnant mass resulting from total loss of forward motion. It is very likely that the same kind of dissipation took place when the glaciers of the Ice Age on the Tibetan plateau were melting. Flint has called special attention to the fact that the rate of melting is a variable factor which depends upon the different degree of exposure of rock-slopes and ice. The rate of melting is controlled by topography, for in the neighbourhood of mountains and nunataks the ice will melt rather quickly and marginal lakes are formed. The more the ice is melting the more water covers the plains and valleys, especially in regions which have no outlet. Many of the big broad valleys on the Tibetan plateau were once transformed into lakes, which afterwards shrunk more and more, till nothing was left but the comparatively small sheets of saline water which we find to-day.

Dainelli states that the stratified clay deposits in the Tankse-Drugub valley, as well as those in the Upper Indus valley, were deposited in lakes during his third glacial period.† I could prove that at the western end of lake Pangong the old lake sediments are covered by moraine deposits. When during the later glacial periods the glaciers advanced from the tributary valleys, pushing their snouts often into the main valleys and right across them, the melting waters were often dammed up and could find no outlet, so that the valleys were transformed into lakes. The same phenomenon is still going on to-day. I only remind the reader here of the lake which was dammed up in the Upper Shyok valley by the Chong Kumdun.‡ Many lakes of this kind were in existence during the Ice-Age. We can recognize their remnants in the old stratified clay deposits which are so widely distributed across the Tibetan plateaux (Pl. 8).

Our knowledge of the former glaciation of the Sino-Tibetan Ranges is very meagre. According to Tafel's studies glaciers once advanced through the Upper Yangtze valley. In South-Eastern Tibet the glaciers ended at 3000 m., while their snouts are at present as high as 4500 m. When referring to his journey from the sources of the Hwang Ho to the Upper Yangtze Valley Tafel points out that the longitudinal valleys were almost completely scooped out by the former enormous Tibetan Highland glaciers ("Inlandgletschermassen").§

*_Geographical Review_ (New York, 1929), xix.

†Dainelli, 'Studi sul Glaciale,' vol. i, pp. 383 _et seq._

‡_The Himalayan Journal_, vol. i, No. 1; "The Shyok Dam in 1928," by F. Ludlow; "Indus Floods and Shyok Glaciers," by Major Kenneth Mason; ➞ _G.J._, 74, 1929, p. 383, "The Glaciers of the Upper Shyok in 1928," by Captain Malcolm Sinclair.

§_Ztschr. Ges. Erdunde_ (Berlin, 1908), pp. 389–393.

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MAJOR JAMES RENNELL

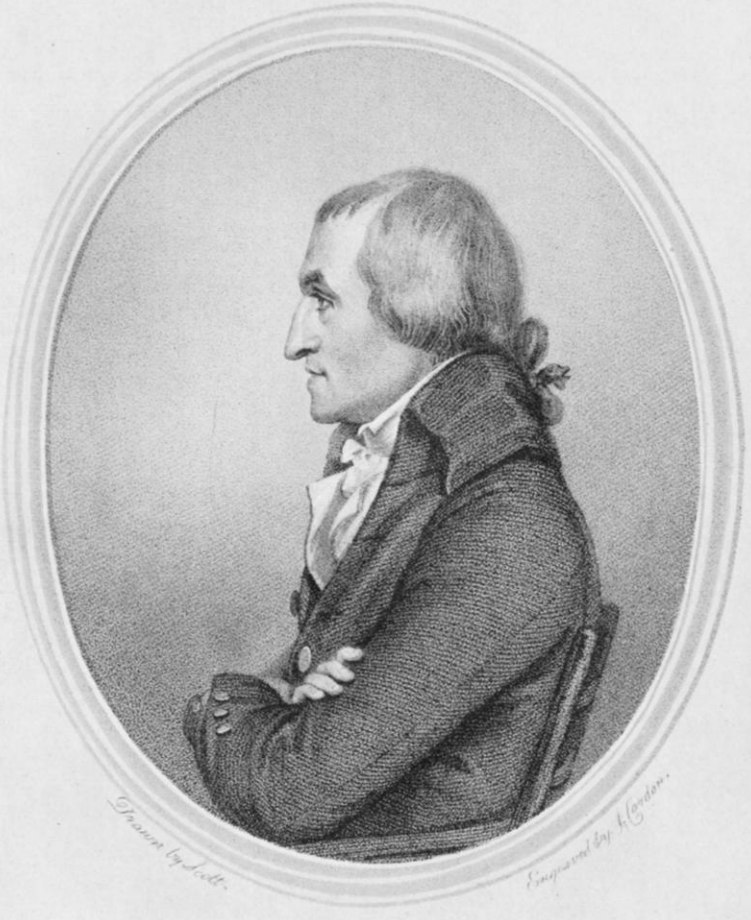
Born 3 December 1742. Died 29 March 1830

ON the centenary of his death, which fell on 29 March 1930, the Royal Geographical Society did honour to the memory of Major James Rennell. Such a tribute was right and just for two reasons. Not only is he recognized to-day, as he was by his contemporaries both at home and abroad, to have been the first eminent British geographer; but it seems hardly open to doubt, though he did not live to see the Society actually constituted, that it was in consultation with him that his intimate friend Admiral Smyth began to enrol members for an institution which was being simultaneously promoted by Sir John Barrow, the secretary to the Admiralty. The society was in fact founded within two months of his death. It is appropriate therefore that a brief commemorative sketch should find a place in its *Journal*.

The career of Rennell may be divided into two periods, that of his earlier years of adventure as a sailor, an explorer or a surveyor, and that which covered more than fifty years at home of laborious and far-reaching study extending over every field of geographical activity.

Life did not open very auspiciously for the future geographer, who was born on 3 December 1742 at Upcot, one of two small Devonshire properties situated about a mile from Chudleigh, on the river Teign, which had been owned for several generations by his family. His name, which has been spelt in more ways than one, appears to be a variant of the better-known Reynell, borne by an ancient Devonshire family of French origin. His grandson learned from him that one of his earliest memories dated from his fifth year, when his father embarked as a captain of artillery for the war in the Low Countries. And there soon afterwards, in July 1747, Captain John Rennell was killed in action, leaving a widow with a son and a daughter in such straitened circumstances that they were obliged to part with the Devonshire estates, one of which however was eventually recovered after a lawsuit in 1769, while James Rennell was in India.

The widow with her children found a temporary home with a cousin, the rector of Drewsteignton, near Exeter, but on the transfer of this Dr. Rennell to a living in Northamptonshire she made a second marriage to a former



Major James Rennell, F.R.S.

Chudleigh neighbour. Having a family of his own, Mr. Elliot the stepfather, whose means were small, was unable to provide for two additional children, and young Rennell was at the age of ten practically, if not formally, adopted by the new Vicar of Chudleigh, the Reverend Gilbert Burrington, with whom he found a very happy home. There is a family tradition that already in those early years he showed evidence of his future tastes by making a map of the country surrounding the village and the venerable church in which the effigies of Sir Piers Courtenay and his wife may still be seen kneeling side by side. The only schooling he enjoyed seems to have been at the local grammar school.

But young Rennell was one of those who absorb all the books which come in their way and educate themselves. Like so many other lads of Devon in the days of Hawke and Anson, he felt the call of the sea. Through the influence of a mutual friend his guardian was able to secure for him an appointment as midshipman in the frigate *Brilliant*, which Captain Hyde Parker was then engaged in commissioning. And so at the age of fourteen he left his kind friends at the vicarage for good, as it was to prove, and took the Exeter coach which ran through Chudleigh to Plymouth. A month or two later a boy's dream of adventure seemed to be fulfilled when the war with France broke out which was to last for seven years. Life was rough and fare monotonous in those days on the orlop deck for the midshipman who, as Rennell's contemporary Falconer described him, had to wield "the sword, the saucepan and the book," and was not "passing rich on 30 pounds a year." But he was fortunate in his messmates, and particularly in his commanding officer. Hyde Parker had served under Anson in the famous voyage of circumnavigation, and his interest in all marine problems no doubt led him to encourage his midshipman's natural disposition for surveying.

The first chart made by Rennell which has been preserved was a careful study, dedicated to Lord Howe, of the Bay of St. Cast, where he witnessed the disastrous re-embarcation of the troops originally landed for an attack on St. Malo, which had to be abandoned. A rearguard of Grenadiers, 1200 strong, under Colonel Davy, was practically annihilated under his eyes, while the frigate drew too much water to get within effective range of the enemy. In the following year the *Brilliant*, under a new commander, had the fortune to capture two French privateers. A modest but very welcome share of prize money fell to the midshipman, who after a long spell of service at sea was granted leave. It was characteristic of him that he spent a portion of this money on books.

His first protector, Captain Hyde Parker, now in command of the *Norfolk*, a 74-gun warship proceeding to the East Indies, had consented to give him a berth. But the transport on which he had secured a passage to Portsmouth, where she was fitting out, ran on a shoal, and though she got off again the delay had been fatal and he found the *Norfolk* had sailed. After some weeks of the uncertainty incidental to the seaman's life in the days of sail, he secured a place as a midshipman in the frigate *America*, and started for Madras on 6 March 1760. Eighteen years were to pass before he saw his native land again. The voyage out, during which Rennell made plans of harbours and anchorages, occupied six months, which included a fortnight's stay in Madagascar to give

the crew the necessary antidote to scurvy—fresh food and fruit. The ship would have been a happy one but for the violent temper of the captain, whose use of his fists and his stick aroused the bitter resentment of the midshipmen.

On their arrival at Madras the influence of Hyde Parker secured Rennell's transfer to the *Grafton*, of which he had taken over the command when the *Norfolk* became the flagship. The British fleet, consisting of sixteen ships of the line with six frigates under Admiral Stevens, proceeded to Pondicherry, to co-operate in a blockade which Colonel Coote had organized on land. Rennell was selected to take part in an expedition to cut out the French frigate *Baleine* and an Indiaman, which were lying under the guns of the fort. The frigate, which was boarded at two in the morning, was for at least an hour under their fire before she could be got to sea. But the operation was completely successful and the losses relatively small. During the rainy season the majority of the ships went to Ceylon, and there Rennell made a survey of the harbour of Trincomali. It was no doubt also at this time that he first investigated the chain of sandbanks, known as Adam's Bridge, separating Ceylon from the south-eastern extremity of the Coromandel coast, across which he declared that a navigable passage could be maintained by dredging the strait of Ramisseram. It was pointed out in a biographical sketch of Rennell issued in 1842 by Baron de Walkenaer, the secretary of the French Academy, that, though no notice was taken at the time of the suggestions put forward by so young and unknown an officer, the idea was revived some sixty years later. Almost immediately after their return a hurricane burst with disastrous effect upon the fleet while lying at anchor. An Indiaman and two ships of the line were lost, five more were dismasted, and three fire ships were driven ashore. The only vessels which saved their masts were the *Grafton* and the *Norfolk*, both of which Hyde Parker had commanded. The blockade of Pondicherry was none the less maintained until it capitulated on 17 March 1761.

A project for the capture of Bourbon and Mauritius, conceived by Admiral Cornish, who after the death of Stevens succeeded to his command, next took the East Indies squadron to Rodriguez, an island 344 miles east of Mauritius, originally discovered by the Portuguese, which the Governor of Bourbon had annexed. There Cornish had been instructed to await a fleet under Keppel, who was to take over the direction of the expedition. Rennell employed his time in making a survey of the harbour, Port Mathurin, and studied the natural history of this curious volcanic island surrounded by a reef of coral. It was then well wooded and haunted by giant land tortoises. The coastal waters were alive with fish and turtle, of which, Rennell wrote in one of his letters, the fleet was calculated during its stay to have consumed sixty thousand. But seamen cannot live on turtle alone, and after a stay of seven weeks the exhaustion of his supplies compelled Cornish to return to Madras, where he learned to his chagrin not only that Keppel had not started, but that no preparations had ever been made for the expedition. The plan which he could perfectly well have carried out with the resources at his disposal was thus rendered abortive by the ineptitude of the authorities at home.

Commissions and promotion in the navy were in those days only procured by favour, and young Rennell was wholly without interest, though he never

lacked friends. There was evidently some endearing quality in the young sailor which made him popular with his messmates, that quality no doubt which his letters reveal of always making the best of things. Six years of meritorious service at sea had gained for him the esteem of his captain, who suggested to him the advantages of entering the East India Company's navy. He was accordingly lent experimentally as surveying officer to one of the Company's warships which was to endeavour to establish trading relations at various places on a cruise, the ultimate destination of which was the Philippines. When he returned to Madras about a year later with charts from the Nicobar islands, Malacca, and North West Borneo, he was at once offered the command of a ship which, in consequence of the absence of his captain, he was then unable to accept. With the termination, however, in 1763 of the Seven Years' War, which made any prospect of a naval career precarious, he decided to enter the Company's service and was discharged from the Royal Navy.

The first ship of which he was given the command was destroyed by a hurricane in Madras roads. Being on shore at the moment when the vessel was struck, Rennell was fortunate in escaping with his life, but all his modest possessions were lost. It was however not long before he was appointed to a small coasting vessel, apparently chartered by the Company. The Governor of Madras, Mr. (afterwards Sir Robert) Palk, was also a Devonshire man whose home at Haldon was close to Chudleigh. This may account for the interest he took in the son of a former neighbour. Through the governor's influence Rennell was given a commission to superintend the transport and landing of troops and stores destined for the siege of Madura in the south of the Presidency. The work of the small squadron commanded by this very young commodore earned for him the thanks of the Madras Government and a donation, which was the more merited because in the intervals of service he had carried out a number of valuable surveys. Then the miracle happened. At Calcutta he fell in with a squadron under a Captain Tinker who had shown him particular kindness during his naval service, and he renewed acquaintance with a former messmate who had been his closest ally in the *Brilliant*. This Mr. Topham, who had joined the Company's civil staff, was in intimate relations with the Governor of Bengal, Vansittart, the brother-in-law of the Governor of Madras. Vansittart was anxious to have his province carefully surveyed, and through the recommendation of these friends Rennell found himself at the age of twenty-one appointed to carry out this important work. To facilitate his duties he was given a commission in the Bengal engineers, first as an ensign, from which rank he rose quickly to be a lieutenant. In 1766 he became a captain, and finally on his retirement a major. Thus it happened that the geographer who was essentially a sailor came to be distinguished thereafter by the modest military title of which Baron Walkenaer wrote many years later: "ce simple titre de major, que l'on s'est habitué à ne point séparer du nom du géographe anglais pour le distinguer de ses homonymes, semble, lorsqu'il est question de lui, acquérir un lustre supérieur aux autres titres."

His first attention was paid to the course of the Ganges. A manuscript recording meteorological and geographical observations made on the river, which was found among his papers and sent out to India some hundred and forty years later by his great grandson, was found by the Survey Department there to be

extremely valuable for comparative purposes. The initial work accomplished was highly esteemed by Mr. Vansittart, whose recommendations to the Company secured for Rennell an income of £1000 a year, out of which he at once made adequate provision for his mother and sister, while he testified his gratitude to Mr. Burrington by handsome presents to his guardian's sons.

Before two years were over his survey had brought him within sight of a vast mountain range to which he gave the name of the Tartarian Mountains. To-day we call that system Himalaya. His headquarters were established at Dacca, where he built himself a house. It was there that he learned to know Mr. (afterwards Sir Hugh) Inglis, a wealthy India merchant, who in 1812 became chairman of the Company, and remained until his death in 1820 one of Rennell's most intimate friends. Ensign Richards of the Engineers was appointed to be his assistant by Lord Clive, who gave every encouragement to the pioneer work of the young surveyor in a difficult, unhealthy, and at that time almost unexplored country.

In 1766, on the frontier of Bhutan, Rennell came very near to losing his life, through volunteering to join an old naval acquaintance, Lieutenant Morrison, then serving in a Sepoy regiment, on a dangerous expedition against a fanatical tribe known as the Sanashi Fakirs, who had looted a town just off the line of march. While reconnoitring a village where they had not expected to meet with any of the enemy, the officers found themselves surrounded by the Fakirs. Morrison, Richards, and the Sepoy adjutant cut their way out, the two last with wounds. Rennell's Armenian assistant was killed, and he himself, his pistol having missed fire, retreated, defending himself with a short sword against the sabres of his assailants. He was so severely wounded that his case seemed desperate, and he was therefore only pursued by a single tribesman, whom he managed to put out of action. His remaining strength he used to run, under a constant fire, towards the detachment coming to the rescue. Before they could reach him he had fainted from loss of blood. His shoulder-blade and some ribs had been cut through by a sabre. He had a number of lesser wounds and very severe cuts in the arms and the left hand, the forefinger of which he was never after able to use. There was no surgeon with the expedition. He was carried, as all believed in a moribund condition, with pounded onions on his wounds, and laid in an open boat which took six days to reach Dacca, where his friend Dr. Francis Russell, the surgeon of the station, despaired of saving him.

But the strong vitality which in seafaring days had kept him immune from scurvy when the majority of a ship's company were affected, carried him through. Slowly his wounds healed and the movement of his arms was restored. But his health was permanently affected by the loss of blood, and his right arm never entirely recovered its freedom of action. Lord Clive, who created for Rennell the definite rank of Surveyor-General, gave orders that thereafter he should always be escorted by a company of Sepoys. Rennell owed much to Clive, who did justice to good work, but as a man dependent on his salary he greatly resented a measure which the Governor, who had been instructed to enforce economies, now took to reduce military allowances. He was himself curtailed of six rupees a day. In a letter written at that time, when the officers of the first and third brigades threw up their commissions, so far from condemning their insubordinate action Rennell compared the spirit of a State composed of

merchants to that of the Carthaginians who disbanded their mercenary troops after they had saved them from ruin.

The actual field-work of the survey occupied some seven years, and in the country east of the Brahmaputra, where both man and beast were savage, might almost be said to have been carried out at the point of the bayonet. An attempt to ambush the expedition was defeated. A leopard mauled five of his men before Rennell succeeded in killing him with a bayonet driven down its throat. In 1771, as a diversion from his normal duties he was instructed to lead an expedition against a band of border raiders. It entailed a rapid march over 320 miles, accomplished in fifteen days, probably a record in such a climate. Malarial fever also frequently interrupted his work. In after years he used to recall these stories of his Indian adventures to his grandson, who repeated them to the present writer.

In 1768 Mr. Cartier, the former Resident in Dacca with whom Rennell had become very intimate, succeeded to the Governorship. It was in his house at Calcutta that the Surveyor-General met his future wife, Jane Thackeray, sister of the Governor's secretary. She was one of fifteen children of Thomas Thackeray, headmaster of Harrow and archdeacon of Surrey, whose family played a distinguished part in the early administration of India. The youngest son, William Makepeace, grandfather of the author who was himself born in Calcutta, entered the Bengal service in 1765, and two of his eight sisters had gone out to keep house for him. After a year's engagement the marriage took place at the Governor's house in October 1772, the year in which Warren Hastings relieved Mr. Cartier. The union was a very happy one, and Mrs. Rennell had the pleasure of seeing her sister, who was seventeen years younger, married to Mr. Harris, the Resident, during a visit which she paid to Dacca.

The period following his marriage was chiefly devoted to co-ordinating materials accumulated during many years of collection and in the preparation of the fourteen sheets of the Bengal Atlas. When this work was practically completed by the beginning of 1777 Rennell, whose health had been seriously undermined by wounds and fever during his long and uninterrupted residence in India, applied to the Governor for a pension, which Warren Hastings, in view of his exceptional services, recommended the Directors to fix at £600 a year. He left Calcutta with his wife in March 1777 in the *Ashburnham*, which made St. Helena without incident. The first child of their marriage, a daughter born at Dacca, had only survived a year, and, as another confinement was expected and the duration of sea voyages was in those days incalculable, they decided to await the event there. And so it happened that a daughter, who was to become the active collaborator of her father in after years, was born in St. Helena on 12 October 1777 and was given her mother's name. Only a storm which kept the decks awash for several days broke the monotony of a two months' voyage to Portsmouth, where the *Hector* at length arrived in February 1778. Rennell's mother had died two years earlier, but the family were made very welcome by Mrs. Thackeray at Harrow. The analogy which some twelve years earlier Rennell had suggested between the conduct of the Carthaginians and the attitude of a Merchant State towards its officers must have recurred to his mind when he found on returning home that the Directors had cut down the

figure proposed for his pension from £600 a year to £400. Nor were they disposed to defray the cost of publishing the Bengal Atlas, the fruit of so many years of labour, which was produced by subscription from the Company's servants in India. Two years later however they repented of their former decision, and in 1781 decided to grant the full pension which Warren Hastings had recommended.

After visits to his relatives by marriage and to his old home at Chudleigh, where his former guardian and constant friend Mr. Burrington was still in charge of the rectory, the Rennells settled in London, first in Charles Street, Cavendish Square, where two boys were born, and subsequently, in 1781, at 23 Suffolk Street, which has since been renamed Nassau Street. There began the second period of his life's activity, with the preparation of his Map and Memoir of Hindoostan, which first gained him fame with a wider public. Lack of opportunity in his early years had deprived him of a classical education, but his assiduous reading had taught him that the Greeks had been the first students and exponents of the science to which he had devoted his life. As a basis from which to set out he accordingly resolved to investigate with his habitual thoroughness the legacy of the ancient world as bequeathed not only by such exceptional travellers and observers as Herodotus, Xenophon, and Thucydides, or geographers like Ptolemy and Strabo, but by all the authors of the ancient world whose writings could throw light on the subject. Unfortunately their works were only accessible to him through English and French translations, many of which in those days were, like Beloe's Herodotus which he used, of inferior quality.

Of the geographical literature of the Middle Ages and the Renaissance, so far as it was in those days accessible, Rennell made himself a master. A very retentive memory assisted his comparative analysis, and reflections and analogies introduced into the text of his geography of Herodotus show how wide had been the range of his studies. As his reputation became established, moreover, he had the advantage of receiving informative communications from British travellers and from such eminent authorities abroad as Niebuhr and Von Hammer. He entertained the greatest respect for his French predecessors in geographical research, Delisle and especially D'Anville, who was born some forty-five years earlier, and, though he sometimes differed from the conclusions of one whom he looked up to as master, his criticisms were always advanced with deference and respect.

The qualities of simplicity and sincerity which had won him many friends in his seafaring days and in the Company's service quickly drew round him in London, where his wife's family had a numerous connection, a group of remarkable men. In 1781 he was elected a Fellow of the Royal Society, a privilege to which the publication of the Bengal Atlas entitled him. Its president, Sir Joseph Banks, the naturalist and traveller, who had been with Captain Cook on his first voyage round the world and who contributed from his considerable fortune to the advancement of science, became his close intimate. The great Whig peer, Lord Spencer, to whom he dedicated his Herodotus, took him into very cordial friendship. Dr. Gillies the Scotch historian, Marsden the translator of Marco Polo, and Inglis his former acquaintance at Dacca and afterwards chairman of the Company, were members of the

group with whom he was constantly associated. These and many more meeting in each other's houses formed one of those pleasant coteries of the learned which were possible in the less distracted London of the late eighteenth and early nineteenth centuries. Like most of the men with whom he was in touch, Rennell was a Liberal or rather a Whig in politics, but while holding strong opinions he was careful to restrict his activities to a purely scientific field.

The contribution to geographical knowledge on which Rennell's fame is established included three distinct branches of research. He had, in the first place, contemplated a comprehensive study of the geography of Western Asia, from the Mediterranean to India, beginning from the earliest records, and for this purpose had amassed a vast number of notes. A treatise and a map indicating the scope of the work which he had in view were published after his death by his daughter. To this ambitious project belong his 'Geographical System of Herodotus,' the 'Expedition of Cyrus,' and the 'Topography of the Plain of Troy.' The 'Geography of Herodotus,' whose accuracy of observation and correctness in marking relative positions he strove to vindicate, acquired for him an European celebrity. The second volume is entirely devoted to Africa. He brought his knowledge of currents and trade winds to bear on the legend of the circumnavigation of Africa by Phoenician sailors, and after a careful examination of the conditions prevailing in those days, concluded that such a voyage might have been accomplished in two and a half years. Applying similar criteria he also devoted a section of the book to the Periplus of Hanno.

The foundation in 1788 of the African Association, of which Rennell was at once made an honorary member, led him to concentrate his activities for a considerable time on the study of African geography. He worked on the routes and classified the observations of the travellers who had personally investigated the northern half of that continent, or had been despatched for that purpose by the Association, William Browne, Major Houghton, the German explorer Friederich Horneman, and the most remarkable of the four, Mungo Park. Rennell, who died before the problem of the Niger had finally been solved, published a series of Memoirs with Maps prepared for the African Association.

The third field of research, of which he may be regarded as the originator, was connected with the science of oceanography, a name which does not seem to have been established in the language until the systematic co-ordination of his studies of winds and currents created the need for such a designation. He had, as has been shown, begun from his earliest years to prepare charts to assist navigation, but his first serious effort as a hydrographer was his Chart of the Bank and Current of Cape Lagullas, which was published in 1778. As a sailor he had studied by personal observation the currents of the Atlantic, the Trade-winds, the Monsoons, and their influence on the drift in the Ocean, and he assembled over a number of years all the information he could gather from the experience and the log-books of his naval friends. His seven charts of the winds and currents with a memoir, based on an immense store of material which he had reduced to system by 1810 and continually revised in subsequent years, were only published by his daughter after his death. The last of the seven is devoted to the current with which his name is associated. He had already, in 1793, read before the Royal Society a paper embodying his "Observations of a current which often prevails to the westward of Scilly, endangering the safety

of ships that approach the English Channel." Up to that time navigators had not realized that the current which turns eastward round Capes Ortegal and Finisterre and sweeps along the French shore of the Bay of Biscay, continued to flow, with varying force according to the state of the winds, across the mouths of the English and the Irish channels. And yet the deviation from their course of vessels when the drift was exceptionally strong had been responsible for many disasters and, as now became clear, accounted for the loss of Sir Cloudesley Shovel's flagship and two others of the line in 1707. Further evidence regarding the action of this current was submitted in a second paper read to the Society in 1815. The great service rendered to navigation by this identification makes it right that his memory should be preserved in the name of Rennell's Current.

This indefatigable worker also found time to write papers on historical or archaeological subjects associated with geography, such as the Marches of the British Army in the Peninsula of India, the Ruins of Babylon, the Identity of the Site of Jerash, the Landing of Julius Caesar in Britain, and the Shipwreck of St. Paul. His correspondence with Lord Spencer covers a wide range of interests, including details connected with the naval service, and his letters to friends and fellow-workers are full of valuable suggestions and evidence of close observation. But it is not possible in a brief memoir to do justice to the contents of the many publications in which his researches are recorded. Those who may be interested to pursue the subject will find them summarized in the excellent biography of Rennell prepared by the late Sir Clements Markham for the Century Science Series. A valuable appreciation of the great geographer was also contributed by Sir Henry Yule to the *Royal Engineers Magazine*.

Rennell's unquestioned authority as a student of oceanography led to an offer of the post of First Hydrographer to the Admiralty, which however he did not see his way to accept, as it would have interfered with his work of research and co-ordination. This seems to have been the only official recognition ever entertained of his eminent services to science and navigation. But he received universal recognition from the learned in every European country. In a contemporary record of the 'Public Characters of 1803–4' it is maintained that scarcely any work having reference to geography had been published in preceding years which had not been submitted to his correction, and that none were ever returned without attention. The courtesy and generosity with which he assisted the labour of others were indeed characteristic of this kindly sage, and in his obituary notice in *The Times*, where it is repeated that few ever applied to him in vain, the following passage occurs: "Adapting himself to the level of all who consulted him, he had the happy art of correcting their errors without hurting their feelings, and of leading them to truth without convicting them of ignorance."

As early as 1791 Rennell had been awarded the Copley Medal of the Royal Society. In his presidential address Sir Joseph Banks referred to the Bengal Atlas as having been "executed with a degree of exactness that has not been paralleled by the most applauded geographers of this or any preceding age," and in discussing the Memoir of the Map of Hindoostan he went on to say: "The perspicuous and masterly style in which it is composed clearly indicates that, though geography is the field on which he has principally relied for the

cultivation of his laurels, he is able to reap no inconsiderable crop when he chooses to labour in the more capricious harvest of *belles lettres*."

Rennell had indeed acquired a clear and masterly command of English. His feeling for the value of language is reflected in a passage in his 'Geography of Herodotus,' where he writes: "It ought perhaps to afford a triumph to literary men to reflect that the English language had received its highest degree of improvement before the epoch of our great colonization." He therefore frankly admitted his gratification when the gold medal of the Royal Society of Literature was conferred upon him in 1825. He had been made a foreign Associate of the French *Institut National* in 1801, in token of which he received a silver medal inscribed with his name. The Academy of St. Petersburg and the Gothenburg Society had also enrolled him among their members. As a testimony of the esteem in which his work was held on the Continent Rennell very greatly appreciated the visit paid him in 1825 by the illustrious Baron Humboldt, who came to London to consult him on the problem of winds and currents. No more graceful tribute has been paid to his memory than that contained in a historical note on his life's work read to the French Academy in 1842 by the permanent secretary, Baron de Walkenaer, who, in his appreciation of Rennell's investigation of ocean currents, pointed out that he was never wholly satisfied with his own work, which he continued constantly to correct and amplify, so that he became reluctant to publish results during his own life. In the 'Public Characters of 1803,' to which reference has already been made, Rennell is represented as tall and well made, with a countenance no less expressive of dignity and sentiment than of general benevolence. His simplicity, his courtesy, and his genius for friendship had indeed made him one whom all regarded it as a privilege to know.

After the death of Sir Joseph Banks and when age and infirmity were contracting the activities of this genial philosopher, the distinguished society of travellers, of *savants*, and men of the world who had held reunions in their houses and in those of a few mutual friends decided that the time had come to provide some means of perpetuating such occasions for social intercourse. And so it was that a group of Rennell's most intimate friends founded a dining club which received the name of the *Raleigh*. Among them were Sir Arthur Broke, the organizer, Admiral Smyth, Colonel Leake the topographer of Greece, Franklin the arctic explorer, Cam Hobhouse the friend of Byron, Marsden, Roderick Murchison, Captain Beaufort, Basil Hall, Mountstuart Elphinstone, Sir George Staunton, and many more; worthy successors of the old fellowship of the Mermaid Tavern. It was at a meeting of the Raleigh Club, barely two months after Rennell's death, that the decision was taken to found a Geographical Society, and less than two months later four hundred and sixty Fellows had already been enrolled. The Raleigh Club, which assisted at the birth of the Society, became in due course the Geographical Club. There can be little doubt that Rennell had during the last weeks of his life been interested in the project which his intimate friend Admiral Smyth and the Secretary of the Admiralty, Sir John Barrow, had simultaneously elaborated.

Of Rennell's two sons the elder, who had some talents of an artistic order, lived a retired life in the country. The second entered the Bengal Civil Service and died in India at the age of thirty-eight. It was his daughter Jane who

inherited his tastes and much of his ability. Having been his constant companion and assistant, she was well equipped to become his literary executor and superintend the publication of his posthumous volumes. She married in 1809 Captain, afterwards Rear-Admiral, Sir John Tremayne Rodd, whose long and varied experience at sea was of great service to Rennell in his hydrographic studies. To their children the veteran geographer particularly devoted himself in his latter years, and his letters to his grandson at a private school and afterwards at Eton, which are in the possession of the writer of this memoir, show how well he understood the art of being a grandfather. Those who believe in the transmission of inclinations by heredity will be interested to note that in the year preceding the centenary of his death the Founder's Medal of the Royal Geographical Society was awarded to his great-great-grandson, Francis Rennell Rodd, for his surveying work in the central Sahara.

By abstemiousness, exercise, and regular habits Rennell succeeded to a great extent in overcoming the constitutional weakness resulting from his wounds and fevers in India. But with advancing years he suffered repeatedly from an acute form of gout, which kept him for long periods confined to his bed or reclining on a sofa. A fall from a chair at the end of 1829, which caused a fracture of the thigh, finally precluded him from any further physical activity, and he died in his eighty-eighth year on 29 March 1830. He was buried in Westminster Abbey in the middle of the nave opposite the West Cloister door. An inscribed stone over the grave and a bust on the window-ledge of the Belfry Chapel under the north-west tower commemorate the Father of English Geography.

RENNELL RODD.

THE CLIMATIC CONDITIONS OF THE TARIM BASIN:

A paper read at the Afternoon Meeting of the Society on 17 February 1930, by

LIEUT.-COLONEL REGINALD C. F. SCHOMBERG, D.S.O.

THE Tarim Basin is the name given to the great amphitheatre of plain, largely desert, that is girdled on three sides by the Kunlun and Tien Shan mountains, and which forms the most valuable and important part of the province of Sinkiang, or Chinese Turkistan. These notes put forward a few observations made in a two-years journey in the country.

The conditions generally have led some travellers in Chinese Turkistan to believe that in recent, certainly in historical times, the climate of this region has been greatly modified, and that a marked increase in aridity has taken place: briefly, that the country is drying up. In proof of this theory, the remains of extensive towns, especially of Loulan, the diminished length of the Keriya and other rivers east of it, and the decrease of water in the Lop Nor, are all cited. The Turfan depression has also been brought to witness as having had a very different climate from its present one. (There was a note on this in the *Geographical Journal*, 72, 357, October 1928.) It has therefore been argued that in the Tarim basin a continuous and appreciably rapid process of desiccation has been going on, caused by failure of water as evidenced by the phenomena above quoted. An endeavour will be made in this paper to modify this proposition.

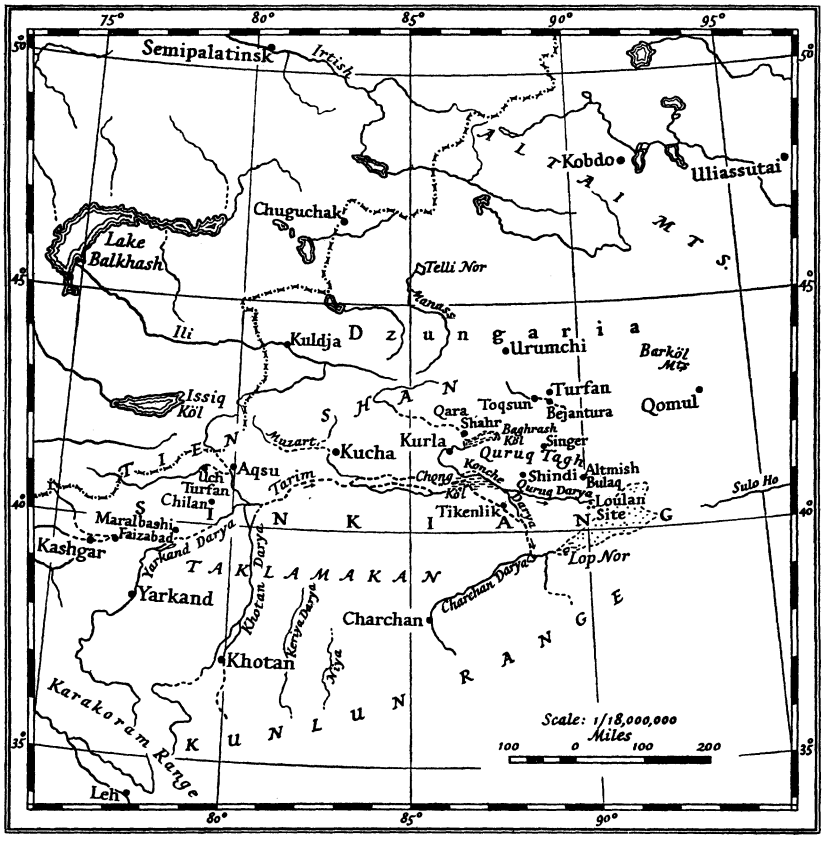
The theory of desiccation has been chiefly built on the aridity existing in a district stretching from the Keriya river inclusive to the eastern boundary, where the Niya and other rivers have decreased in length, and where several sites of abandoned towns have been excavated in the desert. Here it is well to make it clear that the writer has never been east of Khotan or south of Tikenlik in the lower Tarim. It is generally admitted that at no time was the population east of Keriya other than sparse, and that the whole of this small corner of a large province is, and has been, a barren and forlorn area, occupied only by gold-miners and convicts. Conditions therefore prevailing in this part of Sinkiang cannot be regarded as typical of the rest of the province. Such an assertion would assuredly be far fetched. It is also difficult to believe that the climate should have changed here, and not elsewhere—or, to put it differently, that the decreased flow in rivers east of Keriya should be caused by climatic rather than by other natural causes.

There is one theory that deserves mention. As all rivers in Turkistan are fed by the melting snows, it has been suggested that the Keriya and other rivers have failed to obtain their supply, owing to the coating of debris, detritus, or other deposit covering the glaciers, or even to actual decrease in the glaciers themselves. Yet no decrease whatever has yet been observed in the neighbouring Khotan river.

It is hoped in this paper to put forward other causes for the diminished flow in the rivers of this area; and to bring to bear on the subject observations made elsewhere.

Swinburne was no geographer, or he would not have said that even the weariest river winds somewhere safe to sea. There is probably nothing so

striking geographically in Central Asia as the ubiquity of drainageless basins, which vary from basins so large as almost to lose their individual character, such as the Aral or Caspian seas, to small cups in the mountains or shallow lagoons in the plains. The whole of the Tarim Basin south of the Tien Shan is of this character, but so too is the Dzungarian region north of those mountains. Both these immense districts are similar in many respects; and it is thought that the behaviour of the rivers in both places explains at once the



Sketch-map to illustrate Colonel Schomberg's paper on the Tarim Basin

decrease in the waters of Lop Nor as well as the gradual disappearance of the Keriya and other insignificant streams to the east.

It is significant that south of the Tien Shan, although there are several minor depressions and drainageless areas, the lakes formed are comparatively trivial. There are the fresh and salt lakes of Lop Nor—these should be kept distinct, as no water from the north is likely to reach the salt-water lake in the Lop depression; and the lake in the Turfan area. The Baghrash Köl or Tenggris Nor near Qara Shahr is a true lake. Thus south of the Tien Shan with a greater water supply there are markedly fewer lakes, and this difference can be attributed to irrigation and the porous nature of the soil.

The Tarim is the name given to the aggregate of rivers that fall into the main stream of the area. This great stream centuries ago fed Lop Nor, whose shrinking and exiguous waters point either to a failure of supply in the Tarim; or, what is more likely, a failure of the Tarim water to reach the lake.

The chief river north of the Tien Shan is the Manass, a very large and imposing stream, but not the equal of the Tarim. The behaviour of this river is worth attention. It leaves the cultivated area of Manass and flows through extensive swamps and backwaters, overgrown with reeds and jungle, and fringed with dense forests of toghraq, elm, and other trees. The right bank of the river is often a high and dangerous cliff, and from the top the traveller looks over a waste, impassable as it is impenetrable; and through this territory the Manass has made for itself many new channels, a process of which it never wearies.

For years the Manass fed the Telli Nor (lake), reaching it through swamp and morass just as the Tarim ages ago reached and fed Lop Nor. But the Manass is now abandoning the Telli Nor, and in April 1928 there was not a trace of moisture in the lake-bed. It was possible to ride everywhere over it, and very exhausting work it was, for the going was heavy. At that time of the year the river was not full, and the people, who said the lake was drying up, said that later a little water would reach it. The remains of canals and lines of trees at the northern end of the lake bore witness to a departed period of irrigation. It was due to no lack of water in the river that the Telli Nor was degenerating into a mere dismal depression and a mass of flickering mirage. Its cruel fate is caused by the Manass leaving it. The river has already turned to the east, and as time goes on it will form another lake, unless with the fickleness of all these Central Asian rivers, it turns once more to its former channel.

This seems to have been the fate of Lop Nor, as a brief examination of the state of the Tarim river will show. The Tarim alone is mentioned, as no one suggests that the Keriya and its diminished neighbours had any influence on Lop Nor, always excepting the Charchan river, not even in the happy days when a slight trickle from the Keriya occasionally found its way to the Tarim. It seems very doubtful if the former river flowed perennially as far as the latter, since there are practically no remains of man in its northern half.

In the behaviour of the Tarim the secret of Lop Nor must be sought. The rivers of Turkistan depend wholly on the snow which usually varies little, although it sometimes happens (as in the winter of 1928–29), but without affecting the argument, that the fall is excessive. Taking however the average winter, the rivers begin to rise in April when the first melting snow comes down. The greater part of the water is taken for irrigation, and it is very rarely that a river is untapped after it reaches the plains. So much is this the case that in the height of the season, the season of highest water and intensest cultivation, many rivers—the Kucha, for example—are but a mere trickle; the whole volume has been deflected into the fields.

In April and late autumn, when the first and last snow water comes down, the rivers are practically untouched for irrigation, but at both these periods, owing to the diminished melting on the high peaks, arising from colder weather, shorter days, and in autumn less snow, the rivers never carry their full capacity, and so the full force of the current is now never felt in the Tarim.

As the cultivated area of the Tarim basin has greatly increased of late years, for example between Maralbashi and Yarkand, the fields are almost continuous, though Sir Aurel Stein's map of twenty years ago shows many gaps; so year by year more water is taken for irrigation and less reaches the rivers. A comparison with Turkistan as it is now, with the account given by Mr. A. D. Carey of his journey in 1885 (Proc. R.G.S., N.S. 9, 731; Dec. 1887), will still further support this point and emphasize the contrast. The difference is really amazing.

The flood water has in fact been decreasing for fifty years, as the irrigated land has extended. A brief glance is necessary at the nature of the country watered by these rivers. The plain of Turkistan consists of a soft friable soil, and there is thus nothing to control or guide the rivers as they roll down into the plains. When they reach this level yielding plain, there is no hill, no rock formation, no immovable forest, to curb their will: unrestrained and unchecked, they wander aimlessly through this monotonous region. Indeed, it is remarkable that they do not roam more freely.

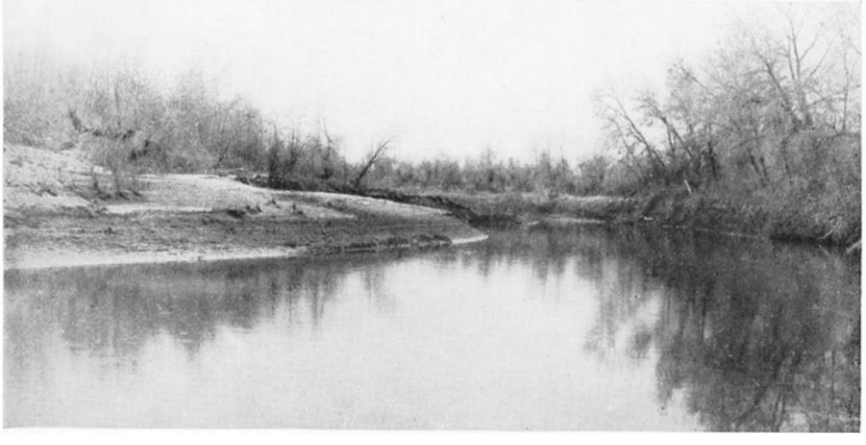
Flowing north from the Kunlun, until stopped by the Tien Shan, which turns them east, the rivers are again diverted by the Quruq Tagh, and finally find their grave in the Lop district. Throughout their course, they lose volume steadily, through irrigation and in the immense marshes, swamps, and backwaters which they form as they go. It is true that their affluents are important. The chief is the Aqsu, which took two hours to cross in August 1929, and others are the Muzart and the Kucha; but the toll of irrigation from both these tributaries is severe. It is however south of Kucha that the Tarim begins to lose volume as lagoons, lakes, and bogs absorb its water.

Mr. Rickmer Rickmers, in his lecture before the Society in April 1929 (*Geogr. Journ.*, vol. 74, p. 213), remarked that he cherished the belief that the riddle of the dead cities of Chinese Turkistan was to be sought amongst the Pamir glaciers, and added that nothing warranted a zone of rainfall cultivation for the Tarim basin. A brief digression with reference to the rainfall will settle the latter point. The average rainfall at Kashgar is 2 inches, and the influence of rain may be disregarded in discussing the climate of Southern Sinkiang. It is generally agreed that in recent centuries there has been no change in the rainfall. To show how dependent the whole country is on irrigation, it is interesting to note that not a single piece of unirrigated cultivation was seen anywhere south of the Tien Shan, whether in the plain or in the hills.

To take Mr. Rickmers' other point, it is presumed that he means that the Tarim river has decreased in volume owing to a decrease in snow and glacier in the Pamirs, thereby causing the Tarim to fail to reach Loulan; and it is Loulan, after all, which is the largest of the derelict cities in the whole country, and compared with which the other cities are negligible. When the Quruq Darya ran dry, the water turned more southerly and formed the lower Tarim. The process of drying up in Lop Nor meant the same process in Loulan, for the fate of lake marshes and city was the same.

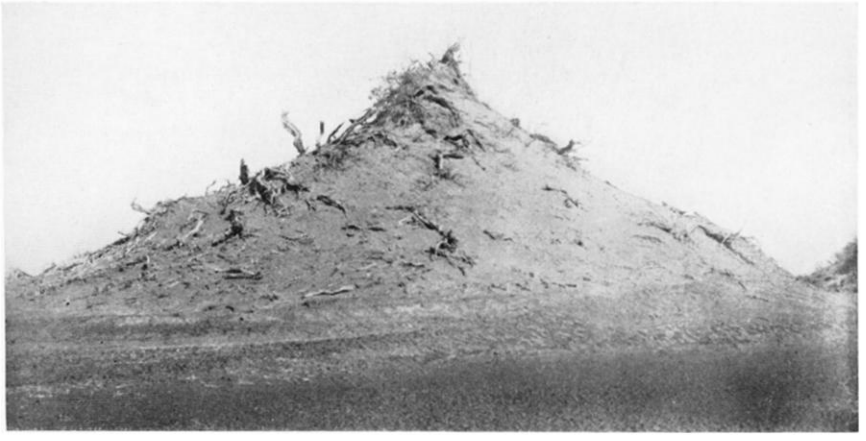
Now, however, the Quruq Darya has again come to life, and in process of time perhaps Loulan too will be habitable. This great change must rule out any diminution in snow-fall or glacier formation in the Pamirs, as it indicates that Loulan came by destruction, not through an altered climate but through

Dead toghraqs on the banks of the Qum Darya



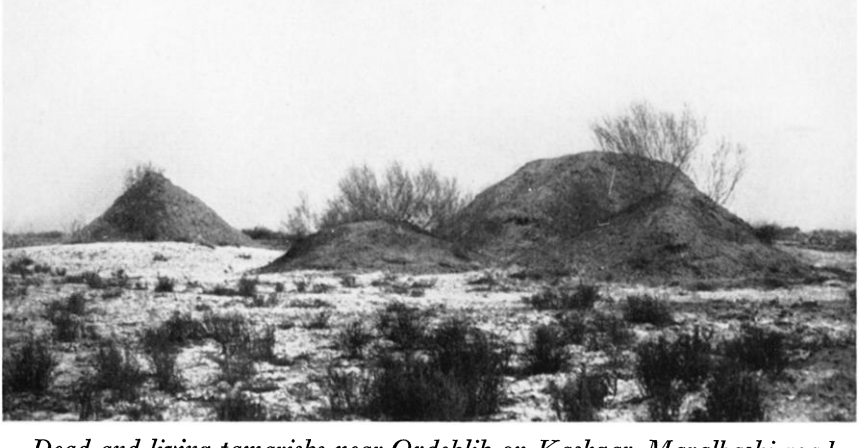
The Qara Köl river south of Maralbashi

The Qum Darya near Yingpan



Tamarisk cone near Tikenlik

Toghraqs growing in sand by the left bank of the Manass



Dead and living tamarisks near Ordeklik on Kashgar–Maralbashi road

riverine vagaries. If it can be shown that Loulan was abandoned because the river left the course to which it has now returned, the case against a climatic change as the causative reason must be in part established.

It is interesting to note that Professor Ellsworth Huntington ('Pulse of Asia,' pp. 280 *et seq.*) mentions a period of increase in Lop Nor in the middle ages, which perhaps indicates the time when the Quruq river definitely flowed for the last time. In the *Geographical Journal* for December 1929 there was a note on the recent fluvial changes in the Tarim Basin, but perhaps it is desirable to amplify in this paper the recent events in the eastern part, so as to indicate clearly what is happening.

Until five, or perhaps six, years ago the Tarim, reinforced by the Konche Darya, a most important stream, flowed south through Tikenlik and so into the swamps of Lop Nor. At that time the greater part of the Konche river water was lost in the Chong Köl and Tais Köl, and the main river was a comparatively narrow stream, some 40 yards wide, when it flowed near Tikenlik into the Tarim. The Tarim river, too, carried in its lower reaches in those days a comparatively small proportion of its proper volume. The result was that both the Konche and Tarim rivers had lost the greater portion of their volume by the time they had reached Tikenlik, with the result that the flow at the Lop Nor end, but not to the lake itself, was correspondingly scanty.

The present condition of affairs is very different. The Tarim has turned more east, taken the Konche Darya with it, and has flowed into the Quruq Darya, now the Qum or Yangi (Sand or New) Darya; with the result that the combined volumes of the two are now much greater than they were before after their union at Tikenlik. The Chong and Tais Köl are still full, but their water is now diverted to the new river, as is manifest from a glance at the attenuated Yarkand river, as just at this point the Tarim is called, flowing close by, lower in level than the lakes, and deriving no benefit therefrom.

The new river, flowing past Yingpan, forms an immense swamp south of Altmish Bulaq, making it impossible to reach Loulan from the west; indeed, it is difficult to say how Loulan can be approached, except from the east. If, therefore, the new river remains faithful to its bed, and if it can extricate itself from the swamp, it is a fair presumption that the Lop Nor marshes will become a considerable lake, but not the present salt lake. The unhappy people at Tikenlik, Daral, and Yangisu, the settlements on the lower Tarim, are now suffering the lot of the Loulan people when their river capriciously turned elsewhere.

The Yangi or Qum river itself was a remarkable stream in October 1929, broad and powerful. As it rolled along it tore down forests of dead toghraq, and undermined high sand-hills. Day and night the thud of falling sand sounded in the silent air, as the river restlessly rolled hither and thither, scouring new channels for itself out of the great shallow bed of its age-dead predecessor. Delicate patches of new reed were replacing the grey remnants of a thousand years ago, and a gradual but definite change was taking place in the environs of the Quruq Darya. The river had gone down considerably, for it was October, and a month previously it must have been an even more wonderful spectacle. As it was it was truly inspiring, and the reflections it evoked gave an added glamour.

Having thus discussed the present state of the Tarim, it is worth while noting the conditions in the Quruq Tagh, as this small offshoot of the Tien Shan has been regarded as a victim of the effects of desiccation, and as having played a part in the destruction of Loulan. Sir Aurel Stein—for no paper can dispense with his admirable and well-reasoned observations—remarks that he found the Quruq Tagh less dry than he had anticipated. A journey in October 1928 in these mountains left Sir Aurel's route at Singer, and passing beneath the Heita Shan (Black Head or Big Black Mountains) joined his route at Shindi. The country was pleasant, and certainly the name Quruq or Dry was a misnomer, as indeed the people at Kurla had already told us. Brushwood and grass were ample, the toghraqs abundant and well grown, and vegetation generally good. Indeed, the conditions were far better than in the lower valleys of the Southern Tien Shan, and at Heita Shan the water was copious. The snowfall is heavy in the Quruq Tagh, and although the soil fails to retain much water, the verdure is considerable. It is remarkable, too, that the Quruq Tagh is the winter pasture of the Khoshut Mongols from Qara Shahr.

Speaking generally, it would not seem likely that the Quruq Tagh had ever any effect on the fate of Loulan: it is difficult to see how it could; still less that it shows any climatic changes, though the visit was admittedly brief and observation cursory.

The rivers of Turkistan, owing to their circumstances, appear subject to erosion and to sub-soil changes, and the effects of both react on the country in the vicinity, leading to serious dispersion or loss of the water supply. It is accordingly suggested that the real explanation of the shrinking of the Keriya and other rivers must be sought in local influences of such a nature.

The process of erosion may be pictured as follows: A river carves its way in the soft desert soil, and the water at first is near the surface. The cultivator comes, and starts to irrigate; but gradually the water eats into the soil, the level falls, the fields become unirrigable, and the peasant departs elsewhere, leaving his fields behind him. To the uninitiated these marks tell their sad tale, of withering rivers and homeless men, of ruthless desiccation, and a harsh drying clime.

The next development in the river is the formation of backwaters, caused by the high eroded banks falling in, and gradually being silted up in the narrower parts with fallen trees and brushwood to aid the process. Good examples of this were evident on the left of the Yarkand river, south of the main Maralbashi–Aqsu road, where there was a maze of backwaters and old channels, often hidden by forest, with abandoned fields and irrigation cuts. All this is more easily understood if it is realized that the most trivial alterations will have considerable results in the soft friable soil.

Sub-soil changes accompany erosion, but are frequently distinct. The soil in Sinkiang is very porous, and often incapable of retaining the water. In Hami (Qomul), in the hills north of Kucha, near Uch Turfan and Kona Turfan and elsewhere, the tendency of streams issuing from the foothills is to lose themselves in the sandy plain, often but not always, reappearing again at a lower level. This action is common enough everywhere, but it does explain much in Sinkiang. For example, in the very well-watered Yai Döbe plain, north of Faizabad, in the Kashgar district, the water supply is always altering. Several

villages marked in the maps have been abandoned, owing to failure of water which has come to the surface again in other parts of the plain.

At Tang Toghraq, 40 miles north-east of Maralbashi on the main road, the results of both erosion and divagation of the water are evident. There half the cultivated area is in good workable order. The other half has been abandoned, as the erosion first made the level of the water too low, and then caused the supply to fail, which prevented all tapping of the stream higher up. It was noticeable as new settlements were being made some way off, where the water was more accessible.

In the southern slopes of the Barköl Mountains the streams would disappear at the point where they reached the plain, and either reappeared a great deal farther on, 15 or more miles away, or else vanish.

So too the Karez system of the Turfan depression demonstrates the presence of abundant sub-soil water—every year new Karez are being made, and the latest series is at the western extremity of the depression, near Bejantura, which will alter the whole character of the present arid plain. An even more remarkable case is the Algoi Sai, a beautiful mountain stream which vanishes completely into the desert to reappear 25 miles east, at the settlement of Toqsun, west of Kona Turfan.

There are two small points connected with the effect of aridity on vegetation in Chinese Turkistan to which brief reference is necessary: the value of the toghraq and the tamarisk as evidence of defective moisture. Sir Aurel Stein has remarked that the tamarisk can never exist without moisture, and although careful watch was kept, in no place was a tamarisk found where it could be said that the ground was true desert. Either occasional or periodical water is essential for tamarisks. The toghraq (*Populus balsamifera*), or desert poplar, appears to be less sensitive to aridity, and better able to resist drought. The argument from these two plants in favour of aridity is drawn from the dead and not living organism. It is a common sight to see forests of dead toghraqs, gaunt and melancholy, thrusting their barren trunks starkly through the cloying sand. But although failure in the water supply usually kills them, they can die from other and not always easily distinguishable causes. Near Chilan, on the main Aqsu road, there is a forest of these dead trees, killed by a flood. At Aqsaq Maral, south of Maralbashi, there is a grove of dead toghraqs, with a belt of living tamarisk close by. The inference is that the water disappeared and killed the trees, it then returned later and enabled the tamarisks to grow. As it is the habit of the toghraq to grow in sand, the cause of its death must, as has been just said, often be obscure.

The tamarisk cone, whose age has been ably estimated by Sir Aurel Stein, has often some perplexing habits. It is often difficult to tell why plants have died, especially when new seedlings are found growing in the humus of long-dead cones. Again, there will often be a number of these cones scattered over a plain, all of them rotted; yet between them will be found abundant tamarisk, often growing comfortably in the protection of their defunct kinsmen. As the tamarisk grows, after surviving with some trouble the fierceness of the dust-storms, or "Burans," it collects round its roots sand, leaves, and other dejecta; and this hill of debris rises with and finally stifles the plant, if the latter is not killed by lack of water.

Sometimes there is a plain covered with dead tamarisk cones and also with a luxuriant growth of new low tamarisk. Owing to the age and state of the cones, and the small size of the new growth, it would appear that there was an interval between the death of the one and the advent of the other, and this predicates subterranean water changes, as the neighbourhood seldom shows any alteration in itself. These two references to the toghraq and tamarisk indicate that these, when dead, are not a certain sign of permanent aridity subsequent to their growth, though of course in certain places the dead toghraq plants are but the inevitable result of the desert's victory.

To summarize the remarks in this paper. Climatic changes in the Tarim Basin have been based on two distinct and unreciprocating features: (1) the drying up of Lop Nor and the destruction of Loulan; (2) the increased aridity east of Keriya. Owing to the fluvial changes in the Tarim Basin and the rejuvenation of the Quruq river, the evidence drawn from the first point needs revision. The argument for the second appears too vague and certainly too local to be applied with any force to the rest of the province; and the withering of the rivers can be explained by causes observable in many parts of the country. It may be noted parenthetically that in the south of the Punjab whole rivers have vanished, to flow elsewhere. It is admitted that the district east of Keriya, although now more populous and cultivated than before, is drier than the rest of the country, and this is a predisposing cause in itself, for sub-soil and erosive changes.

The river system of the Tarim Basin must remain an ineluctable problem, as the nature of the swamps and jungle, lagoon and river, makes true exploration impossible. Even an aeroplane would be useless, as the depth of the various sheets of water, the identification of the true river, and its separation from some vagrant tributary, could not be arrived at from the air.

Let a poet who never saw Central Asia describe accurately how the rivers of that distant region flow: a remarkable description indeed of the Tarim:

> He flowed
> Right for the polar star past Orgunjé
> Brimming and bright and large. Then sands began
> To hem his watery march and dam his streams
> And split his currents, that for many a league
> The shorn and parcelled Oxus strains along,
> Through beds of sand and matted rushy isles,
> Oxus—forgetting the bright speed he had
> In his high mountain cradle in Pamere,
> A foiled circuitous wanderer. MATTHEW ARNOLD
> (*Sohrab and Rustum*).

DISCUSSION

Before the paper the PRESIDENT (Colonel Sir CHARLES CLOSE) said: Colonel Schomberg is going to give us a paper this afternoon on "The Climatic Conditions of the Tarim Basin." Colonel Schomberg has seen much service in India and has always taken a great interest in Central Asia. He has spent some years in the Tarim Basin, the Tien Shan and neighbouring regions, and has some important observa-

THE MOUNTAINS ABOUT TATSIENLU

IN the charming map which illustrates the 'Trail of the Giant Panda' the Messrs. Roosevelt have shown south-west of Tatsienlu a Mount Koonka with the attractive height of 30,000? We naturally ask whether there is the more virtue in the 30 or the mark of interrogation, for the accompanying photograph shows a hillside with little evidence of permanent snow, and the text is not quite so bold as the map; the authors say:

> Early one morning we got our first glimpse of mysterious Mount Koonka, rising high in white majesty. At Yungning, Rock had told us of his ambition to put in three or four months studying its flora, and once more we regretted the lack of time that made it impossible for us to make a reconnaissance of its fauna. The altitude of this mighty peak is unknown, but there are those who claim that it rises more than thirty thousand feet and is the highest in the world. A geologist from Chengtu made a special expedition to establish Koonka's height, but after he had taken his observations he refused for some entirely unaccountable reason to divulge them. When any one questioned him he merely imitated the beaver and "looked unaccountably shy" (*Trailing the Giant Panda* (1929), p. 129).

As we reflected on this matter we received a visit from Mr. Herbert Stevens, who had been a member of the Kelley-Roosevelts Expedition, but had been detached on a separate collecting trip, and passed through Tatsienlu some days behind them. He had been favoured with exceptionally clear weather, and brought sketches of several remarkable snow-peaks seen from the passes in the neighbourhood: peaks evidently rising several thousand feet above their neighbours, and clothed for at least that height with permanent snow and ice. But Mr. Stevens had made no surveys, and could throw no light on the question of their absolute height.

Remembering then that Mr. Kingdon Ward had once worked around Tatsienlu, we asked his opinion on the probability that there might be very high peaks in that country, and have his permission to print the following reply:

> I have now been a little into the question of the snow mountains round Tatsienlu. One must admit at the outset that as there are no certain facts to go on, we have to argue from analogy, and draw conclusions from circumstantial evidence; but I think you will agree that there is not much hope of finding a second Mount Everest here. The line of argument I take is this. Several travellers have commented on the great height of the peaks round Tatsienlu; but one must remember that it is the suddenness of the appearance of great snow ranges that is the most remarkable feature. One is immediately prone to exaggerate their height (coming from the Szechwan plain). Few if any peaks south of Tatsienlu are fixed. Davies shows one or two, height under 17,500 feet. Legendre shows one or two, height 6000 metres. Not much help there.
>
> Now the snow line may be taken as 17,000 feet, possibly 17,500. This agrees with my experience round Muli; Wilson says definitely, "the snow line cannot be less than 17,500 feet"; on the other hand Johnstone says he crossed many passes from 12,000 to 17,500 feet high, "some of them above the line of perpetual snow." Put it at 17,500. If the average height of the peaks were 20,000 feet, the view of snow peaks from any vantage point would be stupendous; and although Gill is almost lyrical about the view, he is not stunned into any wild calculation. He concentrates chiefly on the view to the north of Tatsienlu, and says quite soberly

that the peak called Ja-ra (Ja-ri?) rises 4000–5000 feet above its neighbours; he saw it from 30 miles distant, at a height of 14,454 feet himself. Now any mountaineer knows that a peak 5000 feet above its neighbours is, at the right distance and the right angle, a pretty conspicuous object. Namcha Barwa rises perhaps 4000 feet above the surrounding peaks, as seen from the north; and it is like a church steeple surrounded by cottage roofs. Ka-kar-po (Kagurpu) is perhaps 2000 feet higher than its neighbours, and Gregory guessed its height at 24,000 feet, though I believe I hazarded 22,000 feet. But suppose we do allow 20,000 feet for the Tatsienlu peaks, which is very generous, then a peak 25,000 feet high would be a stupendous sight. There would be over 7000 feet of snow, and the glaciers would descend to 15,000–16,000 feet, if not much lower; at least they might reasonably be expected to descend 2000 feet below the snow line.

Therefore it seems to me quite impossible that there can be anything of the order of Mount Everest near Tatsienlu. Had there been, every traveller must have raved about it. Pratt, who spent some time in the neighbourhood, says little about the snows. Cooper says nothing. Wilson says little. Davies says little, and so on. Hence I maintain that it is extremely unlikely Minya Gongka exceeds 25,000 feet at the outside. I hope I may be wrong.

Meanwhile we had been visited by another traveller from the same country, Mr. G. S. Stavely Gordon, who discussed the problem and afterwards wrote thus:

In October last year I travelled down the caravan route from Yachow to Ningyuan via Ch'ing Ch'i, Fulin, Yeuhsi and Luku. Just north of Ch'ing Ch'i we crossed the Ta Hsiang Ling (Great Elephant Pass) at an elevation of approximately 10,000 ft. (Aneroid height as Boiling Point instrument failed). The weather on top of the pass was somewhat overcast and visibility not of the best. The general elevation of the mountains south of Tachienlu and west of my route appeared to be about 5000 feet higher than the Ta Hsiang Ling—*i.e.* about 15,000 to 16,000 feet, and these mountains were visible all over an arc extending from about N.W. to S.W. One particular mountain S.W. of the pass seemed to rise isolated from out of the general mass of 15,000-ft. mountains and to stand up several (say 4000 or 5000 ft.) thousand feet above them, but the top was not visible. I reckon this peak to have been about where Tzumei is indicated on the Survey of India 1/Million sheet (Kiatingfu), *i.e.* about 45 to 50 miles S.W. of the Ta Hsiang Ling. An attempt to get another sight of this peak from the Hsiao Hsiang Ling (Small Elephant Pass) situated about half-way between Yeuhsi and Luku (elevation about 9000 feet) failed owing to the pass being covered with mist and sleet. Photographs taken from the Ta Hsiang Ling do not show any distant snow mountains, owing to the poorness of the visibility. The above is all I can give as first-hand information. I was informed both by Mr. L. A. Lovegren of the American Baptist Mission at Kiating (and a keen geographer and traveller) and by Dr. R. L. Crook of the American Baptist Mission at Yachow that during the summer of 1928 some American members of the staff of Cheng Tu University spent a considerable time (say four to six weeks) in triangulating and getting sights of Tzumei Shan (which is considered to be the highest mountain in the district), and that the result seemed to show that Tzumei was certainly over 28,000 feet—probably over 29,000 feet. The results of this survey were not however being published for the present, as it was intended to make further observations; and for one thing the final elevation depended a good deal on the true elevation of Cheng Tu University standard barometer, to which the triangulation of Tzumei had been tied.

Here we had fuller reference to what was probably the same attempt at survey, for it had the same feature that the result was not published, but it referred to a different mountain. Examination of the not very numerous maps of the region then revealed the curious fact that our knowledge seemed to have been going backwards during the last fifty years. The earlier maps showed names and heights that had been gradually dropped, and this demanded examination. We have therefore put together the following notes, as bearing upon a problem that demands solution:

In Volume II of 'The River of Golden Sand' Captain Gill describes two peaks Ja-ra and Ruh-ching, and on the accompanying route-map, opposite p. 117, marks Kung-Ka, which is not in the index and which we do not find in the text. He says:

[Starting south from Tatsienlu in August 1877] . . . right in front a fine snow-field on Mount Ru-ching glittered in the bright sun; and to the south-east another mountain every now and then showed in patches of snow, as the clouds came and went from its lofty summit (*River of Golden Sand* (1880), vol. ii, p. 119).

[Turning west to the Cheh-toh-shan pass (Jeddo of Cooper)] The morning was beautifully fine: there was a delicious feeling in the air, and looking back down the valley, there was a glorious view of a snowy mountain, whose edges were just lit up by the rising sun, and whose glittering pinnacles of ice and snow shone like points of brilliant light (p. 121).

[Continuing westward on the road to Batang, after a descent:]
The first crest we reached is called in Tibetan Ka-ji-La, or in Chinese Ko-Erh-Shi-Shan, 14,454 feet above the sea. The view when we reached the summit was superb. Looking back in the direction from which we had come, range after range of mountains lay at our feet, culminating at last in the most magnificent snowy heights, one of which raised its head about 4000 or 5000 feet above its neighbours. It was a magnificent peak, and at this distance looked almost perpendicular. Its name in Tibetan is Ja-ra (King of Mountains), and I never saw one that better deserved the name. Never before had I seen such a magnificent range of snowy mountains as here lay stretched before me, and it was with difficulty I could tear myself away from the sight (p. 133).

Closely following Gill came the expedition of Count Szechenyi in 1877–80. His account, published in three volumes in Hungarian between the years 1890–97, was translated into German, illustrated by an atlas of fifteen sheets of routes and topographical sketches (3 vols., Vienna, 1893–97), and seems to be the only systematic account of the country we possess. The surveys were made by Lieutenant Kreitner of the Austrian Army, who gives on p. 60 the following account of his methods, as translated by Mr. G. R. Crone:

A precise triangulation during our journey in Eastern Asia was obviously impossible. Hence I determined the position of conspicuous peaks and summits of mountains and other prominent objects by compass bearings, and, as far as practicable, from several, or one other, similar bearings, plotted the angles graphically. I thus obtained a distance, within the possible limits of accuracy, for the fixed object from my position, in order to ascertain the relative difference of height by measuring the vertical angle. On a rapid journey on public roads, it is

possible only occasionally to set up the theodolite, so a few only of the determined heights were measured with that instrument. I generally used for sighting the corners of my rectangular survey-box, on the reverse side of which I had constructed a quadrant with a 5° scale, or else the compass of the expedition's geologist, fitted with a contrivance for reading vertical angles. Since the distance of the measured point or the approximate vertical angle can in accuracy by no means approach the components of the barometrical determinations, I have in most cases, after correction for refraction and for the difference between apparent and true horizon, rounded them off to the nearest hundred metres. Regarding the heights determined by eye, I admit freely that they have no positive scientific value, but nevertheless they should not be rejected, until a Chinese survey comes into existence. To estimate heights correctly is rather luck than skill, and I can only record that during the journey through the loess region I already doubted my critical faculty for height judging (*Die wissenschaftlichen Ergebnisse der Reise des Grafen Béla Széchenyi in Ostasien* 1877–1880 (Wien, 1893–98, vol. 1), p. 60).

and on pp. 265–6 an account of the country which may be translated thus:

On the south and east the valley [of the Tar-Kjo] was bordered by high mountains, sharp, steep and conspicuous, which, in the main west-east chain, attained over 6000 metres. A mighty glacier, 7 km. long and wide in proportion, invested the imposing mountain and its jagged rock peaks and abysses with special interest. On it were ranged several small glaciers. The snow-covered portion of the main range extended for 65–70 km. from the central "knot," Bokunka, to beyond the meridian of Ta-tsien-lu on the east. While the upper parts of the mountain are bare rock, the spurs are covered with a thin layer of humus, on which sparse brushwood grows. Between Ta-tsien-lu and Tscheto only a few pasturing grounds were seen. The range west of Ta-tsien-lu is less steep and, in the summits near the Tar-Kjo valley, reaches a height of 4500–5500 m. . . . The way leads from here (Tscheto) up the north-west valley, and one reaches after four hours, without much strain, the 4499 m. pass, the Dje la, or the divide between the Ya long kiang and the Tatu ho. Right up to the head of the pass dwarf trees grow on the sides (sloping 25–45°), and some 100 metres higher sparse grass. To the north of the Dje la, the rock summits of the Tscheto san tower like a gigantic, completely bare wall, whose relatively low saddles are filled with snowfields. The highest peak lies about 30 km. north-west of the pass, and reaches with a 1000-metre relative elevation above the main chain, the magnificent height of 7800 metres. Its name is Dschara, or "King of mountains." Some 30 kilometres farther north I caught sight a few days later from the pass Dorka La a second peak dominating in equal majesty the main chain. This peak marks the (administrative) frontier of China. Both, with dazzling white snow-covered peak, have a sharp cone-shaped form.

South of the Dje-la pass the rocky chain stretches with increasing height and wildness to the pinnacled Kunka massif, broken by gorges and precipices, which is dominated by the wonderful 7600-metre (absolute) rock pyramid Bokunka. This summit towers about 1300 m. above the angular snow chain, which runs like a half-moon from west by north to east. The chain itself extends still farther, though with less imposing peaks, its grey rock pinnacles also shooting up above the snows (p. 265–6).

The names have been left in the German spelling. In the geological results of Loczy (vol. i, pp. 703–5) we have a little more on Bo-Kunka:

Dson-go lies on a spacious valley bottom. . . . In the southern opening of the valley a high cone stands up, which is very like the Matterhorn, and, to conclude from its shape, formed of granite: its flat surroundings must apparently be formed of such clays and sandstones as are to be found on the similarly formed hills at Dson-go. This stone pyramid which rears itself like a monolith bears the name Bo-Kunka, and on its abrupt slopes snow lies only in a few places. In Fig. 125 the Bo-Kunka is drawn as seen from the Dson-go valley. The snow-covered range lying E.N.E. from it, the Kunka mountains, appears to be gneiss. . . . The triangular mountain group of the Ta-tsien-lu can be overlooked in its whole extent [from Kaschi-La pass], and we can recognize its structure and even its rocks at a great distance with sufficient certainty. In the north-east the panorama is dominated by the gneiss-granite mass of Dschara (Loczy, *Geological results*, vol. 1, pp. 703–05).

These heights for Jara (7800 m.) and Kunka (7600 m.) are, so far as we have been able to discover, the only instrumental heights ever published for these peaks. The details of the observations are given on p. 88. They are evidently the authority for the heights given by E. Bretschneider in his "Map of China . . . to illustrate the author's History of Botanical Discoveries in China, 1896," which shows a mountain south of the Dabo Pass and 30 miles north-north-west of Tatsienlu as 25,592 feet, and another about 25 miles south-west of Tatsienlu as 24,900. But already in the "Second thoroughly revised edition" of this map published in 1900 Bretschneider has dropped the former height, and the latter has since disappeared from later maps, such as the Kiatingfu sheet of the India 1/Million published in 1922.

Kreitner's maps on 1/Million are drawn in the style of the old Austrian 1/750,000, with hachures so heavy that the map is almost illegible. They are full of detail extending about 20 miles on each side of the route of the expedition, and there are many spot heights rounded to the nearest hundred metres. It would seem unfair, in the absence of any equally detailed maps, to conclude that all this detail is unreliable; yet if we make a tracing and superimpose it on the Survey of India compilation of the same scale we observe that Bokunka is very much out of position, and Mr. Stevens is clear that his sketch of Minya Gongka from Yingkwanchai (No. 2) is of the same mountain and in nearly the same aspect as Kreitner's sketch of Kunka from Dsongo (p. 703), which it much resembles. But Mr. Stephens is also certain that the high peak on the extreme right of the panorama from the Haja La (No. 3) is the same Minya Gonka, and the Haja La is south-east of Kreitner's position for Bokunka. That is, he was turning his back on the place of Bokunka when he drew No. 3, and it seems certain that Kreitner's Kunka was much farther from Dsongo to the south-east than he supposed. But this does not help us to diminish the height assigned by Kreitner to the mountain. On the contrary, if the mountain that Kreitner observed was really farther away than he thought, his angular elevation of over 14 degrees would make it much higher than the 7600 metres which he calculated for it; but we are no nearer the solution of the curious fact that Kreitner's figures have gradually, or perhaps rapidly, faded away from later map compilations.

Since his time many travellers have passed through Tatsienlu. Some have been favoured with clear weather as they crossed the high passes which lead from one deep valley to another, and make brief reference to the snows; others

seem to have been less fortunate and have scarcely mentioned them. In the following extracts we have collected most of these references from the more obvious sources, and shall be glad to receive others.

[Rockhill, coming from the north-west from Tailing.]

On the eastern side of this valley rose precipitous mountains, the summits of several of them deep in snow; and at its head was the huge, rugged mass of the Ja-ra ri, with deep beds of snow and ice extending several thousand feet down its steep flanks.

The Ja-ra ri is composed of a cluster of three peaks, and must reach an absolute altitude of about 16,500 feet; its southern continuation forms the Jeto la, over which passes the southern route to Ta-chien-lu. Along its eastern flank are the Ché ch'u and the road we were to follow; the country bears the name of Girong. This name [Ja-ra ri] cannot have the meaning given it by Captain Gill. It appears to me to mean "Horn of China," marking from afar where China commences; or else it is *Chalari*, "mountain of Ta-chien-lu" (W. W. Rockhill, *The Land of the Lamas* (1891), pp. 268–9).

[Johnstone, coming from the east from Hualinping.]

For the remaining three days of my journey to Tachienlu the scenery was of great beauty and grandeur. I have seldom seen anything more magnificent than the view of mighty mountains that greeted me as I left Hua-lin-p'ing, and continued to face me nearly all the rest of the way. The lustre of the snow, the rich azure of the sky and the sombre shadows of the gorges and ravines combined to make a series of pictures which no words can describe (p. 123).

There are times, of course, when the glories of the scenery are hidden by clouds or dimmed by rain and mist, and many a traveller must have gone through this country with very little idea of the wonderfuls ights that were hidden from him (p. 124).

After Ta P'eng Pa there is a long upward climb, followed by a short and sudden descent to a wooden bridge crossing a mountain stream. From here there is a magnificent view of the snowy mountains in the south-west (p. 127).

Tachienlu is a long, narrow little city which has had to adapt its shape to that of the mountains by which it is hemmed in. The summits of these mountains are covered with snow all the year round, and some are very lofty. According to Bretschneider's map, one of them is estimated at 25,592 feet, and another at 24,900 (p. 129).

The road from Chê-to rose steadily, but not steeply, through a confined valley, following the left bank of a stream. About midday we were picking our way laboriously through deep snow, and early in the afternoon we reached the summit of the pass of Chê Ri La, 17,400 feet above sea-level. The pass is a double one, the two summits being divided by a long valley which appears to have been at one time the bed of a glacier. High as we were, there were peaks in the north-east that still towered several thousand feet above us, and to the south and south-west we saw nothing but a vast ocean of billowy mountains with innumerable trough-like valleys (R. F. Johnstone, *From Peking to Mandalay* (1908), p. 155).

[Wilson, coming from the east from Kweiyung.]

With the weather conditions so favourable the view from the summit of the pass far surpassed my wildest dreams. It greatly exceeded anything of its kind that I have seen, and would require a far abler pen than mine to describe it adequately. Straight before us, but a little to the right of our viewpoint, was an enormous mass of dazzling eternal snow, supposed to be, and I can well believe

it, over 22,000 feet high. Beneath the snow and attendant glaciers was a sinister-looking mass of boulders and screes. In the far distance were visible the enormous masses of perpetual snow around Tachienlu. In the near distance, to the west-north-west of the pass, another block of eternal snow reared itself. Looking back on the route we had traversed we saw that the narrow valley is flanked by steep ranges, the highest peaks clad with snow, but in the main, though bare and savage looking, they scarcely attain to the snowline (p. 200).

The mountains on either side of the valley in all their higher parts range above the snowline; their lower slopes are covered with grass, small conifer trees, and brushwood (p. 201).

During the day, which was beautifully fine, we had grand views of the snow-clad peaks around Tachienlu and the steep ranges with pinnacled peaks to the east-south-east of that town (E. H. Wilson, *A Naturalist in Western China* (1913), p. 202).

The frontier town of Tachienlu, where I was stationed for nearly two years, is the gateway through which the teas and silks of Western China enter Tibet. Here, in a narrow ravine hemmed in by steep mountains whose summits are clothed with glaciers, converge the two highways which unite Lhasa with China, the official highway through Batang and the caravan road through Jyekundo (p. 231).

On the way up one catches a glimpse of the magnificent peaks and glaciers to the south-east of Tachienlu, the highest summits of which rise to over 17,000 feet. . . .

Just below the pass we parted from the Batang main road and turned north-west across a stony waste at the foot of a barren range of mountains trending in much the same direction. At its farther end is a fine snow-capped peak called Zhara Ri by the Tibetans (in Chinese Hai-tzu Shan, "Lake Mountain"). Among the tarns which lie at its foot is a beautiful turquoise lake fed by a waterfall issuing from a glacier (Oliver Coales, "Eastern Tibet," *Geogr. Jour.*, 53, 233, April 1919).

Another very prominent mountain feature in Kam is the big range which runs parallel to, and on the right-hand side of, the main road from Jyekundo to Tachienlu. It is a huge and imposing barrier wherever seen. South of Jyekundo it forms the divide between the basins of the Yangtze and of the headwater streams of the Mekong, and is here crossed by the Shung La, a high pass on one of the roads from Jyekundo to Chamdo. Proceeding south-east, it is pierced by the gorges of the Yangtze below Chunkor Gomba (Tengko) and thence serves as the Yangtze–Yalung divide down to below Kantze. On this stretch of its course it contains some very high peaks and glaciers behind Dzogchen Gomba, below which it is crossed by the Tro La on the main road to De-ge. Farther down it appears as the magnificent snow-capped range which stretches along the southern side of the Yalung plain from Rongbatsa to below Kanze; in this neighbourhood it is crossed by the Tsengu La and the Hön La on the road to Beyü and Southern De-ge, and by another high pass on a road to Nyarong. Below Kanze it is pierced by the gorges of the Yalung, which are overlooked by a giant snow-peak, Kawalori, a sacred mountain of Nyarong. From here it continues south-east to Tachienlu, where it serves as a clear-cut ethnographical boundary between Chinese and Tibetan inhabited country; it is here split into two by the valley of the river of Tachienlu, which is overlooked by snows on both sides. From Tachienlu it continues south, containing here some very big peaks, towards the Yunnan border. I suspect this great range to be a south-easterly continuation of the Dang La

mountains north of Lhasa, and to be therefore one of the principal features of the mountain system of Tibet.

There are some very high mountains on both sides of the Yangtze between De-ge Gonchen and Batang, including the giants immediately east of the latter; but I have not been able to distinguish the continuity of particular ranges in that neighbourhood.

It is to be hoped that the heights of the principal mountains of Kam will some day be ascertained by scientific measurement, the results of which will probably show the existence of some very high peaks. I believe that amongst the highest will prove to be the group of peaks behind Dzogchen Gomba (bearing roughly north from the Mizo La near Beyü); Kawalori on the Yalung below Kanze, some of the peaks on the Mekong–Salween divide between Chamdo and the latitude of Atuntze; the peaks east of Batang; and the peaks north and south of Tachienlu (Eric Teichman, "Journeys through Kam," *G. J.*, 59, 1 January 1922).

Mr. A. E. Pratt ('The Snows of Tibet,' 1892) remarks that on the way to Tatsienlu from Wassu "views up various ravines disclosed snow-capped mountains," and that north of Tatsienlu the snow-line is at about 16,000 feet.

Dr. A. F. Legendre (*La Géographie*, 15 Dec. 1911) gives heights of passes but little about peaks and no heights or names of peaks on his map. Mr. Edward Amundsen (*G.J.*, 15, 620), going S.S.W. from Tatsienlu, speaks of a succession of mountain ranges clothed with luxuriant pine forests, but makes no mention of any high peak.

Major H. R. Davies (Yunnan: C.U.P. 1909) came over the Gi La to Che-to and descended "a narrow green valley to Tachienlu . . . shut closely into a narrow valley by high steep hills," but neither in his book nor the accompanying map (T.S.G.S. 2112) are there any high peaks.

One may gather from these extracts why our knowledge of the mountains about Tatsienlu is very defective. The valleys are deep; the passes are often wrapped in cloud; the visibility is generally poor. If so good a traveller as Mr. Oliver Coales could be stationed two years at Tatsienlu and afterwards write a paper on the country with such slight references to these peaks, they must be very inaccessible, and seldom seen.

Mr. Herbert Stevens had better weather than usual, and we are much indebted to him for the following note, which gives the best account of this country since Szechenyi's journey more than fifty years ago. He cannot assign any height to these peaks, but his sketches show that they are of striking form; and we may hope that they will inspire a survey of the ranges at the first opportunity.

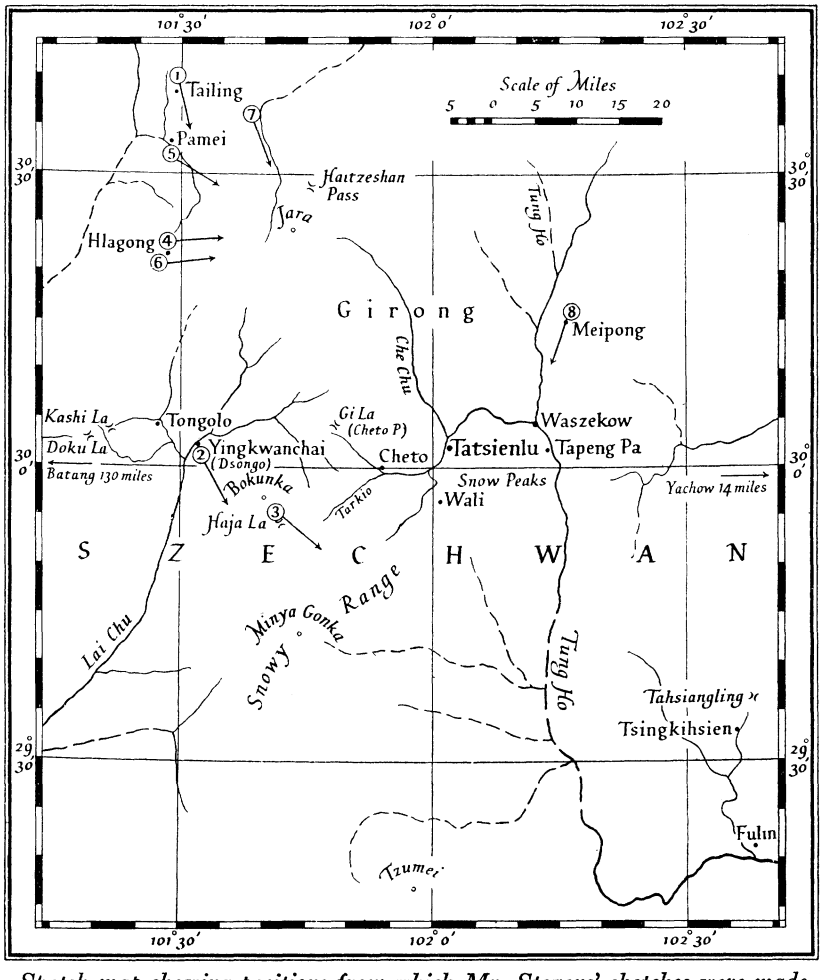
SKETCHES OF THE TATSIENLU PEAKS

HERBERT STEVENS

IT was my good fortune to be a member of the Kelley-Roosevelts' Expedition to Yunnan and Szechwan. To enable our party to work to the best advantage, in accordance with pre-arranged plans we separated en route and, for me, finally at Likiang, owing to my missing connection at Tatsienlu. The collection of zoological and botanical specimens was my first consideration; but, owing to the time required by these duties, and exceptional climatic conditions giving good visibility which must have been phenomenal for a time of year under the influence of the south-west monsoon, I saw much of the country traversed to perfection. Our party left Bhamo on 26 December 1928, arriving in nine days at Tengyueh. I left this place a day later than my companions, and after crossing the Mekong struck easterly to Mingshih, taking fourteen days to reach Tali, where our party was again united. It took five days via Kienchwan to reach Likiang. On March 7 I left Likiang, spending fifty-five days en route in camp and thirty-eight days on the march, via Yungning, Muli, Kopadi, Kulu, Kon La 14,600 feet, Yonka La 15,000 feet, Tiyu 12,900 feet (Gompa), Yatsu 11,200 feet, Baurong 8000 feet (Rope ferry below village), Patei (Pass 15,300 and 15,000 feet), Wushi 12,000 feet (Pass 15,000 feet, descent to 12,700 feet, Pass 15,600 feet), Kusata (Gompa), Chentze 13,100 feet, Laila hamlet 12,400 feet, Chaulu 13,600 feet (Gompa), Lai Chu (Bridge), Zamba Ku 11,600 feet (bridge, stone towers, open valley), Trazya 12,100 feet, Haja Tungu 13,000 feet (Gompa), Haja La 15,300 feet, Cheto, to Tatsienlu, where I arrived on June 1. After work at two camps near at hand, Cheto and Wali, I was joined by my friend Huston Edgar on two journeys. The first was through the Tibetan Borderland via Cheto (Pass 15,000 feet), Anyangpa 12,900 feet, Yingkwanchai 12,400 feet, and Tongolo 12,500 feet, where we left the Batang track and struck north to Pehsang 12,500 feet, Chengmengka 12,700 feet, Hlagong 13,300 feet (Gompa), Pamei 12,300 feet (Gompa), Tailing 12,600 feet (Gompa), Kwanchai 13,700 feet, from which place on our return we went south with a diversion east to Tailing, crossing the Haitzeshan at 15,000 feet on the eastern side of the Jara mountain, Sintientze, Tsongku, to Tatsienlu: time on march eighteen days. The second journey was east to Waszekow, where we turned north following the right bank of the Tung Ho to Kutsa (Gompa), crossing the river by ferry-boat at Chingshui 6000 feet, stiff ascent of 3800 feet to ridge circ. 8500 feet overlooking Meipong 7900 feet, descent followed by stiff ascent of 3800 feet to ridge overlooking the Tung Ho gorge at 10,800 feet. From this point our route continued north-easterly with descent to Tienta 9000 feet, river crossing above hamlet 7400 feet, small gorge, perpendicular crags on right, Kochaihopa 7500 feet, Trashichoten 8300 feet (Gompa), Shwang Yu 8900 feet, Tongling 8800 feet, the last house to the west of the watershed; camp in river-bed 9800 feet, Santochai camp 11,500 feet, Lianghokow (remains of single house, open grass-lands 12,200 feet), gradual rise to 13,100 feet, followed by a sharp descent in a south-easterly direction to Tupakö 7400 feet, Laoyingkö 6500 feet, Pashku 5400 feet, Moaten 4400 feet, to the town of Muping 4000 feet, thence to Yachow via Lingkwang, Renjaba and Feihsien. (Innumerable hanging plat-

forms, tree-trunk bridges, and one rope crossing.) Time on march twenty-one days. I reached Shanghai on 6 November 1929.

Early in the year, when traversing Yunnan, distant snow-capped mountains had been seen to the north; and when I arrived at Likiang and camped during February in the village of Ngulukö, some 12 miles north at the base of the mountain Satsetö, the glaciers and snow-capped peaks of the Likiang Range



Sketch-map showing positions from which Mr. Stevens' sketches were made

were seen at comparatively short range, the summit of Satsetö being visible from the narrow street in the village. Another peak Ginalakö is visible from the track which runs north and south over the plain about half a day's journey to the north.

On the evening of March 25, from my camp at 12,000 feet, two and a half days' journey south of Muli, this range could be clearly seen on the horizon 80 miles to the south. On the morning of April 23, after leaving Kulu, an impressive

view of a massive snow-capped range, somewhat obscured by clouds, was obtained from open country at 12,500 feet looking west-north-west, which range the lama who was accompanying me called the Shola Gonka; while on the afternoon of the 30th, when between Yatsu and Baurong before the descent to the gorge of the Yalung, I had an impressive view to the east of snow mountains, which the lama and carriers spoke of as the Minya Gonka, evidently a portion of the same range which I was later to see to perfection: the culminating mountain admits of no error in identification under favourable circumstances. On May 31 my caravan, comprising villagers, yaks and ponies, left the village of Haja Tungu and were laboriously traversing a long ascent on a track with an execrable surface little better than that of a moraine, when I decided to forge ahead. On reaching the narrow gap on the summit of the Haja La, with the first gust of wind over came a butterfly (Parnassius), a genus I had not met with up till then. On coming through the gap I was held spellbound by the utter solitude and sterility of a range of mountains, fantastic in shape and outline. I had immediately to make the most of a double opportunity. Leaving my boys to the difficult task of netting as many insects as they could catch on the screes in a high wind, I ascended the ground on my left, where a blue Meconopsis was sparingly in evidence, working in the direction which would be likely to disclose a more extensive view to the south-east. After gaining some 200 feet I was amply rewarded with the view of the pyramidical snow mountain shown in sketch No. 3. My camera had failed me before reaching Yungning, but my sketches are substantially accurate to the best of my ability. My altitudes are only approximate from aneroid readings.

From above Wali, some 15 miles south of Tatsienlu and north of the Yajajen Pass, on June 30, I had hoped to get a view to the south-west of the dominating peaks of this same range, but the weather was not propitious, and though I obtained a momentary glimpse of what was most likely this particular peak, from this direction it showed a slightly inclined summit with a steep face on my left while the opposing face was almost perpendicular. [Perhaps the Ru-ching of Gill.]

It was not until the afternoon of July 15, when at Yingkwanchai, that Edgar and I saw to perfection the same mountain, figured in sketch No. 2, showing from this viewpoint as a pyramid completely covered with snow, in a southerly direction; a rough guess would place it about 30 miles away. Again from Tailing about 2 miles north of the monastery, on the morning of the 26th the whole range was visible as in sketch No. 1. There was every indication of an extensive glacier to the left of the culminating peak.

Another imposing mountain, at the extreme end of this bend of the Himalaya to the north of Tatsienlu, is Jara, which was seen first from the west of Yingkwanchai at an elevation of 14,500 feet, a portion of the summit being disclosed in a north-north-easterly direction; but it was not until we reached a point south of Hlagong monastery on July 19 that the whole mountain mass above the perpetual snow-line was revealed to the east in all its majesty, and though less of it was seen from our camp July 19–22, to the north of Hlagong, later at Pamei on the evening of the 23rd it was seen to perfection. The Tibetans speak of this mountain as higher than the Minya Gonka, probably owing to its isolation. Judging by the amount of perpetual snow,

some of these mountains are very high, and in shape are eminently beautiful. On the evening of August 3 from our camp at 13,000 feet Jara appeared to block our route to the south, and the following evening when we camped on the Haitzeshan pass at 15,000 feet, we had nearer views of its glaciers and snow when we pitched camp in a perishing blizzard. Early next morning a few glimpses were obtained, but soon the clouds settled, and in our descent south it was soon lost to view. Nearing Tatsienlu on the evening of August 6, a snow-peak of this same range was visible from one viewpoint some 7 miles north of Tatsienlu in a south-south-westerly direction, which would be a peak of the same group as seen from our mid-day halt on August 20, after leaving Meipong, on the mountains above the left bank of the Tung Ho looking south-west 200° (Sketch No. 8). These mountains are visible from water-level at certain points on the Ya river, and there is also an excellent view from Omeishan; but whether the commanding Minya Gonka is visible from the summit of Omeishan I am unable to say. It was blocked by a shoulder of the mountain when I stayed at Shihshahshu on October 5 to 9; but I did manage to obtain a fleeting glimpse of the peaks in a west-north-westerly direction.

[The sketch-map is based upon the Survey of India 1/M sheet Kiatingfu, with additions depending on rough compass traverses. The positions from which the sketches were made are shown by numbered circles, and arrows show the general direction. The bearings given in the titles of the sketches are magnetic, but the variation at Tatsienlu in 1929 was very small, about 0° 25′ west by the Carnegie Institution Survey brought up to date with approximate secular change. Mr. Stevens had the assistance of Mr. Edgar in recording the names, and considers that Minya Gonka is near the correct spelling. The name Tatsienlu of the Chinese Postal Guide is pronounced Dachienlu.]

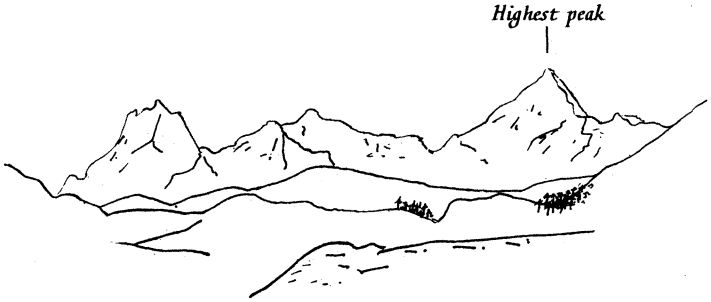
CANADIAN GEOGRAPHICAL SOCIETY

THE newly formed Canadian Geographical Society held its inaugural meeting at Ottawa on 17 January 1930. The President, Dr. Charles Camsell, was in the chair, and the Governor-General (Lord Willingdon) honoured the proceedings with his presence.

Dr. Camsell, in opening the meeting, said that for some years past Canadians had had in mind the formation of a Geographical Society for the advancement and diffusion of geographical knowledge, more particularly relating to Canada. Such a Society had now been formed, and he looked forward to its being of great service to Canada. He also read out a telegram of greetings to the Canadian Geographical Society from the President and Council of this Society.

Lord Willingdon congratulated the Society and said he hoped it would enable Canadians to know more of Canada. He had had to travel much about the country, and he was surprised to find how little those living in one part knew of other parts of their own country. This deficiency the Society should help to make good.

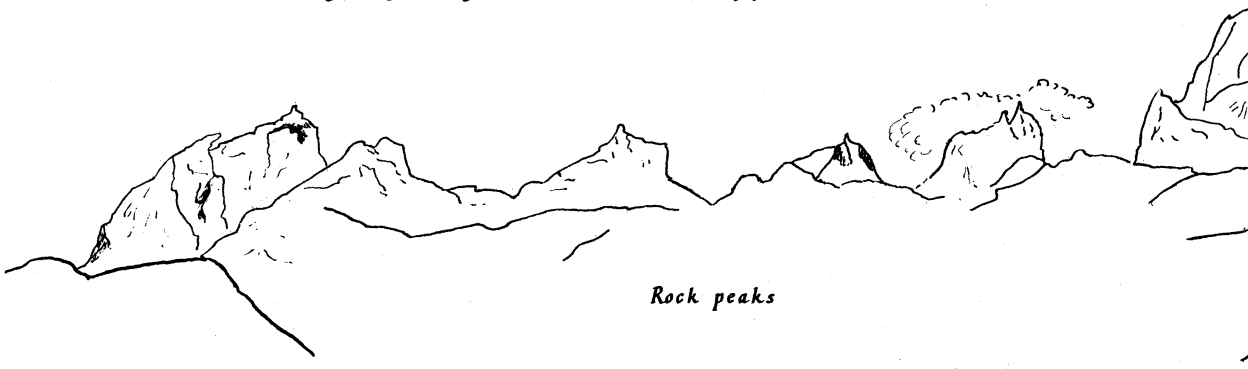
Dr. Isaiah Bowman, Director of the American Geographical Society of New



1 *Minya Gonka from a point (12,900 ft.) two miles north of Tailing Gompa, looking S.S.E. Peak N. 165° E. 26 Jul. 1929.*

4 *Jara from camp (13, Hlagong Gompa, loo*

2 *Minya Gonka from Yingkwanchai (12,450 ft.). 15 Jul. 1929.*



3 *Range S.W. of Tatsienlu from Minya Gonka on extreme rig*

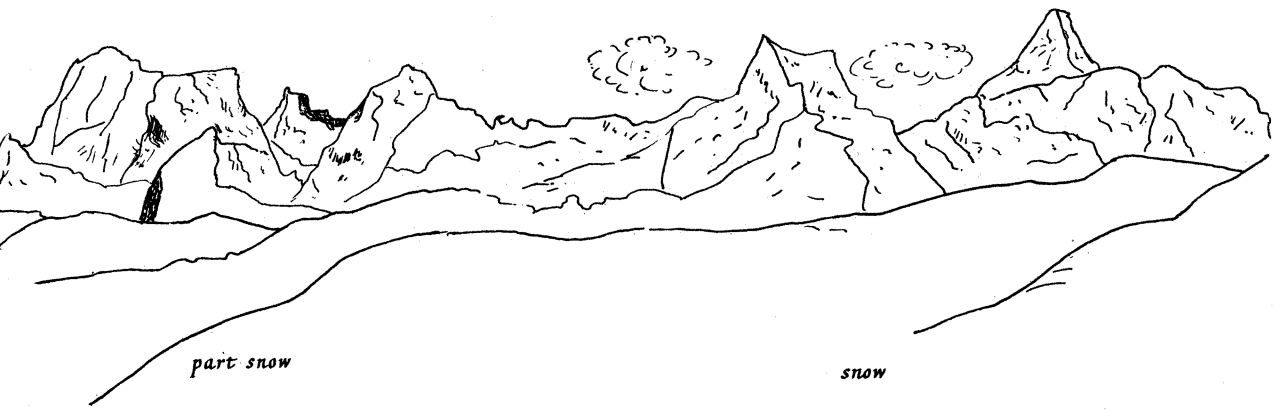
SKETCHES OF THE TATSIENLU PEAKS

By Herbert Stevens

n camp (13,500 ft.) a little north of Gompa, looking east. 19 Jul. 1929.

5 Jara from camp (12,300 ft.) south of Pamei Gompa. 23 Jul. 1929.

6 Jara from a point (13,600 ft.) south of Hlagong Gompa, looking east. 21 Jul. 1929.



sienlu from Haja La (15,300 ft.) extreme right. 31 May 1929.

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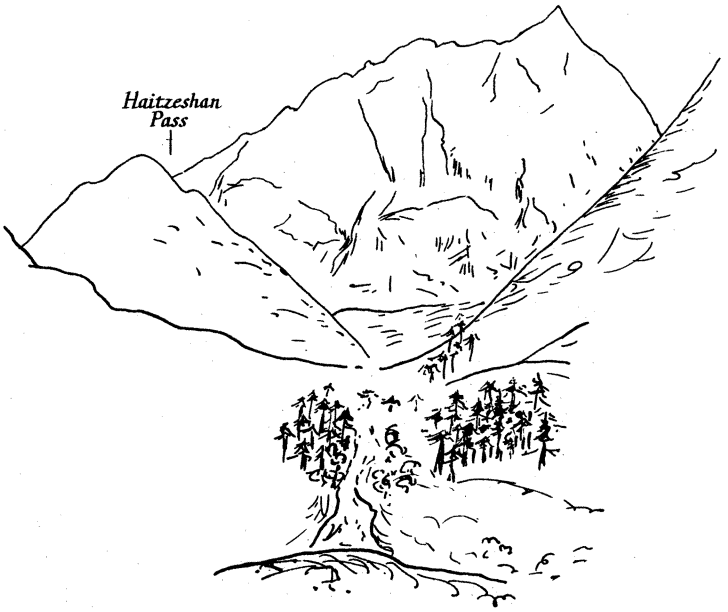

7 *Jara from camp (13,000 ft.) about 10 miles east of Tailing, looking S.E. 3 Aug. 1929.*

8 *Mountains S.E. of Tatsienlu from north of Meipong, looking S.S.W. 20 Aug. 1929.*

TATSIENLU
Stevens

The
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THE ITALIAN EXPEDITION TO THE KARAKORAM IN 1929: *A paper read at the Evening Meeting of the Society on 24 February 1930, by*

H.R.H. THE PRINCE AIMONE OF SAVOIA-AOSTA, DUKE OF SPOLETO

IN 1927 a private committee was formed in Milan to finance an expedition to the Karakoram. With the assistance of the Milanese Section of the Alpine Club and of the Italian Royal Geographical Society, a general plan was outlined, comprising an attempt to climb Mount K_2, the highest peak of the Karakoram, by a group of mountaineers, while the scientific members of the expedition were to investigate the geographical problems connected with the Baltoro Glacier, make stereographic, gravity, and geological surveys, and collect the fauna and flora.

The mountain system which goes by the name of Karakoram lies to the north of Western Himalaya, between the Indus and the Upper Yarkand, or Raskam Darya, and is bounded on the west by the Gilgit river, and on the east by the Shyok. In no other region of the world is there to be found in such a confined space an equally large number of big mountains and glaciers. Besides K_2, ten other peaks ranging from 23,000 to 28,000 feet crowd round the Baltoro glacier. Although the district has been the object of repeated explorations, there remains much to be done both from the mountaineering and the scientific point of view.

The final decisions of the Committee were only reached in the first months of 1928, too late to organize and take out the expedition in the same year, the useful season for work on the high glaciers of the Karakoram being limited to the few months between April and September. It was then decided to carry out a preliminary expedition with the purpose of bringing up and depositing at Askole, the last village on the way up to the glacier, all the materials and provisions which could be got ready in time for the following season. Dr. De Filippi was of great assistance to me with his expert advice, and the experience gained in two expeditions in the Karakoram.

I landed in Bombay at the end of May, where I found a great welcome awaiting me. The Government of India offered every possible assistance, and I

should like particularly to express my obligation to Major Mason, who had explored the Shaksgam Valley in 1926. His valuable information was of the greatest help to me.

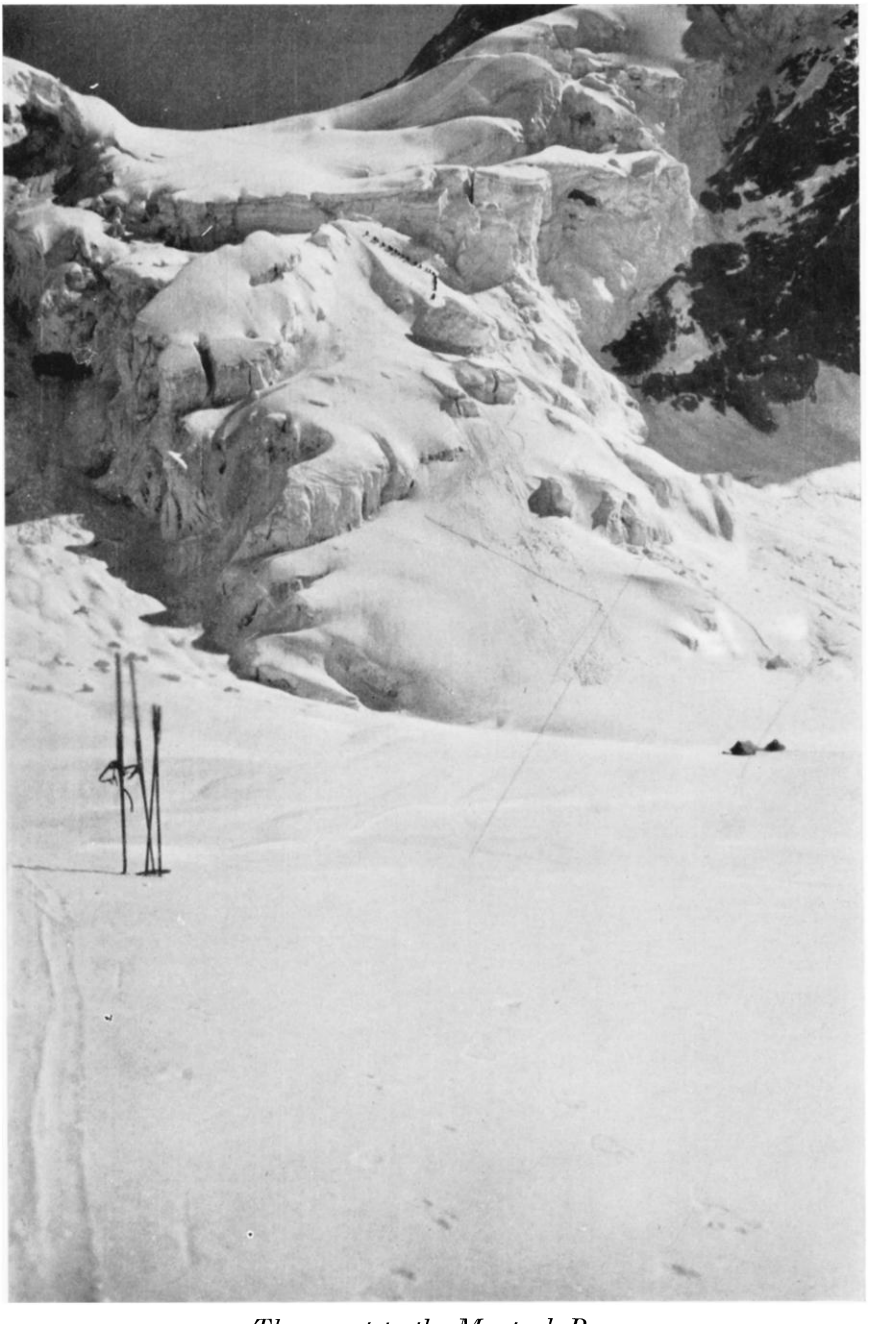
Having reached Srinagar at the end of May, I left it again at the beginning of July, with a caravan of two hundred ponies, making for Skardu, the capital of Baltistan. Two roads lead to Skardu: one over the Deosai plain, and the other by the Sind, Dras, and Indus valleys. We planned to go out by the former and return by the latter, so as to see as much as possible of the country and to get to know the people with whom we would have to deal in the following year. We passed through Skardu, and from there across the Indus and up the Shigar and Braldo valleys, reaching the village of Askole, where we stored 18 tons of material and provisions in huts hired from the lambardar. We then started on the return journey, crossing the Skoro La (16,700 feet), which shortens the distance between Askole and Shigar by three stages. Having travelled by the Indus Valley road, we reached Srinagar in the last days of August. The party then returned to Italy to complete the preparations for the following year.

Meanwhile the Committee had changed the plan of the Expedition, transforming it into a purely scientific one and giving up the idea of attempting the ascent of K_2.

The Expedition finally left Italy in February 1929, travelling straight to Srinagar, where the caravans were prepared without delay. The party consisted of twelve Europeans: Myself in command; Comandante Cugia, second in command, in charge of geophysical and astronomical observations; Dr. Allegri, R.N., medical adviser, entrusted with anthropological researches; Professor Desio, geologist and geographer; Professor de Caporiacco, naturalist; Col. Balestreri, Signori Ponti and Chiardola, mountaineering experts, with two Alpine guides from Courmayeur, Bron, and Croux; Signor Terzano, cinema operator; and Anfossi, wireless operator.

Owing to the great number of loads (nearly six hundred) the caravan was split into three groups, which proceeded separately. The first difficulty we met on our way was the Zoji La (11,230 feet), which at this time of year has to be climbed by the steep narrow gully, exposed to snow avalanches; but fortunately we all got over the pass without suffering any loss, although we were caught by a heavy snowstorm at the top. Skis were very helpful, saving us many hours of heavy tramping for the following two stages. By the end of April we reached Askole, where we found in perfect condition the stores which we had left in the previous year. Here we reorganized the caravan, and enlisted the permanent coolies for the high-mountain work. Five more marches brought us to Urdokas, on a spur of the southern buttress of the Baltoro glacier, which we had chosen as the place for our base camp.

While the supplies were being carried up, Professor Desio made a preliminary exploration of the Dumordo valley, which joins the Biaho a few miles below the front of the Baltoro glacier. Into the upper part of the valley flows the Punmah glacier, which is fed by five principal tributary glaciers, covered by surface moraine up to a height of 14,000 feet. In the lower valley are scattered groups of diminutive huts occupied during the summer months by shepherds. Desio went up the Punmah to the foot of the watershed range, and made a hasty survey



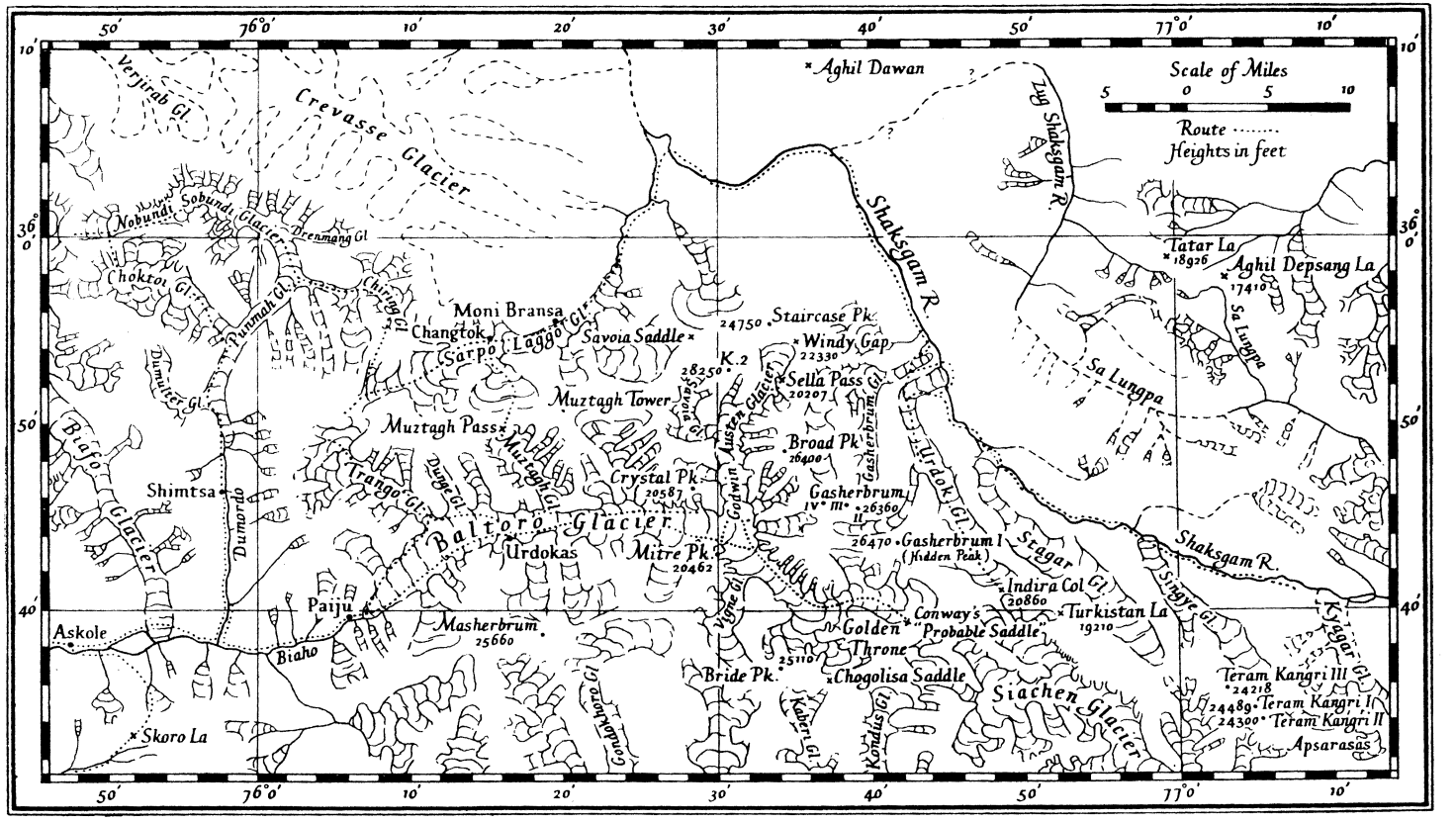
The ascent to the Muztagh Pass

The Sarpo Laggo glacier north of the Muztagh

of the valley and the glacier, collecting geological data and observations on the limits of vegetation, etc.

During the second half of May Professor Desio made two further excursions for geological researches in the valley of the Baltoro. From the Concordia amphitheatre he ascended the northern branch of the glacier, or Godwin Austen, to 18,300 feet, not far from Windy Gap, and later the southern branch to the upper basin. The great pyramid of K_2 appears to be made entirely of gneiss, more or less schistose, while the Gasherbrum group is mainly built of limestone, with occasional fossils, which is continued as far as Hidden Peak, confirming the conclusions arrived at by the expedition of the Duke of the Abruzzi. Meanwhile we were rapidly organizing the base camp, and preparing for an exploration into the Shaksgam valley. The Shaksgam had been first discovered in 1887 by Sir Francis Younghusband, who came into it from the north, over the Aghil Dawan. Two years later he again explored it at its western end. Major Mason, in 1926, explored its eastern, or upper end. We had planned to enter the intervening part of the valley, and connect the two previous explorations by a survey of the portion of the valley hitherto unknown. Sir Francis Younghusband had passed from the Shaksgam valley into the Baltoro, crossing the divide by the Muztagh Pass, which once used to connect Kashmir with Turkistan, but had been abandoned many years ago, owing to changes in the conditions of the glaciers which blocked the way. After Younghusband, only one other European, Herr Ferber, had reached the summit of the Muztagh from the Baltoro, but did not push forward to the other side. We decided to try and reach the Shaksgam by this pass, although the reports were not very encouraging. A first reconnaissance was made by Balestreri and Chiardola, to ascertain whether it would be possible to convey a party of laden coolies over the pass. I received a report from them after ten days. They had been delayed by bad weather. They had tried at first to follow the way described by Sir Francis Younghusband in Major Mason's report; but it led over rocks which they considered too difficult for the porters. Therefore they kept to the right of the col, by a slightly easier passage, although they had to pick their way through the seracs near the top of the col.

As soon as the news reached us, we prepared immediately for the exploration. It was to be carried out by a party of five, with thirty coolies, supported by an auxiliary party of twelve coolies led by another European, which was to advance supplies to a place called Moni Bransa, two days' distance from the top of the pass. This small group, having supplied the main body during the five days' march from the base camp, would still have a small amount of provisions to be left at Moni Bransa, and would then return to the base camp. Thus the exploring party had supplies for twenty-five days, and, in case of emergency, had this small store to fall back upon. The planned itinerary beyond the Muztagh Pass led down the Sarpo Laggo valley, then turned up the Shaksgam valley, north of K_2, allowing for the exploration of the glaciers which flow into the valley, and proceeding, if possible, as far as the lowest point reached by Major Mason in 1926, where he found his way blocked by the snout of the Kyagar glacier. They then would try to find a way over one of the passes to the east of K_2, back into the Baltoro, returning to the base by the Concordia amphitheatre.



Preliminary sketch-map of routes of the Italian Expedition

On June 2 we sent the supplies to the foot of the Muztagh Pass, and on the 6th the exploring party left the base camp. Unfortunately I was taken ill on the way up, and unable to proceed any farther for the time being, so I had to hand over the leadership to Balestreri. With him went Desio, Ponti, and the guide Bron.

They reached the top of the pass in the early morning of June 9. The col, 17,500 feet high, is situated on the eastern side of the upper basin of the Muztagh glacier, and leads to a tributary glacier of the Sarpo Laggo. The descent is easy, and with the help of skis in a few hours they crossed the Sarpo Laggo and reached Changtok on an old moraine covered with grass. Moni Bransa, also situated on the left lateral moraine, was reached next day. Here the auxiliary party led by Caporiacco and Chiardola left the caravan to return to the base, according to plan. The remaining four, with thirty-six coolies, proceeded on their way down, reaching the front of the Sarpo Laggo glacier on June 12. The Sarpo Laggo is a large glacier, and it flows far towards the west, terminating at an altitude of 16,300 feet. Below stretches the valley, very wide, flat, and dotted with clumps of vegetation. In one of these oases, perhaps the Suget Jangal of Younghusband, were found traces of camps, some of them very recent, and a small enclosure of stones, looking like a grave. This oasis, covered with thick bushes with intervening grassy stretches, is a resort for wild asses, or kyangs, and hares. A few miles below the glacier a large tributary joins the valley on the left, filled to near its end by a glacier, the "Crevasse Glacier" of Younghusband. A little farther another, smaller, valley closed by a large moraine, comes down on the right.

The opening of the Sarpo Laggo valley into the Shaksgam, where remains of old camps are again to be seen, was reached on June 13. The junction is marked by an isolated rock, nearly 500 feet high, capped by a stone cairn possibly erected to indicate the old caravan road, from which one can see K_2. The Shaksgam valley above the junction is narrow and deeply cut between high limestone cliffs; below it suddenly opens out and looks almost like a continuation of the Sarpo Laggo.

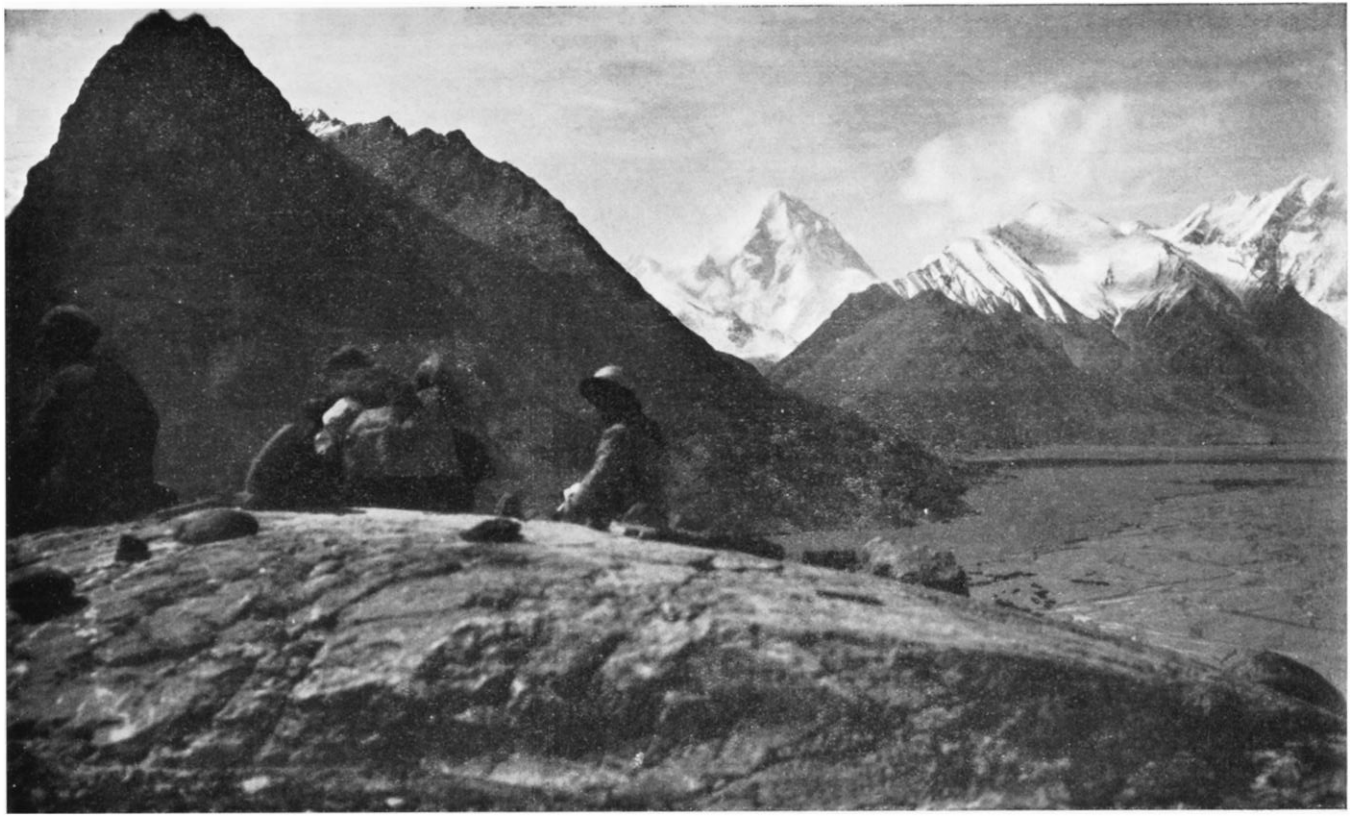
A march of a day and a half along the bottom of the valley, which entailed the wading of the narrow river on several occasions, brought them to the mouth of the small valley coming from the Aghil Dawan. The Shaksgam is sprinkled with small oases, the sides are bare of vegetation, the surrounding mountains have dolomitic shapes with towers, needles, and pinnacles, terraced sides and big accumulations of detritus at their feet. The evening of the 15th they camped on one of the big alluvial fans which lie at the foot of all the side valleys. Above them the snout of the Gasherbrum glacier stretched across the valley; and beyond were visible the Gasherbrum peaks. A few miles below the Gasherbrum a considerable valley opens into the Shaksgam, which is probably to be identified with the Zug Shaksgam of Major Mason. A little lower below it there is a fine oasis watered by a thermal spring. It is the highest oasis of the Shaksgam valley; but its position does not correspond with the Durbin Jangal, which the Indian Survey map places higher, but of which no trace was found. Shortly before reaching the Gasherbrum a kyang was killed, providing some excellent fresh meat for the party. On a rock spur was noticed a heap of stones looking like a signal, which might possibly denote the Gasherbrum Jilga of Younghusband.

On June 18 they tried to find a way round the front of the Gasherbrum glacier; but they were stopped by a deep pool of water, beyond which rose a perpendicular wall of ice. They then climbed the left moraine, and succeeded in crossing the glacier bristling with ice pinnacles to the right moraine, where they camped at the foot of the buttress dividing the Gasherbrum from the Urdok. Next day they reached the Urdok by climbing to a saddle on the said buttress from which the whole glacier could be seen stretching south-west as far as the Indira Col. In the next two days they ascended the glacier, covered with moraine to considerable height, to the steep terminal ice-wall, swept by avalanches, which leads to the col. The weather had changed, and the whole district was covered with a deep layer of newly fallen snow. They had considered for a time the plan of attempting to cross the Indira Col; but, the weather having broken and the supplies being reduced to half, they decided to split the party: Balestreri and Desio proceeding towards the upper Shaksgam with eight coolies, while Ponti and the guide returned to the Baltoro.

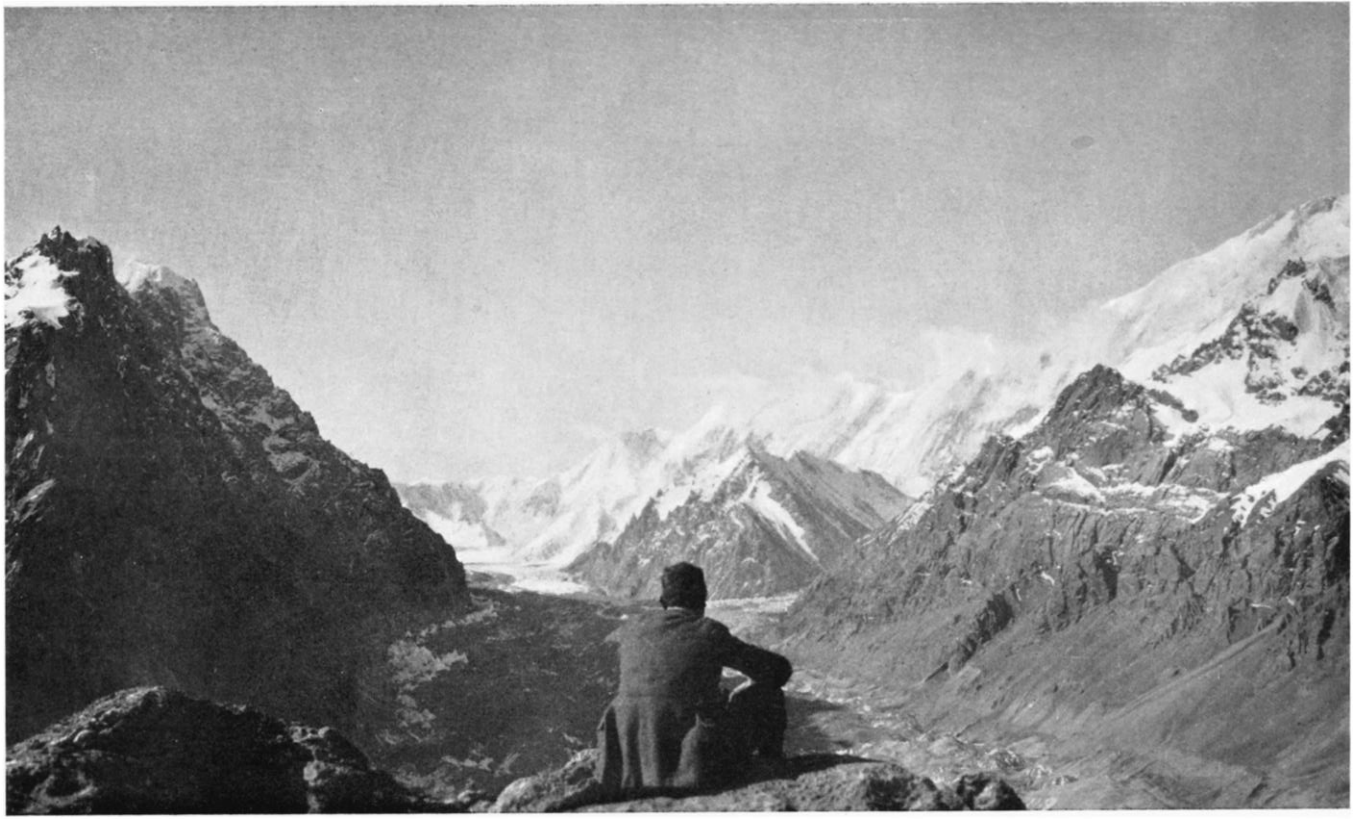
A small dump of supplies was made near the front of the Urdok, and the reduced caravan proceeded on the wide flat bottom of the Shaksgam valley. The limestones prevalent lower down continue above the Urdok, and contain a fair number of fossils.

On the evening of the 24th camp was pitched near the next glacier cutting the valley, to which the coolies gave the name Stagar, the Balti word for "many coloured," owing to the alternating strips of ice and moraine. The glacier stops at a distance of about 450 to 500 feet from the opposite side of the valley, leaving an open corridor in which flows the river. Through this, crossing and recrossing the stream, they got beyond the glacier. The characteristics of the valley remain the same. A third protruding glacier was overcome with considerable difficulty. The front reaches the right side of the valley; so they had to traverse it higher up, struggling for hours in the labyrinth formed by ice pinnacles, some of which were over 200 feet high, helping the coolies, who baptized the glacier "Singye," meaning "difficult." The sand deposits above the Singye, and the terraced sides of the valley prove the formation of temporary lakes during the intermittent damming of the Shaksgam by the side glacier. Above the Singye the valley narrows and the river is considerably smaller, and can be crossed by stepping from stone to stone. On the 27th the march was resumed along the big reddish buttress forming the right side of the valley, the Red Wall of Mason. About midday they sighted another large glacier, covered with pinnacles, stretching across the valley, the Kyagar, and they reached it the same evening. Next morning, from the top of a rock on the left side of the valley they had the sight of the whole Kyagar glacier up to the Apsarasas range. Across the glacier, on its right side, they were able to identify the stone signal built by Minchington of the Mason expedition. The Kyagar, which has been minutely described by Major Mason, has the same features as those of Singye. They built a stone signal on their observation point, 16,300 feet high, and hid in it a record of the expedition in a tin box.

The return journey began next day. They recrossed the Singye with the same difficulty but with better weather, which allowed them to see the upper part of the glacier and the majestic group of Teram Kangri which rises at its head. They passed round the front of the Urdok, which does not block the



K2 from isolated rock at junction of Sarpo Laggo and Shaksgam valleys



The Urdok glacier

valley, leaving an open space for the river. The weather, uncertain and foggy, prevented them from pushing an exploration into the Zug Shaksgam, so as to connect with Mason's survey of the valley.

They cut the corner between the Sarpo Laggo and the Shaksgam valleys by climbing over the right buttress of the Sarpo Laggo. Just beyond the top K_2 was distinctly observed. They also noticed some well-preserved bits of an old caravan path, and everywhere remains of old camps. On July 9 they arrived at Moni Bransa, where the depot of supplies had been made. From there they proceeded toward the upper part of the Sarpo Laggo glacier, reaching on the third day the saddle at the head of the valley, 18,500 feet high, from which they pushed on a short way beyond the watershed in the upper basin of a large glacier tributary of the Baltoro, which, according to Conway's map, they believed to be the Dunge glacier. Wishing to return to the base camp in the prearranged time, they did not attempt the new way which was opening up, but returned on the Sarpo Laggo, and, having recrossed the Muztagh, reached Urdokas on July 14.

While my companions were carrying out this task, as soon as I had sufficiently recovered, I turned my attention to the Upper Baltoro, where another geographical problem remained to be solved. In Sir Martin Conway's map of 1892 there is mentioned a "probable saddle" in the upper basin of the Baltoro glacier. Professor Desio, in his excursion of the latter part of May, had climbed part of the way towards it. It seemed to me worth while to carry out a closer investigation. Owing to the absence of most of our coolies with the exploring parties beyond the Muztagh, I was unable to leave the base camp before the end of June. I then went up to Concordia, where for a few days I was engaged in survey work. Then a heavy snowstorm confined us to our tents for six days. Finally, on July 9, the weather having cleared, I set out with Ponti, the guide Croux and sixteen coolies. Three days of difficult march over the glacier covered with soft snow, where skis proved very useful, brought us to the foot of the saddle which was our aim. Some of our coolies were tired and suffering from mountain sickness; but with a little persuasion they were induced to carry on.

The morning of the 12th we started off at 4 a.m. For the first few hours we proceeded easily over the hard frozen snow; but later, with the rising of the temperature, our progress became slower. The incline is very steep; and at times we were compelled to make long détours to avoid deep crevasses and dangerous seracs. Our coolies, although heavily laden, followed us fairly well. Not far from the summit a long and gentle slope allowed us to use our skis; and shortly after noon we reached the crest. To the east of us rose a range of steep high mountains extending eastwards to a snow saddle, which connects it with an isolated peak in the shape of a pyramid. This saddle, which appeared to be at the same height with ourselves, is impassable, owing to a cascade of seracs about 900 feet high, capping a perpendicular wall which extends to the bottom of the valley. To the south-east we saw a large group of mountains. Between these and the pyramid peak just mentioned flows a glacier. Until my observations have been worked out and allow me to identify the groups of mountains, I cannot positively assert that the valley we looked down into is the Kondus.

While waiting for the coolies to bring up the photo-theodolite I took my compass bearings; and it was fortunate I did so, for a few minutes later the clouds had blotted out the horizon, making further observations impossible.

We pitched out tents on the col itself, at an altitude (recorded by altimeter) of about 20,000 feet. During the rest of the afternoon we were only able to get occasional glimpses of our surroundings; and later a snowstorm broke, which lasted the whole night. Although we three Europeans were in good physical condition, the coolies were obviously very depressed and worn out; so that I did not think it advisable to remain longer at this height, and decided to return down to the valley. The descent was complicated by a dense fog. We reached the camp at the foot of the pass in the early afternoon. The skis came in very useful next day, when we covered in three hours a distance which had taken us two days' march to cover on the way up. On our way back to Urdokas we made occasional halts to complete the survey of the Baltoro.

Here I should like to make a short parenthesis to suggest that the col which we reached at the head of the Baltoro should hereafter bear the name of Conway's Saddle, as in the whole field of his pioneer exploration work there is as yet no record of his name. If European names are allowed to survive, I hope that the Royal Geographical Society and the Survey of India will consider this suggestion.

Our work on the Baltoro was finished, and it was time to prepare for the return. It took us ten days to strike camp, and by the end of July the expedition was on its way back.

During a lengthy stop in Askole for some scientific observations and to rearrange the loads and organize the transport, Ponti and Desio made a further exploration of the Trango and Punmah valleys.

Desio was anxious to reconnoitre from the south the easy saddle at the top of the Sarpo Laggo, which he had reached with Balestreri on their way back from the Shaksgam. He had then the impression that it led on the Baltoro side into the Dunge glacier. He therefore proceeded with Ponti to ascend the Dunge; but they found that the valley ended in a *cul de sac* a few miles above its mouth. They then turned lower down to the Trango glacier, another tributary which reaches the Baltoro from the north. They found a fairly wide valley, enclosed by steep walls crowned by lofty rock pinnacles. The glacier is covered with moraine material. The long valley ends in a vast upper glacial cirque, on the east of which they recognized at once the ice slope which rises with an easy gradient and few crevasses to the Sarpo Laggo saddle. Having thus connected with the former survey, they joined the expedition at Paiju, at the foot of the Baltoro.

They then turned their attention to the Punmah valley. This valley had been partly explored in 1856 by Adolph Schlagintweit; in 1861 by Col. Godwin-Austen; and in 1887 by Sir Francis Younghusband, all bound for the so-called New Muztagh pass, at the head of the Chiring glacier, an eastern tributary of the Punmah, which, after the old Muztagh had become impracticable, had been used for a time by the natives to cross into Turkistan. Only Godwin-Austen nearly reached the pass.

From a camp at the confluence of the Chiring with the Punmah, Desio and Ponti in two days reached the upper basin of the Chiring at an altitude of 18,000

feet, in view of a pass which they had already observed from the Sarpo Laggo. This col, probably to be identified with the New Muztagh, can be easily reached and crossed with skis. Having returned to the foot of the Chiring, they proceeded up the Punmah towards its large north-western tributary, Nobundi Sobundi. The upper Punmah is flat, bare of moraine and perfectly easy. Here and there they observed feathers and bones of birds, including the carcase of a large vulture, the victims of cold, starvation, and snowstorms. The Nobundi Sobundi was ascended to the upper end, where an ice wall about 60 feet high leads to a small saddle marked by a rock pinnacle shaped like a blade. They stood upon this saddle (17,000 feet) on August 14 and saw that it led south into the next large tributary of the Punmah, the Choktoi glacier. Desio also climbed another saddle at the head of the glacier, 18,300 feet high, which leads into the upper basin of the Biafo glacier. They then crossed the col first explored into the Choktoi glacier, following which they returned on the Punmah and so back to Askole. They had completed a topographical and geological survey of the Punmah.

The return journey of the expedition was uneventful, except for some difficulty in crossing the Indus, still swollen by the flood which had happened a few days before, due to the bursting of the Shyok dam. We crossed the Deosai plateau and arrived at Srinagar in the first week of September.

Having thus outlined a sketch of the expedition, I shall briefly summarize the results achieved in the various fields of research, although definite conclusions will only be possible when the elaboration and careful study of the data and material collected can be completed.

In the field of exploration the excursions made by Professor Desio and by myself have covered the whole extent of the Baltoro glacier and of both its northern and southern upper branches.

Col. Balestreri and Professor Desio have surveyed the Sarpo Laggo glacier and the saddle which connects it with the Baltoro basin, ascertaining its easy accessibility from both sides. The Shaksgam valley has been explored from the Sarpo Laggo junction up to the Kyagar glacier. The portion of the valley lying between the foot of the Urdok and that of the Kyagar had never before been traversed.

Professor Desio with Ponti explored the Dunge and the Trango glaciers, northern tributaries of the Baltoro, and proved the existence of a comparatively easy saddle between the Trango and the Sarpo Laggo. The Trango glacier is much longer than it had been formerly believed. They also explored the Punmah glacier and its tributaries, ascertaining the accessibility of the New Muztagh pass and its topographical position. They also found a saddle at the head of the Nobundi Sobundi, one of the largest tributaries of the Punmah, which gives access to the upper basin of the Biafo.

Turning to physical geography, Professor Desio will be able to describe the characteristics of several large glaciers, including those that flow on the northern slopes of this portion of the Karakoram into the Shaksgam valley. He has also made interesting observations on the configuration of the mountains in connection with their geological structure and the disintegrating action of the atmosphere.

With the help of my fellow-members of the expedition I completed a survey of the Baltoro basin with the Wild photo-theodolite. The position of our station in Urdokas base was accurately fixed by astronomical observations and by wireless time signals, and connected with the summit of K_2, which is included in the triangulation of the Survey of India. Gravity pendulums were swung at this station, and also in Askole. We were prevented from repeating them in Shigar owing to the bad weather.

Complete series of magnetic determinations were made along the whole way. Some of these magnetic stations were in localities where magnetic data had already been collected by the De Filippi expedition of 1913–14; and the comparison of results will lead to conclusions about the secular variation.

Professor di Caporiacco has made extensive zoological and botanical collections: 20,000 of the fauna, and over 2000 of the flora. The detailed classification will tell how many different species were found, and their distribution. Many specimens of water containing plankton and benthos, animal and vegetable, were also collected.

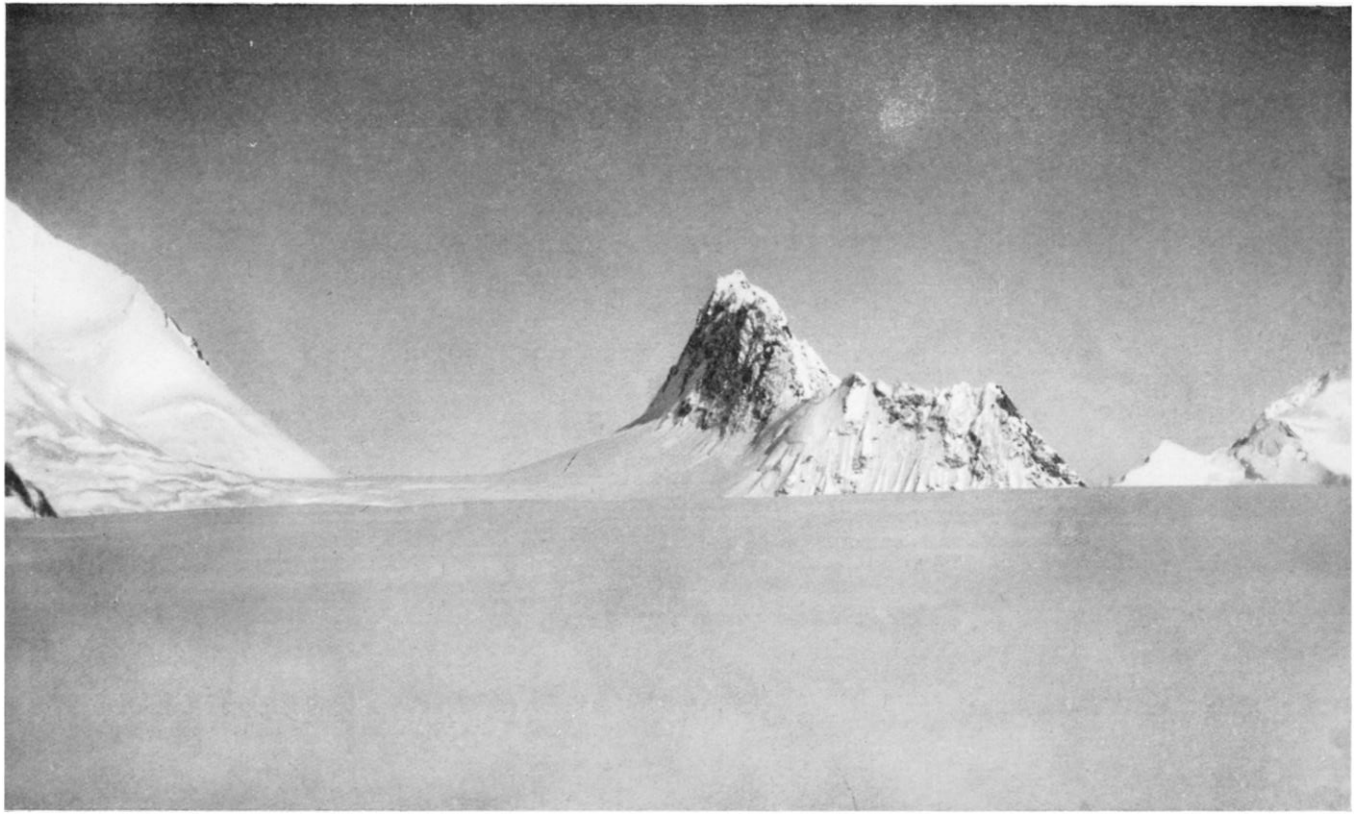
For the first time a systematic geological survey of the district explored was made by Professor Desio. Up to now the geology could only be incompletely surmised, from small collections of stones and rocks brought back by Sir Martin Conway and the Duke of the Abruzzi's expedition. Of great interest is the discovery of fossils in the basin of the Baltoro and of the Punmah, and especially at the foot of the Gasherbrums. Though slightly deformed by orogenic movements, these fossils will enable us to fix the age of the limestone enclosed in the crystalline series of the Karakoram. The Shaksgam valley also yielded a large number of fossils. It is superfluous to point out that in this district, mainly consisting of rocks of marine origin, we had as yet no geological information.

Finally, Dr. Allegri collected a series of anthropological measurements and photographs, which are a further contribution to the anthropological observations of Dr. Ujfalvy, and especially to those of Professor Dainelli.

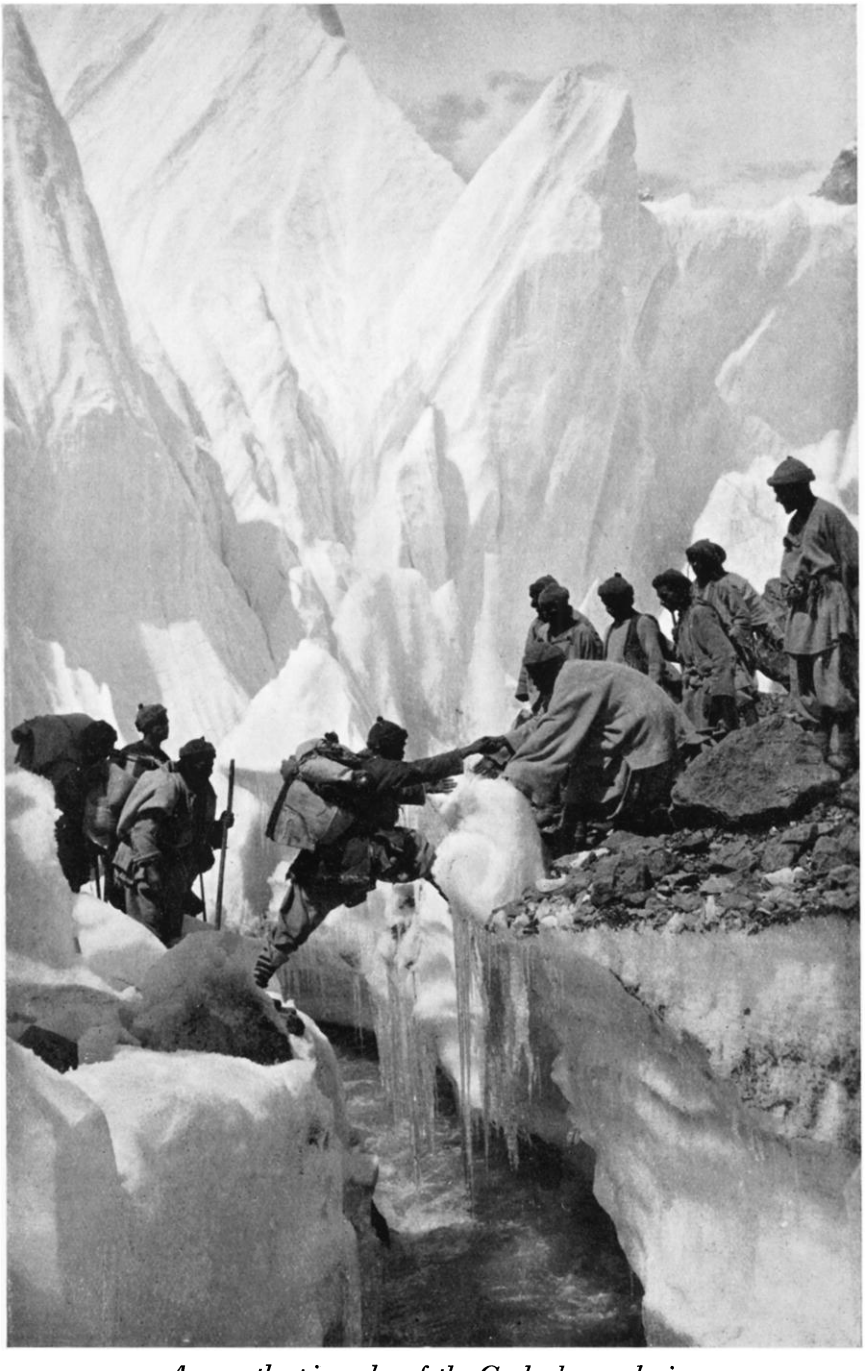
DISCUSSION

Before the paper the PRESIDENT (Colonel Sir CHARLES CLOSE) said: His Royal Highness the Duke of Spoleto has most kindly consented to give us an account of the results of the Italian Expedition to the Karakoram. The expedition took place last year, and His Royal Highness was the leader. I need not remind you that that enormous mountain mass to the north of the Western Himalaya, roughly 100 miles from Srinagar at its nearest point, has been the subject of exploration by most distinguished travellers, amongst whom one may mention Godwin-Austen, Sir Francis Younghusband, Sir Martin Conway, the Workmans, H.R.H. the Duke of the Abruzzi, uncle of our lecturer to-night; Dr. Longstaff, Dr. Filippo De Filippi, General Bruce, Major Mason, Mr. and Mrs. Visser, and Captain Morris. Now amongst those expeditions no work of a more valuable character has been done than that by the Italian Expeditions, and the Duke of Spoleto is carrying on the excellent tradition which was set by H.R.H. the Duke of the Abruzzi and Dr. De Filippi. To-night His Royal Highness will tell us what has been the result of the latest expedition, by the leadership of which he has enrolled himself in the goodly company of Italian explorers in the Karakoram.

Looking up the Baltoro glacier: Conway's saddle hidden by mountains on right



Looking east from Conway's saddle



Among the pinnacles of the Gasherbrum glacier

The pyramid and saddle of Biacheratu, Nobundi Sobundi valley

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H.R.H. the Duke of Spoleto read a telegram of greetings sent by General Vacchelli in the name of the Royal Italian Geographical Society, and then the paper printed above, and a discussion followed.

Sir FRANCIS YOUNGHUSBAND: First of all, I should like to congratulate His Royal Highness on the great skill with which he led the expedition. The Italian expeditions to the Himalaya have gained a reputation for perfect organization. I was very much struck when I was in Kashmir with the organizing ability of His Royal Highness' uncle, the Duke of the Abruzzi. And the Italian expeditions are not only well organized and well planned, but they have also the supremely valuable characteristic of being able to make use of the people of the country, the Baltis, the people of the highest valleys. Their ability to use these people enabled them to get into those very remote parts which, without their assistance, would have been inaccessible.

Personally, I did not think it would be possible to take such a large party into that very remote region of the Shaksgam valley. I have visited that region twice, and on each occasion was the only European. I was of opinion that probably His Royal Highness was making a mistake in taking a large party into that rugged region you have seen on the screen. But he has been able to overcome the difficulties. He has got his geologists, surveyors, and others there, and has brought back a thorough scientific record of the country. To me the most valuable is the collection of photographs. The region which the expedition explored is one of the most remarkable in the whole world. Probably no part of the Himalaya is more rugged than that around K_2, especially on the northern side in the Shaksgam. It is no good bringing back to a London audience a map alone, valuable as that is; we want to know something of what the country is like, and the photographs we have seen give a certain idea of it. They are about the best that have been taken, but I think even those who took them will admit that, after all, they only give perhaps a slight idea of the magnificence of the region.

You can well believe the interest with which I sat here this evening and watched the photographs and heard the description of the country, having visited it so many years ago; and I should like to say a word with regard to the Muztagh Pass, which I crossed in the year 1887, and of which you saw a most beautiful photograph this evening. As I looked at that I felt quite certain that it has altered very considerably in the last forty years. The great mass of ice has advanced. It had evidently come down a good deal farther when I was there in 1887 than when my man Wali had crossed it twenty-five years before. Now it has come down farther still. In my day, at any rate, we thought the glacier was impassable, and so we crossed the pass where His Royal Highness indicated, down the rugged part which was ascended by the German climber, Ferber, about fifteen years after me. Now the ice-fall seems to be more or less accessible. It did not look very nice going. But anyhow the Italians were able to get up it and over the Muztagh Pass and down the Sarpo Laggo glacier into the Shaksgam valley. Before reaching the valley they passed the Suget Jangal, which apparently is much as in my time, a resort of wild asses and hares, and there the expedition found the remains, probably, of my camp.

I have been talking with Professor Desio, and I am sorry to say his party missed a most beautiful view of K_2 up the valley near Suget Jangal. Professor Desio explained that, unfortunately, the day they were near Suget Jangal it was cloudy. I remember perfectly well as I came round the corner and the view of K_2 burst on my sight I was almost overwhelmed; it was so stupendous. On the other hand, I unfortunately crossed the ridge between the Sarpo Laggo and the Shaksgam valley after dark, and so was unaware that from it it is possible to get that magnificent view of K_2 which has been shown to-night.

Then in the Shaksgam valley is the Durbin Jangal, which I so named because I lost a pair of field glasses there. Apparently the Italian Expedition neither found my field glasses nor the Jangal. All seems to have been swept away. I am sorry, because I took great care to fix its latitude and longitude.

Then they came to that tremendous glacier coming down from the Gasherbrum right up against a cliff on the other side. I was fortunately at that spot later in the season, when there was not so much water, so I was able to go between the glacier and the mountain side. Not only that, but I took ponies along there and up the Urdok glacier almost to the foot of the pass at the head, which I think is called the Indira pass.

As to the Baltoro glacier and the southern side, a very important point which has been cleared up by the Italian Expedition is that the northern side of the Karakoram Himalaya can be reached not only by the Muztagh Pass but probably, as His Royal Highness has pointed out, by other passes—by the Nobundi Sobundi pass, and by the other pass or saddle which they explored from the southern side. What that means is that it is possible to get from the Indian side into the Shaksgam valley on the north comparatively easily. And that having been done by the Italian Expedition I hope use will be made of the information they have obtained, because the region on the far side of the Karakoram is, as you have seen from the photographs, one of the most splendid regions in the whole world. If we could only get a photographer up there by himself—it need not be a great expedition or numerous; it might be just one or two men with some good porters, who can get over one of those passes and down the Shaksgam valley. I should like to see them ascending the spurs on the Aghil range opposite K_2 and looking about from there for the best view-points from which to photograph K_2, Gasherbrum, and all those magnificent peaks, including those first noticed by Sir Martin Conway from the southern side. They would do something not only for geographers but also for every mountain lover. I wish, in conclusion, to congratulate you, Sir, on the magnificent photographs you have shown and on the lecture you have given us.

Professor DESIO: I thank the President for the kind invitation to speak, but it is not easy for me to summarize in a few words the geographical and geological results of the expedition. The regions explored south of the watershed of the Karakoram are mostly constituted of crystalline and generally metamorphic rocks, and on these the most extensive outcroppings are the gneisses and the granites, but the country is crossed by a belt of limestone and shales, more or less metamorphic, in which I was able to discover fossil remains of the Carboniferous age. On the northern side of the Karakoram there are rocks of marine origin, but in the Shaksgam valley the sedimentary rocks also outcrop with normal facies generally of calcareous material. In this area the fossil remains are very numerous and well preserved, and belong to the Permo-Carboniferous age.

Enclosed in this crystalline series was limestone, but the tectonic structure was very faulted. I was able to recognize two anticlinal zones. I also observed evidence of the old extensions of the glaciers during the Ice Age in the Baltoro and Shaksgam valleys. Lastly, I collected data on the recent limits of the fronts of all the existing glaciers.

Sir GEOFFREY CORBETT (Himalayan Club): I first came into contact with the Italian Expedition about two years ago, when His Royal Highness the Duke of Spoleto, with characteristic modesty, arrived almost unannounced at Bombay. Some few of us at Simla were at that time occupied in trying to found the Himalayan Club, and one of its founders was Lord Irwin, the present Viceroy, who at once asked the Duke to come to Simla and talk things over with us. Major

Kenneth Mason, to whom His Royal Highness has so kindly referred, was at Calcutta at the time, and we got him up to Simla, ready to meet the Duke and Commander Cugia; and Major Mason spent the best part of one day telling them what he knew about the Shaksgam. I remember he came to me at the end of the day and said, "You know it is all very well to fetch me from Calcutta; but the Duke knows it all already." That, I think, is a characteristic of Italian expeditions to which Sir Francis Younghusband has referred: the very careful preparation which leads to ultimate success. Mason told me that His Royal Highness had thoroughly mastered the previous history of the Shaksgam valley and the Karakoram, and was familiar with the names of places, so that it did not take long to pass on any further information.

Well, I think we had no doubt in Simla that the Italian expedition would not climb K_2, but otherwise would be the great success it has been. Our reasons for expecting that the expedition would be successful were twofold. I was in Ladakh not long after the Duke of the Abruzzi and Dr. De Filippi were there, and travelling through the country I was greatly impressed with the memory they had left behind amongst the natives. If you want to travel in the Himalaya, it is no use trying to drive your men: you only drive them away. I think the whole idea of Italian expeditions is that they do carry their men with them. You never hear of any grievances afterwards. And also the arrangements are very complete. I can say that from personal experience. I was going to the Nubra valley with a very light load, and when I arrived at Leh I heard that it was a wonderful place where there were hares, and more vegetation than usual in that part of the Himalaya. I wondered what on earth I was to do for red-currant jelly, and mentioned my difficulty to the Moravian Mission at Leh. They said they had half a dozen tins which the Duke of the Abruzzi had left behind, and that made a great deal of difference to my comfort.

The second reason why we felt the expedition was bound to be successful was the Duke of Spoleto's own personality. The thing that impressed us most was his modesty and his sense of proportion and of humour, which we have seen to-night. I think we all felt that if we were going on a big expedition to the Himalaya, he was the kind of man we would like to follow. Although he seems to be of a very quiet disposition, we felt that if he were up against it he would be not unworthy of that motto which is derived from a poet of his own country, and which has a great history behind it in India: *Mens aequa in arduis.*

It has been a matter of great delight to me, by the kindness of the Council, to have been present this evening to hear the very brief outline that the Duke has given of his expedition. I tried to suggest to him this evening that he should give us something more for the *Himalayan Journal*, but he said we should have to wait for his book, which we would then be able to review. Listening to what he said, there is one thing I should like to call attention to, and that is that we have heard very little of the hardships of travel in the Himalaya. I have no doubt that the expedition went through a great deal more than His Royal Highness gives it credit for, but at the same time I think he has reminded us that exploration in the Himalaya can be a very pleasant thing and can be enjoyed enormously. The hardships are not insuperable, provided one does not try to do too much, though I am not suggesting that the Duke did that! It is good country to travel in and quite a good country to climb in, so long as you do not try to go too high. There are hundreds of fine peaks in the Himalaya that will give all the climbing one could wish for without getting up to the height at which mountain sickness and atmospheric troubles become insufferable to the ordinary person.

There is one other point that struck me very much in what His Royal Highness said, and that is the use the expedition made of skis. In India a year or two ago we

started a Ski Club which is now a very active organization, and which goes up every winter to Gulmarg, where there are winter sports. Although I admit that just sliding down a snow slope does not appeal to me very much, I always have felt that the encouragement of skiing in the Himalaya is going to be of enormous value to Himalayan exploration, because it will enable one to get on the ground quickly and early when there is still heavy snow, as we saw in the picture of the Zoji La, which a month later is merely an ordinary mule track. I hope those going to the Himalaya to explore will bear that in mind and not despise ski-running as an aid to travel in these regions. I appreciate what His Royal Highness has said, and I regard his paper as a first instalment of a very fine book which is coming out later, and of which I hope the Himalayan Club will receive a presentation copy.

General BRUCE: I am very glad indeed to have the opportunity of following Sir Geoffrey Corbett. I was with the Calcutta Club when attempts were being made to form the Himalayan Club, and I believe that Club is now prospering to a degree we should not, two or three years ago, have thought possible, having amalgamated with the Calcutta Club. We are particularly delighted about that, because we hope to back up from the Himalayan Club all further movements for exploration of the Himalaya.

There are one or two points with which I am particularly impressed, and the first is the immense success which all the great Italian expeditions have had with their native help. I know a good deal about this because I have handled Baltis since 1892. The Balti is not a warrior ; he is quite a timid little man. With good leading it is possible to do anything with him, but he is not a thruster. He is a great carrier of loads, and if you back him up you can get any amount of work out of him. I know of an expedition which got to Askole and the whole village took to the hillside; no porters were available. This was due to fright from previous treatment. I always feel tremendous admiration for those who go out and get real value from the native help they get. Think of the Vissers; but they were dealing with people who are infinitely finer, far stronger, and more intelligent than the Baltis, and yet think what the Italian expedition have done with their, so to speak, inferior help. You can take it from me that if we had had Baltis on Everest we should have done very little indeed. Yet the Italian expeditions have carried out some of the very finest mountain exploration that has ever been done, by intelligently and sympathetically handling that rather low type, people of low mentality; and they have got them to work cheerfully for them. That is a very great thing. I hope His Royal Highness will allow me to congratulate him on that.

There is one thing in the lecture that I missed. From the Crystal Peak on which, with Sir Martin Conway, I made one of the most delightful climbs I have ever made, we got a view of the Muztagh Tower, in my opinion, the most magnificent mountain that I have ever seen, next to Makalu. His Royal Highness did not show that. It is really a wonderful view.

Something else that was not stressed at all was the very hard work entailed in going up a place such as the Baltoro; even to go from Askole to the Baltoro is rough climbing and rough work. You have to cross a shaky bridge over the Punmah stream. The valley is shockingly hot; a miniature Sahara—no trees, no grass, and the sun pouring down on your back. Then you come to the foot of the glacier. Any one who has seen the Aletsch or the Gorner glacier knows what the end is like, but you cannot compare it to the end of the Baltoro, which is, roughly, $2\frac{1}{2}$ miles across, with a stream coming out nearly as wide as the Zermatt River when it joins the Rhone at Visp. Then you get on to the top, but it is not level; wave upon wave covered with moraine, all loose; up and down you go, slipping the whole time, and you have to do that for three and a half days before you are out of it. Nobody is ever required to do this in the Alps, or thinks of it. Such

work was never mentioned by His Royal Highness, and it really is most tiring going.

In one point that country differs from the other end of the Himalaya to its advantage, namely, the lack of wind. When we were up there we only once got into a really terrible wind, and that was on our way down at the beginning of September, when we were camped on the slopes of Masherbrum; but it was nothing to what is experienced at the other end of the Himalaya. At the same time, you have there far more danger from avalanches, far more danger from great cold, especially if you are there early. We were rather late, and right to the foot of K_2 we could never have used skis. It was absolutely dry when we made our attempt, all the way up to the Golden Throne which is itself the left great boundary on the right of which is the Kondus Saddle aud the Chogolisa Saddle; all the way up were open crevasses and no chance of using skis. They would have been absolutely and entirely out of the question. Nevertheless, if the whole of our route had been covered with snow it would have been very much easier to cross and an advantage to use skis.

Dr. T. G. LONGSTAFF: The account which we have had the great pleasure of listening to to-night finally clears up the fascinating problem set us by Sir Francis Younghusband more than forty years ago. Only twenty years ago one could still write in the *Geographical Journal* that there was no other region of the Himalaya of which we knew less: for the 100 miles between the Muztagh and the Karakoram Pass we knew of no passage across the ranges. Notwithstanding the subsequent work of the Workmans, of Dr. Filippo De Filippi and Major Wood, and of Major Mason's expedition, it has been left to H.R.H. the Duke of Spoleto to complete the solution. Topographically, it is the exploration of the upper Shaksgam valley—the joining up of the farthest points reached by Younghusband and by the late Major Minchinton—that is most interesting. This was accomplished by what we may call "polar methods," or supporting parties; the sending forward of a party to dump provisions, so as to give the exploration party that necessary margin of "food-days," in order that lack of food should not force them to return with their work uncompleted, which, as a matter of fact, others had to do. The Italians have successfully achieved what their predecessors were unable to accomplish. I hope we shall learn the lesson to be derived from their thoroughly deserved success.

Then there is the exploration of both sides of the Sarpo Laggo pass. From the photographs we have seen it appears to me as if they have shown us a better route across the main chain than the difficult Muztagh Pass. They have also cleared up the topography of the head of the Punmah glacier system—a very fine piece of work. The topography of that region has puzzled geographers ever since Sir Martin Conway drew attention to it last century. Apropos of that I would plead very strongly for the acceptance of His Royal Highness' suggestion that the name "Conway Saddle" should be given to the saddle on which the Duke camped at 20,000 feet at the head of the Baltoro, which probably looks down on to the Kondus, because Conway's was the first of many "Alpinist" expeditions which went to this very difficult region of the Karakoram. Our prejudice against giving personal names to peaks in the Himalaya is, I know, very great, but the real point is that the Duke went to that point because of the real topographical importance of it, and it was the point that Conway, so to speak, laid his finger on. Though Conway did not reach it he pointed out the importance of that spot. The Duke is the first man to get there, and he suggests, very generously, that Conway's name should be attached to it. In my view the historical arguments for using Conway's name in that connection are very great, and though I know that the Royal Geographical Society and the Survey of India object to personal names, I

still hope that His Royal Highness' suggestion will meet with the support of the Society.

Further, I wish to take this opportunity of making myself still more unpopular with the orthodox. I want to press most strongly for the retention of the name "Younghusband's Saddle," which I put on my map of 1909, for the uncrossed pass at the head of the Urdok glacier. This name has priority over "Indira Col," subsequently bestowed by the Workmans. Of course I only saw it from the south. The Duke's expedition has at last proved that the position I gave for it was correct. Now that after forty years the problem set by Younghusband has been solved, let the map hold the name Younghusband's Saddle. That name is the historical key to the exploration of this region, and should be preserved.

Sir Francis Younghusband, you will remember, came from the north. He was on other business of some importance, but he diverged to come through the Aghils and look for the reputed "Saltoro" pass that led through the 100-mile uncrossed section of the Karakoram, and went up a glacier which he called the Urdok glacier. When I came to make my map, which was a sketchy one, I fortunately got the position of that saddle at the head of the Urdok glacier pretty well correct; Colonel Balestreri, Professor Desio, and Signor Ponti have proved that what the Workmans afterwards christened the "Indira Col" is "Younghusband's Saddle " of my map. The name Indira Col is derived from Sanskrit and French; nothing could be more out of place in a country where only Balti or Turki is spoken. There are no native names in this region because there never were any inhabitants. Even so old and experienced a traveller as Sir Francis Younghusband has to name a glacier after a dead bird he found upon it. I therefore invoke the law of priority of nomenclature also, for the retention of the name Younghusband's Saddle, as recorded in the Society's *Journal* twenty years ago.

It is getting late. I am not here to pay compliments; but we must all realize, and experienced travellers in this audience do realize, that the success of the Italian expedition is due to the leadership displayed. The organization and the handling of so large a party; the complete success in the accomplishment of a large and complicated programme; the reticence of the lecturer as to his own part in the expedition; his care for his coolies and the avoidance of any accidents or unnecessary hardship to them—all these evoke our admiration. I beg to congratulate your Royal Highness on an achievement which I am confident will ever remain most remarkable in the annals of Himalayan exploration.

[I would like to add the following note: When I reached the middle Siachen glacier in 1909 I saw a depression at its head which I marked on my sketch-map (*G.J.*, 35, 744) as Younghusband's Saddle, placing the Urdok glacier on the far side. I think this is confirmed by the Italian explorations from the Shaksgam side. On the Workmans' map (*G.J.*, 43, 232) they rechristened this the Indira Col, and their photograph opposite p. 128 is given as a view of the Gasherbrum glacier from the Indira Col. I think it is clear now that this photograph shows the Urdok Glacier and not the Gasherbrum glacier. They drew the Urdok glacier farther east, articulating with their Turkestan La, which I think must really articulate with the Stagar glacier of the Italian expedition. It is clear that I could not have seen their Turkestan La from my station on the middle Siachen, so there can be no confusion.

I would also take this occasion to urge that the name Saltoro Pass, bestowed by Vigne in 1835, and used on Younghusband's map, ought to be preserved for the pass since called the Bilaphond La (*vide G.J.*, 35, 622, and *G.J.*, 43, 144).—T.G.L.]

The PRESIDENT: I am sure you would wish me in the name of the Society to send a telegram to-morrow to General Vacchelli thanking him for the kind message

which His Royal Highness read to us before commencing his lecture. Secondly, I have to announce that Sir Martin Conway intended to be present but was forbidden by his doctor. Thirdly, I should like to mention that K_2, as far as we know, really is the second highest mountain in the World. Although you will see it stated, in this week's *Illustrated London News*, that Kangchenjunga is the second highest, this is probably not the case; most geographers who have studied the question would say that, although there is some uncertainty, K_2 is the second highest.

We are all very grateful to the Committee which assembled at Milan, to the Italian Royal Geographical Society, to the Milanese section of the Italian Alpine Club, and to His Royal Highness for organizing the expedition. We congratulate His Royal Highness on the thoroughly scientific organization of it. The expedition carried out not only exploration and survey but magnetic and gravity observations; it did geological work, as we know from Professor Desio's remarks; it made careful surveys; it did scientific work in zoology, botany and anthropology. Another fact on which we congratulate the expedition is the use of skis, triumphant use, one might say, in the Karakoram, probably for the first time, certainly for the first time on an extensive scale. And last, but not least, we congratulate the expedition and His Royal Highness on his use of the Wild phototheodolite, from which we expect the most happy results.

As regards the Conway Saddle, I am not, personally, a purist in these matters. I think we shall lose a certain amount of history if we do not attach to features in the Karakoram some of the names connected with the exploration of the region. It would be a good thing for those who follow us 2000 years hence to find a few English names on the maps. Supposing our Anglo-Saxon ancestors had not put a few personal Saxon names about England! We need not overdo it, but I think I can promise that the Council of the Royal Geographical Society will consider sympathetically His Royal Highness' kind suggestion.

It remains for me only to congratulate His Royal Highness on the success of the expedition and to thank him very heartily for the admirable lecture to which we have listened.

GEOLOGICAL WORK OF THE ITALIAN EXPEDITION TO THE KARAKORAM: *A paper read at the Additional Afternoon Meeting of the Society on 25 February 1930, by*

PROFESSOR ARDITO DESIO

THE geological observations that I carried out during the expedition of H.R.H. the Duke of Spoleto to the Karakoram embraced both slopes of that great chain, with special reference to the basins of Baltoro, Punmah, Sarpo Laggo, and Shaksgam.

I shall only be able here to give a summary account of the main results obtained in the field of the stratigraphical geology, tectonics, and geomorphology of the region. As the paleontological material collected has not yet been completely classified by me, and as the lithological collection is still under examination by one of my assistants, this must necessarily be considered as a preliminary report only. The data to which I will refer are really only a summary of my travelling notes.

The information we obtained beforehand about the country that we have explored was very meagre indeed concerning the southern zone (Punmah and Baltoro), and on the northern we found no information whatever. Moreover, what little was known could be traced only to laboratory observations on collections made by casual travellers, not by geologists. One such collection was brought home by Mr. Conway and studied by Bonney and Raisin ; * another was made by the Expedition of H.R.H. the Duke of Abruzzi and had been illustrated by Novarese.† Up to date no fossil was known to have been traced in Baltistan. More information was available as to the morphology of the zone, specially of the Baltoro, because all the preceding expeditions had furnished reports on this subject.

As to the cartography of the region, I had the opportunity of tracing hurried sketches of the territory along the beaten tracks on my trip across Baltistan, and more accurate maps of the basins of Baltoro and Punmah. Of course they are only as accurate as circumstances would allow in a country of inaccessible mountains and very extensive glaciers. The geological sketches were drafted partly on direct observation of the rocks, partly by the examination of morainic material, and finally by diligent inspection at a distance.

The basin of Baltoro is eroded nearly up to the Concordia amphitheatre, in a powerful series of biotitic gneiss, crossed in all directions by numerous wide dykes of granite and pegmatitic granite. All the north slope of the Masherbrum-Bride chain up to the Chogolisa saddle is composed of such rocks, with the exception of a narrow strip of foliated micaceous gneiss and shales which outcrops on the northern side of the Bride and Mitre.

The side of the Baltoro valley which is formed by the southern slope of the axial range of the Karakoram, is also formed of gneiss and granite up to the

*"Notes on Mr. W. M. Conway's collection of rock specimens from the Karakoram Himalayas." Scientific Reports in W. M. Conway, 'Climbing and Exploration in the Karakoram Himalayas.' London, 1894.

†"Appunti geologici intorno alla Spedizione di S.A.R. il Duca degli Abbruzzi nel Karakoram." In De Filippi, F., 'La Spedizione nel Karakoram.' Bologna, 1912.

Muztagh Tower, while farther east the foliated gneiss make their appearance in association with shales and crystalline limestone. The outcrop of the former rocks describes a bow with the convexity towards the south-west, and in the inner side the limestone is found, rising up to form the Crystal Group.

Towards the east the limestone spreads out and rises to form the gigantic tops of Broad and Gasherbrum. On the southern and western slopes of these mountains the shales make their appearance and they go on growing in extension northwards, in the basin of the Godwin Austen Glacier. The isolated mountain between the Savoia Glacier and the Crystal Peak is also formed of shales.

The commanding pyramid of K_2 is composed of well-stratified banks of gneiss, occasionally foliated, the same as on the southern slope between the De Filippi and Savoia glaciers. Granite dykes cross-cut the mass of gneiss. Also the snow-clad top of the colossal mountain must be of clear gneiss, a hypothesis that I found upon the appearance of the rocks (in place) and upon the nature of the detritus carried down by the glaciers. More complex is the case of the Broad. On the eastern side we find limestone (non-crystalline) which extends nearly to the top, but in the hills on the northern side the shales are also in evidence, beside gneiss, granite, amphibolic-diorite with serpentine and green rocks of the prasinitic type, which cut into the limestone masses of the Baltoro.

The most northern outcrop of limestone is that which forms the ridge between the Vittorio Sella pass and the Broad, a narrow strip of microcrystalline limestone of a white and grey colour. South of Broad the limestone series extends over the Gasherbrum group. The enormous group of mountains is almost entirely composed of grey and black limestone, occasionally assuming a schistose character and bearing fossils. Among the debris carried by the glaciers which descend from the southern side, I observed and collected a certain number of fossils, especially lamellibrancs, gasteropods, and corals intensely laminated, in association with foraminifera (*Neoschwagerina*) of the Permo-Carboniferous age.

We have still to make reference to the Golden Throne region, between the ice-stream flowing down from the Chogolisa Saddle and the branch that leads to Conway's "Probable Saddle." In this zone, amid the vast snow cover, outcrop polichromous limestones, yellow, green, and red sand and calcareous schists, brecciated red, white, and grey limestones. Occasionally these rocks present a sub-crystalline facies. According to observations at a certain distance from Conway's "Probable Saddle," the limestone masses extend eastwards, on the other side of the Baltoro watershed.

The Punmah basin, which lies more towards the east, is mostly cut out in gneisses and granites: such rocks form all the eastern watershed to the head of the Drenmang, the chain that divides the branch of the Dumulter from that of Choktoi, and the other chain that separates the latter from the Nobundi Sobundi. The prominent peaks of the Skamri range, which rise at the head of the principal valley and belong to the ridge of the Karakoram watershed, are on the other hand composed of a powerful sequence of white and grey crystalline limestones, with an inter-bedding of shale belts towards the south. This outcrop occupies all the right side of Dremang valley and the left side of the

Nobundi Sobundi valley, but disappears within a few miles of the mouth of the valley. On the hillside the limestone curves towards the north and passes to the other slope of the range. Particular interest is attached to the discovery of *Fenestellae* in the black shales of high Punmah, which I venture to attribute to the Carboniferous formation, also owing to their perfect resemblance to the *Fenestellae* shales of Kashmir.

Let us now pass to the northern slope of the Karakoram. The high valley of Sarpo Laggo is mostly composed of gneisses and granites quite similar to the types already mentioned. In association with them we find shales which reach their greatest development towards the lower and middle section of the glacier. In the former section gneisses and granites alternate with green schists, similar to the Shigar shales, and all the features recall those of the region between Baltoro and Biaho. Towards the end of the Sarpo Laggo glacier, the limestone series is met again, composed of grey limestone, clay limestone with a bluish tinge and fossil-bearing, and red shales and polychromous conglomerates. This series corresponds to that of the Golden Throne, slightly metamorphosed.

The limestone sequence extends in the lower Sarpo Laggo valley, consisting here of grey limestone and black calcareous shales, separated from the preceding sequence by an outcrop of gneiss and granite which descends from the great valley of K_2. In the region where the valleys of Sarpo Laggo and Shaksgam come together, we find formations answering to the normal facies. They are mostly grey and black limestones, often bearing silex and more or less abundant in fossils, including corals, black, red, and violet calcareous shales, brown sandstones, and polychromous conglomerates. In other places whitish quartzites are met and greenstone dykes.

This formation, which can be followed all along the Shaksgam valley, is frequently rich in fossils. A great many collected by me allowed me to ascertain their age as Permo-Carboniferous revealed by the presence of *Fusulina*, *Polipora*, numerous *Productus*, including *Productus punctatus*, and *P. pustulosus*, *Dielasma*, *Reticularia*, including *R. lineata*. The specimens collected were quite numerous, but unfortunately one of the cases containing them went astray during our return trip across Baltistan. The greatest number of specimens were taken in the Sarpo Laggo basin, in the middle Shaksgam valley, and in the Urdok basin. Nevertheless on my return trip I was able to collect a few from this region, which were packed in another case which reached home safely. Above this series lay a dolomitic limestone of light grey colour, in which I noticed the presence of sections of large shells which most probably, on account of their facies and of their stratigraphical position, belong to the Trias.

As to the formation of the region south of Shaksgam, I was able to collect a few data climbing up the Urdok glacier and taking in account the debris from the various glaciers. The northern slope of K_2 must be mainly composed of *augen*-gneiss and of biotitic-granite, because these rocks compose exclusively the moraine coming down from the great valley of K_2, towards the Sarpo Laggo valley. The shales and a few pebbles of red crystalline limestone which can be found in the moraine, seem to be derived from the northern divide. The northern slope of the high ridge, which extends from Windy Gap to the Indira Col, is composed mostly of limestone entirely similar to that of the Golden Throne. But along the western side of the slope the gneisses and the granites

must necessarily pass also to the northern slope, because these rocks make their appearance in the moraine of the Gasherbrum and Windy Gap glaciers.

To the east of the Indira Col the main ridge of the Karakoram is also formed of sedimentaty rocks with normal facies. Of this the moraines of the Stagar, Singye, and Kyagar glaciers bear evidence, carrying slate freely and being entirely lacking in gneiss and granites.

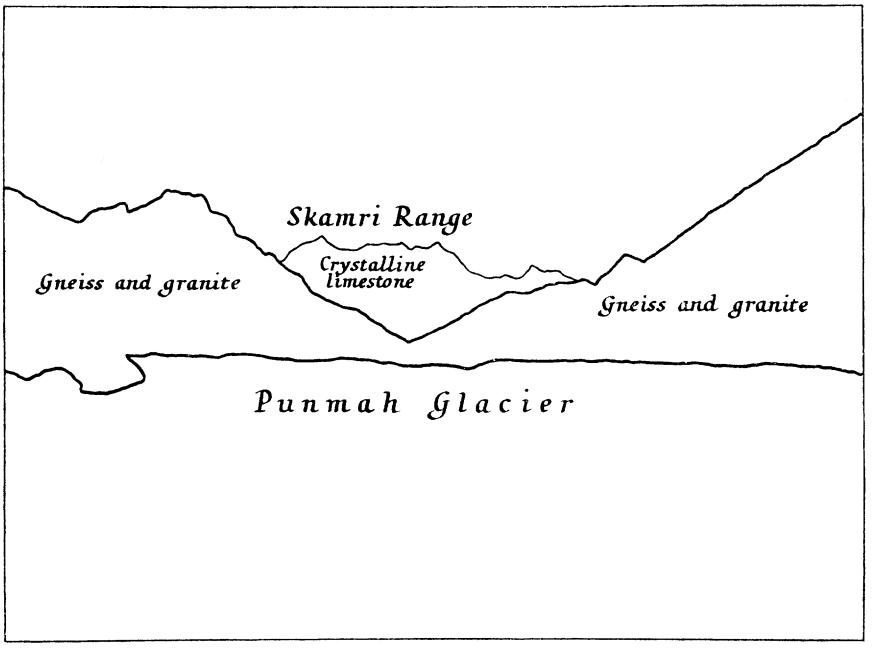
Having thus touched on the main geological regions of the explored country, it may be advisable to refer to the stratigraphical series. The basis of the series is constantly formed of light grey gneiss, nearly always biotitic, occasionally pseudoporphiric, and *augen*-shaped, crossed in all directions by granite dykes which occasionally assume imposing proportions. In the higher levels the black mica content of the gneisses increases, giving them a greater schistosity and a darker tinge. Higher up and next to these occur very thick shales, and farther on crystalline limestones interbedded with shales, amphibolic-serpentine, schists, mica-schists, and plyllites. This sequence, on the lower horizon, is crossed by granite veins. Where the action of metamorphism has been less pronounced, we found a few fossils, as for instance in the high Punmah. I see a correspondence between this series, at least in its lower level, and that of normal facies of the Shaksgam valley, of the Golden Throne, and of the Gasherbrum-Broad ridge, of Paleo-Mesozoic age.

I shall be unable to advance accurate information as to the tectonics of the region until the topographical maps are in order, because only with their assistance shall I be in a position to plot down in their place the collected data and thus recognize their relation to one another. On the other hand, a synthesis on the geology of the Karakoram Range would be for the time being somewhat premature. I will, therefore, here report only a few summary data.

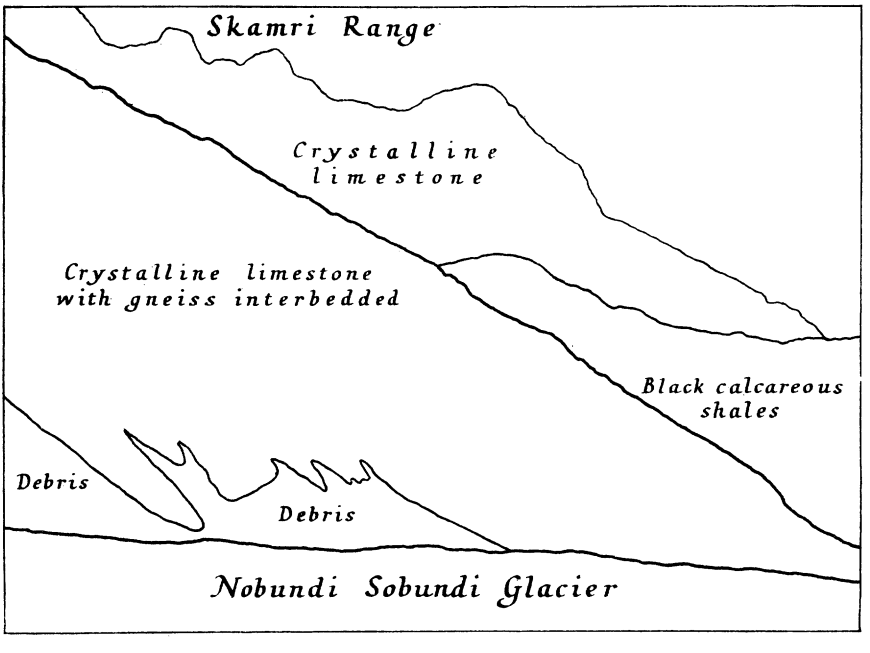
The general trend of the folds of the Karakoram in the region included between 75° 30′ and 77° 30′ E. long. is fairly uniform and directed N.W.–S.E. From the Punmah basin, where this direction prevails, the outcrops show a tendency to assume an east–west trend as they approach the high tributaries of the Baltoro glacier: here they describe a slight curve, after which towards the east they once more assume their original direction.

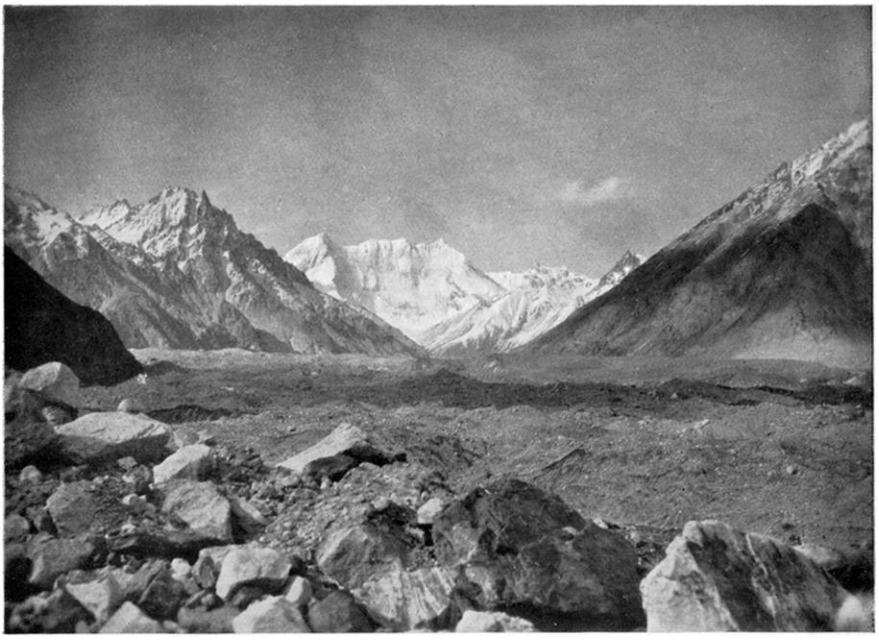
The granite-gneiss principal nucleus, which measures at the surface about 20 km., runs south-east from the watershed ridge between Nobundi Sobundi and Choktoi, with Biaho (going through the principal valley of the Baltoro) in the direction of the Masherbrum-Bride ridge, from which it extends beyond the stretch of country under consideration. The scanty information at our disposal about the south-east country (the basins of Kondus and Siachen) may allow us to think that this nucleus continues in the same direction, towards the Siachen basin and the low Nubra valley.

A secondary nucleus, which has a shorter outcrop, runs to the north-east of the former one and embraces the K_2 group, remaining nearly completely buried under the limestone cover to the west of the Godwin Austen glacier. The calcareous region of Skamri in the Punmah basin lies between these nuclei. Towards the north and south the two nuclei run in between two calcareous-schistose zones, one with normal, the other with metamorphic facies. The latter runs across our region between Askole and the Biaho valley, the former follows the middle and high valley of Shaksgam. Lack of geological records



prevents us from following these zones towards the east and west with any degree of accuracy; but, according to information gathered from the petrographical examination of the specimens collected by various expeditions which have prospected the basins of Biaho, Hispar, and the district of Hunza and



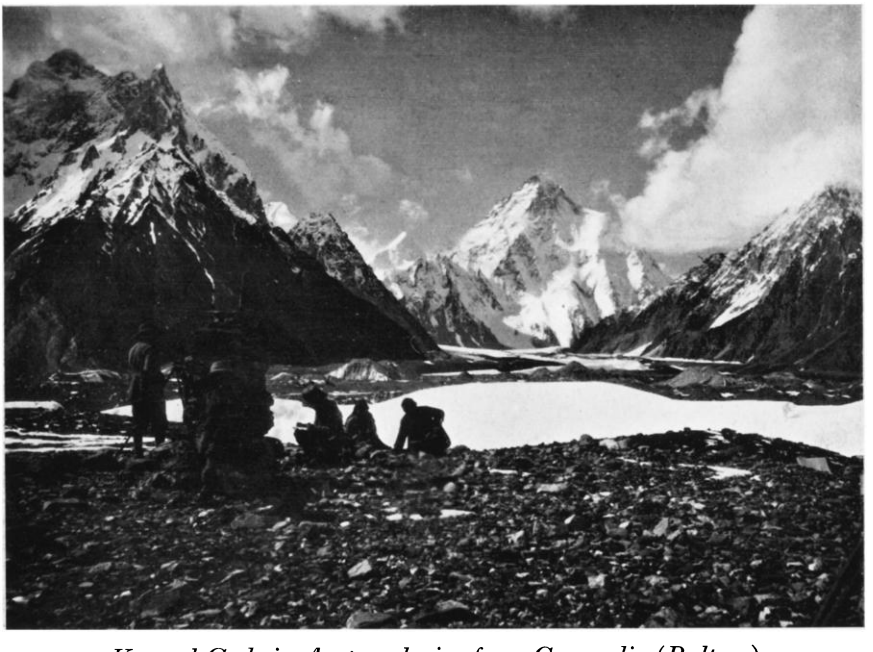


The Skamri range and Punmah glacier

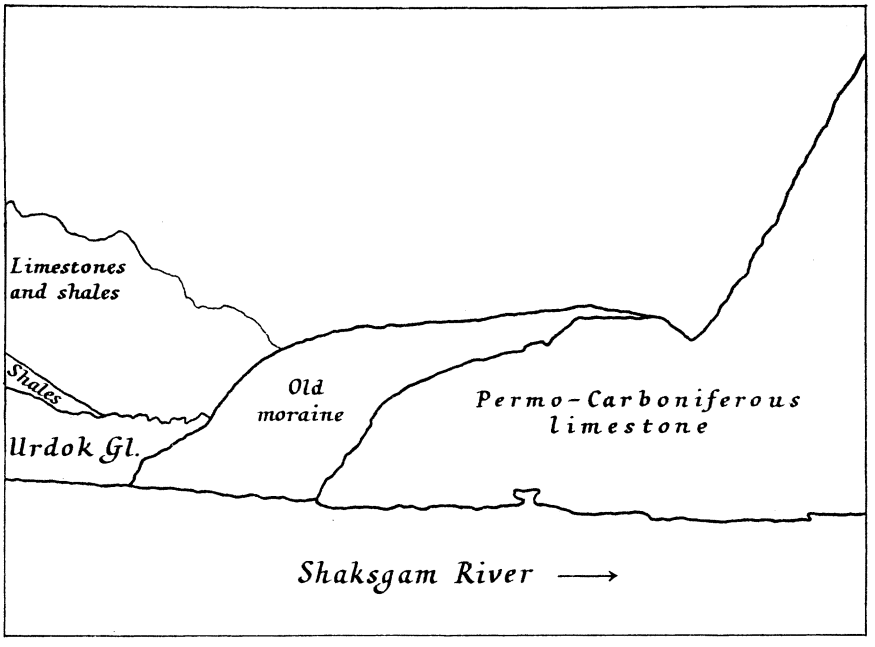
Geology indicated on opposite page

The Skamri range and Nobundi Sobundi glacier

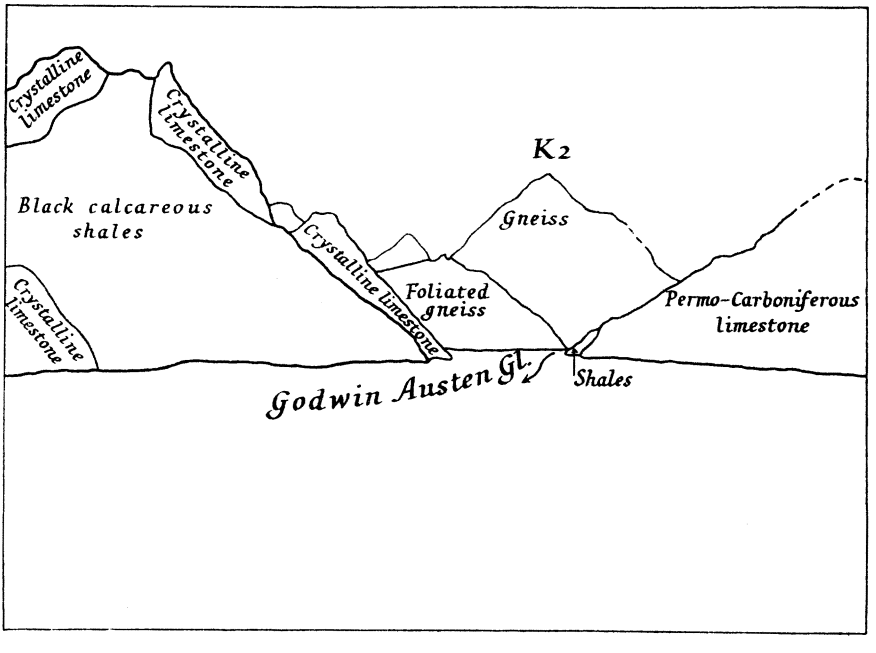
Isolated rock in front of snout of Urdok glacier, Shaksgam valley



K2 and Godwin Austen glacier from Concordia (Baltoro)



Nagar, the extension towards the north-west of the very same formation that we have studied in our region may be considered as likely. The principal granite-gneiss zone extends towards the high Biaho, the Hispar, and the Hunza; more to the north a calcareous-schist zone makes its appearance, following in a general



way the Shingshal valley and the Batura glacier. An indication of the crystalline nucleus of K_2 may be represented by the granite-dioritic outcrops of the Gujirab valley, while more to the north limestones and shales appear. Farther on again we find the granites in the high valley of Barakhum. Certain evidence of the continuity of the zones in this strike is also forthcoming from the observation of the general direction of the strata, a direction which varies from N.W.–S.E. to W.–E., and which coincides with that found by me more to the east.*

Following our zones eastward we see that the crystalline nucleus extends to the south-east in the direction of the Siachen basin. It seems that the calcareous zone of Gasherbrum, with a more schistose texture, crosses the same basin with a slight curve in the outcrop from south-east to east. I cannot advance any statement as to the continuity of the crystalline nucleus of K_2, while it appears that the paleozoic-mesozoic zone points towards the Karakoram Pass. From the old geological map of Lyddeker,† it would appear that the synclinal zone of Gasherbrum ought to join with the syncline of the Chang Chenmo valley in Ladakh, but recent observations on the east Karakoram Range do not agree with the data furnished by this map. Therefore the position to-day is that the meagre geological observations at our disposal hinder us in an accurate interpretation of the present morphology of the country.

Considering only the region that we have examined, we cannot trace a genetic connection between its tectonics and its morphology, because in connection with sinclinals we do not find depressions, nor high ground corresponding to anticlines. Let us recall as an evident proof to this effect that the groups of Broad and the Gasherbrums and the Skamri range are found in a synclinal zone.

On the other hand, it is fairly easy to recognize a remarkable coincidence between the morphology and the lithological composition of the ground. Thus we find in correspondence to soft schists the occurrence of erosion features, such as valleys, saddles, etc., while in connection with hard rocks we find high ground. I may quote as examples the Shaksgam valley just above the Aghil Dawan gulch, cut mostly in the shales interbedded between limestone; the valleys of the Urdok, Stagar, and Singye rather similar; the high Baltoro valley corresponding to a schistose belt, close in between the Gasherbrum limestones and the granite-gneiss of Bride; and the valleys of the Nobundi Sobundi and Drenmang in a similar position. Referring to the high ground, we notice that all the tops of the ridges are composed of crystalline rocks or of very compact limestones.

But numerous valleys, including some of the principal ones, do not show such a correspondence, inasmuch as some of them assume the very same direction as the folds, while other transverse valleys show a completely independent character. Among the last I note the Dumordo–Punmah valley, and part of the Sarpo Laggo valley; among the former the valley of the Baltoro, Choktoi, and Dumulter, and the Shaksgam Valley above the Sarpo Laggo junction.

In these instances the origin of the valleys appears to be quite obscure, if we

*Kuenen, Ph. H., "Petrographic description of rock from the Hunza valley in the Karakoram," *Leidsce Geologische Mededeelingen*, III, 1, 1929. Leiden.

†Lydekker, "The Geology of the Kashmir and Chamba territories and the British District of Khagan," *Mem. Geol. Survey of India*, vol. xxii. Calcutta, 1883.

wish to consider the geolithological constitution without taking into due account the initial topographical surface, on which the primitive drainage system was developed, and of which the present feature of the ground is only a consequence. At the present stage of our knowledge the reconstruction of the original surface of the country is quite out of the question. Nevertheless a rough idea of it may be obtained by supposing all the valleys to be filled up with the debris carried by the agents of erosion, and the tops of the hills that the meteorological agents have in recent times broken and sharpened, rounded. We would then obtain an undulating country with summits corresponding to the central range of the Karakoram and sloping down with a certain irregularity north and southward: a sort of undulating highland in which we would find inlaid, as in mosaic work, the upper plateau of Tibet and Kashmir, and minor tracks of uplands that can actually be found on the Aghil Range. On this imaginary surface the trend of the valleys under discussion only seems to fit indifferently. Therefore, if in a few cases it may be considered as the last remnant of the consequent drainage system, in general we miss a sure and evident connection. This suggests the conclusion that the original topographical surface of the country has not only been deeply cut by erosion, but also remarkably distorted by endogenous forces. But if it may be allowed tentatively to suggest some possible solution to the geomorphologic problem of the region, we cannot, at the present stage, proceed any further without stepping into fancy speculations.

From the far-off ages in which we suppose that the drainage system originated, many facts have evolved and new morphogenetic agents have made their appearance. The present morphology manifests a great prevalence of young forms which lead us to the conclusion that the uplift and folding of the region have not ceased. These are young forms which, though worn by the glaciers, still show a fluvial origin, at least considering the enormous depth of the present valleys, lying thousands of metres below the remnants of the oldest topographical surface of the region, which could not be accounted for only by the theory of the active erosive effect of the glaciers. Also in the Karakoram the glaciers have limited their action in correcting and adapting to their particular requirements the fundamental lines of the features that other agents before them have established.

The glaciers we see at the present time, of the Alpine type, though some of them are amongst the largest in the world, are only the remnants of more powerful ice-streams filling all the valleys of the country during the Ice Age. In the Shigar and Braldo valleys we see two evident systems of old lateral moraines; the highest runs 300–400 m. above the present bottom of the valley and continues towards the Skardu basin. Higher up the valley the moraines go gradually up and connect with the old moraines of the Baltoro basin, between Urdokas and the front of the glacier. The morainic band bordering the great ice-streams during the Pleistocene Age suggests that during the Ice Age the Punmah as well as the Biafo glacier were right-bank tributaries of the great Baltoro glacier, numerous other smaller glaciers flowing down the sides of the valley.

We observe also in the Shaksgam valley old moraines lying 300 m. above the bottom, near the junction of the Sarpo Laggo with the Shaksgam rivers.

The morainic material extends upward in the Sarpo Laggo, Gasherbrum, Urdok, Stagar, Singye, and Kyagar valleys. We can consequently conclude that during the Ice Age large glaciers flowed together in the Shaksgam valley and formed a direct ice-stream towards Yarkand.

Among other signs of the Ice Age we must not forget the *roches moutonnées* and the scratched rocks, everywhere scattered about on the slopes up to conspicuous heights. We also find remnants of more recent ice stages, such as morainic amphitheatres that side glaciers constructed mostly at the bottom of the main valleys, as, for instance, near the Shimtsa Jangal in the Dumordo valley, not far from the front of the Punmah glacier.

All these facts concern rather old movements of the fronts of the glaciers, but we also have proofs of quite recent movements, small though they may be. Before the prominent side of the Baltoro front, Prof. Dainelli,* during the winter 1913, observed a huge morainic block about 80 m. from the end of the ice. In May 1929 I found the same block in contact with the ice. During the last fifteen years the front of the Baltoro glacier has advanced about 80 m., and at the present time it appears so much swollen as to suggest that it may be increasing.

Quite different are the conditions of the front of the Biafo glacier where, 80–100 m. from the ice, there are short morainic heaps. If we compare Dainelli's observations made in the winter of 1913, when the minimum of the distance between the front and the left side of the Biafo valley was about 40 m., with the conditions found by me in May 1929, when the distance was about 180 m., we may conclude that during the last fifteen years the front of the Biafo glacier has retired more than 100 m. But it seems that the retreating movement has not been continuous, because Featherstone in 1922† observed that the glacier was advancing. The information about the Punmah glacier is more meagre and uncertain. Godwin-Austen‡ in 1861 found the glacier retreating, observing that the camping-ground of Punmah was at that time buried by the ice. At the present time it is uncovered again, but the glacier end is very swollen, and other symptoms seem to indicate that the glacier is rising.

I have scanty information about the glaciers of the north side of the Karakoram Range. The most interesting fact is that Sir Francis Younghusband,§ in the year 1889, travelled round the front of the Gasherbrum glacier along a gorge open between the ice and the cliff of the valley side, while in the June of 1929 the glacier pushed its front, bristling with ice-pinnacles, against this cliff, and the Shaksgam river was obliged to flow below the ice. But we possess no information about the movement during the last forty years of the front of the Gasherbrum glacier, now extending farther in the valley, as in 1889. We have lost, also, previous data on the glaciers crossing the Shaksgam valley higher up. The two highest, the Singye and Kyagar glaciers, push their fronts up to the cliff on the right side of the valley; whilst in front of the Urdok and the Stagar

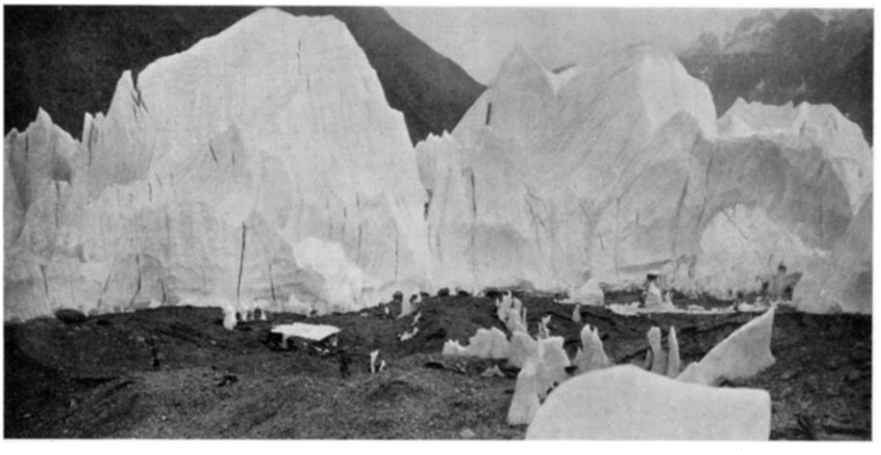
*Dainelli, G., "Le condizioni fisiche attuali," Vol. iv, Ser. ii, of 'Relazione scientifiche della Spedizione Italiana De Filippi nell' Himalàia, Caracorùm e Turchestan cinese, 1913–1914.' Bologna, 1928.

†Featherstone, B. K., "The Biafo Glacier," *Geogr. Journ.*, LXII. London, 1926.

‡Godwin-Austen, H. H., "On the glacier of the Mustagh Range," *Journ. Roy. Geogr. Soc.*, London, 1864.

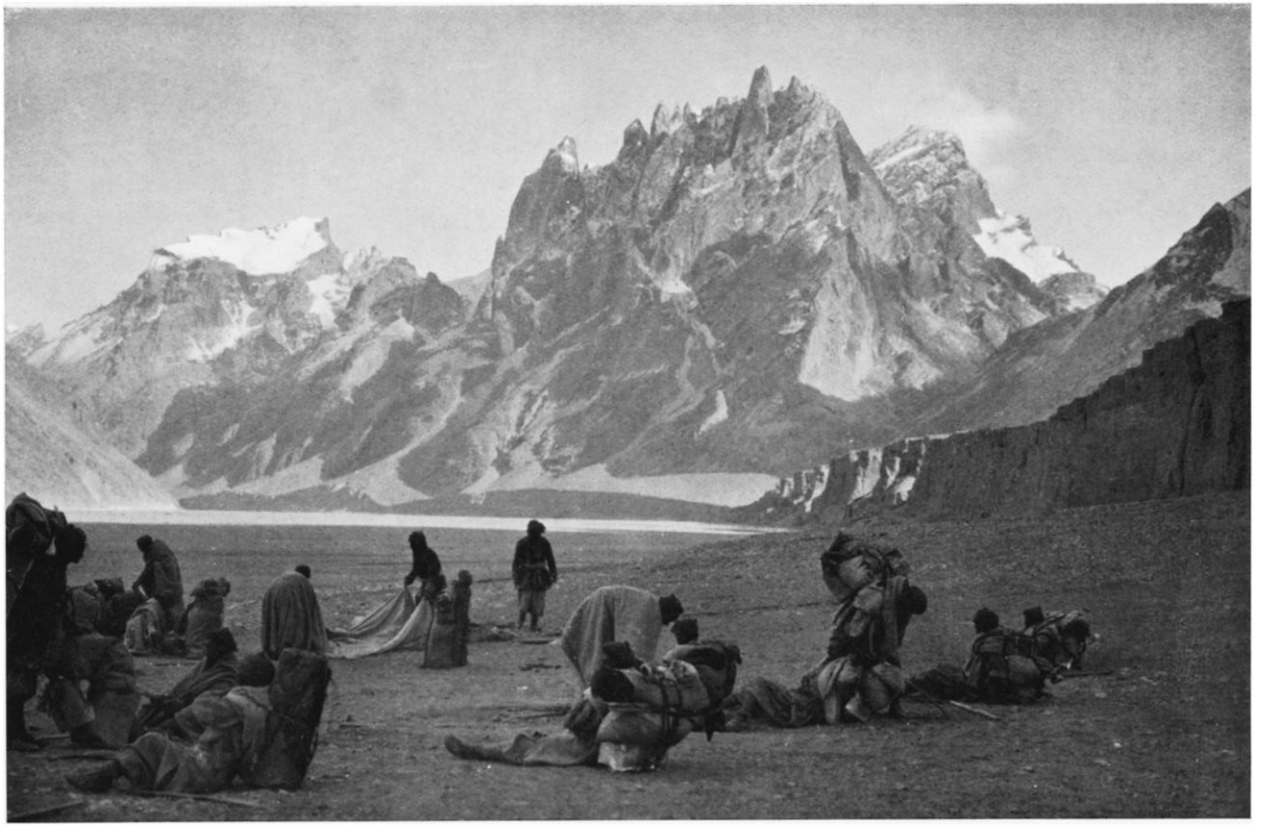
§Younghusband, F. E., 'The heart of a continent.' London, 1896.

Jangal in the Sarpo Laggo valley



Highly inclined ice strata in isolated pinnacles of the Gasherbrum glacier

The front of the Gasherbrum glacier



Dolomite peaks along the Shaksgam valley

glaciers there is a fairly broad gorge. Judging by appearances, it seems that the former are rising and the latter retreating. The conditions of the Kyagar glacier were just the same in 1929 as they were when observed in 1926.*

The last variations affecting the fronts of the Kyagar and Singye glaciers were apparently not very remarkable. The lacustrine terraces above the Kyagar testify that the damming of the Kyagar lake by the glacier may not be of recent date. We observe the same facts above the Singye glacier, where there are sand-beds and remains of terraces testifying the existence of an old lake dammed by the glacier. About the Urdok and Stagar, we observed that beyond the fronts of the glaciers isolated rocks covered by morainic gravels and moraines up to the right bank of the Shaksgam river testify that these glaciers also barred the valley. It seems, however, that at the same time two glaciers—one flowing down the Windy Gap near the Gasherbrum glacier, the other lying between the Urdok and the Stagar glaciers—heaped up two characteristic morainic amphitheatres, some 100 metres from the present front, and that other front moraines observed by me not far from the end of some slope-glaciers, were accumulated at the same time.

I examined some problems connected with the morphology of the glacier surface during the expedition, and one of the most interesting is that of the origin of the ice-needles with which the surface of some glaciers, especially those in the Shaksgam Valley, are filled. If the phenomenon had already been noticed on certain glaciers of the southern portion of the chain, it was certainly not to be compared with the forest of ice-needles of the Singye and Kyagar glaciers (the ice-needles on the latter have already been described by Mason), in which the pinnacles of ice rise to 60–70 m. and almost entirely cover the main ice streams. I will not now refer to the various explanations of this strange phenomenon, but I will only touch on the results of my personal study.

In examining carefully the structure of the ice-needles it is noticed that in every case they are formed from white stratified ice, and the strata are more or less upright. Of these strata, some appear to be made of thick crystalline ice, and others of ice less thick and granular. I think that the development of the ice-needles might be attributed to the minor fusibility of the thicker strata and the intense rays of the sun. It is unnecessary for me to enlarge too fully upon the reasons (considering always composed glaciers) for the strata being upright below a certain height. But if this fact will help to explain the longitudinal decomposition of the glacier surface, some explanation is needed on the transverse decomposition, which is also due to the same causes. It is noticed that in the terminal part of the glacier the strata form a table-spoon curve, or rather that the tops of the ice-strata rise up towards the sky in all directions and therefore transversally also to the glacier. Where the fronts of the glaciers encounter an obstacle this vertical tilting of the strata is stronger, and so we should find a greater development of needles. In fact, in the Kyagar and Singye glaciers, and on a minor scale in the Gasherbrum glacier, whose fronts abut on a rocky wall, the phenomenon of the needles is much more developed than elsewhere.

At the same time higher up, yet always in the melting zone, we find some needles, but always lower and more aligned in the longitudinal sense the nearer they are to the upper limit of the melting zone.

*Mason, K., 'Exploration of the Shaksgam Valley and Aghil Ranges, 1926.' 1928.

EXPLORATIONS IN THE EASTERN KARAKORAM AND IN THE WESTERN KUNLUN: *A paper read at the Evening Meeting of the Society on 24 March 1930, by*

DR. EMIL TRINKLER

DURING the expedition I undertook in 1927–28 I twice crossed the high mountain ranges and plateaux separating the Upper Indus Valley of Ladakh from the Tarim Basin of Chinese Turkistan or Sinkiang. As my caravan traversed these regions on two different lines we had the chance of studying two different sections across those high mountain regions. This was very important for the geologist of my party, Dr. de Terra, who by a thorough study of the structure of the rocks and mountains got a good idea of the geological history of this part of the world. I myself made a plane-table survey covering the area from the Pangong lake across the high barren plateaux to the Upper Kara-Kash river. My main aim, however, was to obtain a good idea of what the Ice Age on those plateaux had been like.

When starting from Leh in July 1927 my plan was to go around the westernmost end of Pangong Tso to the barren plateaux of the western Tibetan borderland. These plateaux are called Lingzitang and Aksai Chin on the Indian Survey maps, but I never met any native who knew these names. After finishing our work there, I intended to start for Khotan in Chinese Turkistan by travelling through the Upper Keriya Darya district. If I speak here of the Lingzitang and Aksai Chin plateaux as belonging to Western Tibet it is only because of their geographical character, for politically these regions are in Kashmir.

As the part of Central Asia which I wanted to visit is absolutely uninhabited we had to take provisions with us for three months for ourselves, for our Indian servants, and for our coolies. So we started with a rather big caravan when leaving the last Ladakhi stone huts at Phobrang, north of the blue Pangong Tso. As I was well acquainted with the reports of explorers, and had studied all the travel reports dealing with these regions, I knew that sheep could be extremely valuable as transport animals. Captain Biddulph, who once crossed those high plateaux with only a sheep caravan, had practically no losses whatever, and it was probable that sheep could stand the hardships of such a journey at least much better than horses could do. The Tibetans also use sheep as transport animals, loading them with salt and wool. So, besides thirty-one yaks and our riding-ponies, I took seventy sheep.

I shall not say much here about the road leading from Leh to Phobrang, because it has been described fairly often before and it is well known. We crossed the Chang La, that high pass in the Ladakh range, on July 16. I was rather astonished to find, even at an altitude of 16,000–17,000 feet, carpets of beautiful flowers in the green short grass covering the valley at Zingral. This small grazing-ground is on the southern slopes of the Ladakh range, just below the Chang La. We did not meet with any snow and ice until we reached the top of the pass. The descent on the northern side was not very difficult. On July 17 we entered the small village of Tankse. Here I had the chance of studying thoroughly the big boulders lying amidst the gravel deposits of the

lower Harong valley. Several of these blocks had been studied already, in 1906 and 1911, by missionaries from Leh. Several of the inscriptions are in Tibetan, others in Soghdian characters. One of the Soghdian inscriptions

was partly read by Prof. F. W. K. Mueller of Berlin. He believes that the inscription dates from the ninth century and that it was written by Nestorian Christians. Among the other inscriptions which I discovered there was one

written in old Indian characters, *i.e.* Gupta. The text unfortunately is only a verse of a Buddhist Mahayana Sutra. My Swiss companion, Mr. Bosshard, took snapshots of all these inscriptions, and we hope that before long some of them will be read. Near Tankse also there is a small old monastery in whose gloomy rooms there are elaborate wall-paintings showing scenes I could not identify. The painting is absolutely unlike that in other monasteries of Ladakh. It is much more artistic and is somewhat like Persian miniature paintings. There are very remarkable wall-paintings, often over three hundred years old, in many monasteries in Ladakh, especially in Himis Gompa, Tikse, Pitok, and Chimre.

Two days after leaving Tankse we saw the Pangong Tso stretching before us. It is the most beautiful lake I have ever seen. Its elongated form reminds us of a Norwegian fiord, and the study of the geology and morphology of this region tells us that the origin of the Pangong valley is similar to that of the Norwegian fiords. Old beaches show that the lake formerly stood at a much higher level than to-day. At the western end of the lake the stratified clay deposits are covered by moraine material, evidently deposited on the former bottom of the lake by glaciers advancing down tributary valleys after a period of high water.

The last place where we met shepherds and villagers was at Phobrang. On August 3 we left this place with our big caravan. I think none of us anticipated that our sheep would eventually save our lives, and that only one yak would reach the distant border-post of Suget Qaraul on the Karakoram road. In order to reach the lower Chang Chenmo valley my caravan had to cross the Marsimik La, which was not so difficult as I had supposed it to be. On the banks of the Chang Chenmo there stretch the grazing-grounds of Pamzal, where we stopped for a few days to give our animals a good rest. After twice crossing the Chang Chenmo we reached the hot springs of Kiam and then entered the less-known country. Deasy and Rawling had been there, but we did not know very much about the detailed topography and morphology of this region. The colours of the landscape were beautiful. Especially remarkable were the deep red sandstone mountains, probably of Tertiary Age, the greenish crystalline schists and light red cliffs of Jurassic limestones.

On August 16 we crossed the Lanak La, my plan being to go as far as a spot called Shum on Deasy's map and to try to reach the Lingzitang by a direct route. We succeeded in going a little farther on, to a place near the Sumjiling Plain. Needless to say, all these places were uninhabited, but old fireplaces told us that now and then the Tibetan nomads or the *Changpas* visit even these distant places. The ascent to the Lingzitang could have been effected fairly easily, but the coolies preferred to take a short cut which in the end proved rather trying. The landscape in this region was really wonderful. From a high snow-covered range, whose peaks rise to 20,600 feet, there stretch broad glaciers like big white tongues into the longitudinal valley bordering the range on the west. The Tibetan type of glacier is unlike any other type of the surrounding regions. The big Karakoram glaciers in the west are bordered by extremely steep-sided mountains which are often so perpendicular that the snow cannot find any hold on the slopes. The mountains on the Tibetan Plateau, on the contrary, are rounded and denuded, and are often so buried under ice and snow that you can scarcely detect any rock in the upper part of the ranges.

Once having reached the Lingzitang plateau we had to wend our way for two days amongst red and green hills. We discovered two small lakes and camped on the shores of a large lake called Sirigh Jilganang Köl on the maps. This is a Turki name meaning "the lake of the yellow valley." Probably it was called this because the old beach-lines surrounding the lake are a yellowish colour. I have tried in vain to find any hint about this lake in travellers' books as well as in any reports, and I cannot trace where the name comes from. Probably one of the members of the Yarkand Mission or Johnson saw the lake from the distance, and when he asked one of the Turki followers about it, the man answered: "It is Sirigh Jilganang Köl," or "the lake of the yellow valley."

We stayed more than fifteen days on the shores of the lake, thoroughly examining the surroundings in every direction. Probably we should not have done so if our horses had not strayed there. Although we sent out coolies equipped with blankets and provisions to bring them in, they could not find them. One of the coolie parties even went back as far as Pamzal, but as there had already been falls of snow at the end of August the footprints of the animals were covered with snow. At this place also, unfortunately, the yaks began to die. At first we could not find out what was the matter. They were unwilling to move on at all, and stood where they were till they suddenly broke down. We dissected several of the dead bodies and found that their stomach walls were pierced by worms or leeches. But I do not believe that this alone was the cause of the collapse of our beasts of burden. I think the bad grazing-grounds also contributed to their collapse. It was absolutely impossible to cover large distances with these sick animals.

We spent two weeks on the shores of this blue lake, surveying the country around and devoting ourselves to our geological and geographical studies. Like all lakes on the Tibetan plateau, this Sirigh Jilganang Köl shows signs of shrinkage. Old beach-lines run along the shore, the lower beach consisting of clay deposits while the higher is represented by a rocky terrace. I believe that these high plateaux, which are at an altitude of about 17,000 feet, were probably covered by stagnant ice-masses and névé. We shall see later on that in the region to the west, in the Karakoram, there are big glacial trough-like valleys of really extraordinary dimensions.

The survey of the lake and its surroundings gave us quite a different idea of the shape of the lake from that shown on the map.

Our next goal was the Aksai Chin, or "White Desert of China," bordering the great valley running along the southern rim of the Kunlun Mountains. In order to reach the big salt lake, formerly visited by Sir Aurel Stein, Crosby, and Sven Hedin, I crossed the mountainous regions rising between the Aksai Chin and the Lingzitang, leaving Hedin's route of 1907 to the west and that of 1908 to the east. We could have crossed these barren mountains easily if our remaining yaks had been in good condition, but already when leaving the Sirigh Jilganang Köl several broke down and we had to shoot them. We had to bury some dispensable stuff here because the loads became too heavy for the remaining animals. The more the yaks died, the more our sheep had to carry; they really worked splendidly and they could even carry as much as 30 lbs. weight. The country we had to cross here was practically barren, so to our great disappointment we often did not find any grass or burtze-scrub for our yaks.

Great cirques in range south-east of the Shyok bend from ridge west of Phobrang

The Tibetan Plateau east of Phobrang

Rock terrace along the Chang Chenmo near Pamzal

Looking south into the Rimdi valley at its junction with the Chang Chenmo west of Pamzal

I think the main reason why sheep can stand the hardships of such a journey better than yaks is that sheep can nearly always get enough food while grazing during the march. They pick up small plants or some grass here and there, however scanty it be. But the yak generally needs a good rest for its meals, and if it really is grazing during the march, it will never get enough to be able to do without a good grazing-ground at the end of the day. So if a caravan does not meet with any good grass for two or three days the yaks are very much weakened. We could advance only slowly towards the north, often crossing mountain ranges rising up to 17,600 feet. When after a three days' march we found a fairly good camping-ground with abundant grass we stayed there for several days, hoping that with a good rest our yaks would recover.

The country we had traversed was very interesting from a geological point of view. The mountains here, consisting of Cretaceous and Tertiary rocks, were of a greenish-grey and dark red colour. I shall never forget the beautiful sunset I saw on an evening in September 1927. I had made for a white coral limestone cliff some 17,500 feet high. This rocky cliff was much farther from our camp than I had supposed it to be, and I only arrived there as the sun was setting. I then had an extremely good view across a country of marvellous grandeur and beauty in spite of the desolation around me. On the western horizon I saw in deep blue and violet tints the mighty rampart of the ice-clad giants of the Karakoram behind which the sun was setting, dyeing the skies with a deep saffron colour. Around me and below there stretched, like a rolling sea, the many-coloured mountains. Blue shadows were lying in the valleys and nullahs. As soon as the sunset was over the whole country, lying in deepest solitude and silence, was dipped in bluish tints. Then the moon rose, and its silver rays led me back to our lonely camping-ground.

Very often when I was quite alone amongst these high plateaux, surveying, sketching, or wandering about, I had the feeling of being no longer on our globe but on a far distant planet. What impressed me most on my expedition to Central Asia was the absolute silence and solitude of the uninhabited regions, be it on the westernmost Tibetan Plateau or in the great Taklamakan desert of Chinese Turkistan. We eventually got so accustomed to the deep silence that when we had to pitch our tents again near human settlements we could not sleep at first.

Several of the valleys in the mountainous region to the south of the Aksai Chin are really valley plains. I found that these big valleys run in quite a different direction from that shown on the maps. These valleys, filled with immense gravel deposits and sand, must once have contained great rivers. Valleys with a breadth of one mile and more contain only a tiny rivulet wending its way between the gravel and clay deposits. Valleys containing no water at all are also often found. Sometimes the country looks absolutely dried up. The valleys and the broad river-beds are entirely dry, the lakes are shrinking and their water has a bitter salty taste. The desiccation which set in after the Glacial Period has made the country what it now is.

The beautiful salt lake on the Aksai Chin, with its turquoise-blue colour, also everywhere shows signs of desiccation. The shore around this lake consists of salt-encrusted clay deposits, very often cracked into polygonal fields. On the

shores of the lake the ground is very muddy. Skeletons of wild donkeys and wild yaks, embedded in the mud, show that these animals did not succeed in getting out of the swampy ground. The white clay terraces bordering the lake in the south are dissected by innumerable corridor-like fissures and gullies with many tributary gullies joining them. At the end of one of these I discovered a real cemetery of antelopes and wild yaks. The whole ground was covered with the bones and horns of these animals which had been driven into this trap by wolves, who knew quite well that their prey could not escape, because the walls of the gullies were too steep to allow them to escape. Although the lake water was very bitter and salt we once saw many wild geese on its surface. On several spots just on the shore-line I discovered hundreds of small flies sitting on the moist muddy sand.

As our yaks had not recovered in spite of a long rest on the old grazing-grounds here as well as on the Aksai Chin, where we also had good grass, we now made for the Kara-Kash valley, where we soon hoped to meet Qirghiz people.

The weather in these regions was rather rough and cold. We had snowstorms in August, and the temperature during the night in September fell to 9° F. There is no question that the monsoon enters these distant regions. If we could carefully collect all data about the influence of the south-west monsoon we should be astonished to see how far the regions of Central Asia are effected by it. The same applies to the south-east monsoon blowing from the Chinese Sea into Eastern Tibet as far as longitude 90° E. But these regions of Central Asia, at least the Western Kunlun and the Westernmost Tibetan Plateau, also get rain during the winter months from depressions wandering from the west probably across Afghanistan and the Upper Oxus Valley into the heart of Asia.

Sometimes we saw beautiful cloud effects on the high plateaux. I remember one afternoon on the Aksai Chin when the rim of every small cumulus cloud was shining in beautiful rainbow colours.

On the southern shore of the Aksai Chin lake we left our big luggage behind us in a depot. Our next goal was the Khitai Dawan, whence we could reach the Upper Kara-Kash. Leaving Sir Aurel Stein's route of 1908 to the north, we crossed the brown mountains separating the Aksai Chin lake from the salt marshes in the west, which had been seen by Johnson in 1865.

Dr. de Terra's explorations in these regions prove that the big broad plain-like valley running along the main range of the Kunlun follows faults which separate geologically the old Kunlun system from the younger folded regions of the Tibetan Plateau. At several places white quartz veins crop out from the detritus of the valley bottom. Dr. de Terra could also follow this line of disjunction farther to the west. The Kunlun is one of the oldest mountain regions in Central Asia, whereas the ranges of the north-western Tibetan Plateau—on the Lingzitang and Aksai Chin—as well as the Karakoram, are as young as of Cretaceous and perhaps even Tertiary age.

The valley leading down from the Khitai Dawan shows traces of former glaciation. It is joined from the south by a broad valley plain which forms a kind of big hanging valley above the easternmost tributary valley of the Upper Kara-Kash River. In the upper part of this tributary, near Haji Langar, there are enormous moraine deposits consisting of granitic boulders. The crossing

of the Khitai Dawan (16,505 feet) was not very difficult, although a snowstorm was raging during the night before our start. Farther downstream I had the good luck to discover a small tributary valley giving access to the main Kunlun range. It would be extremely interesting to explore the upper part of this nullah, which might lead to a pass in the Kunlun range.

I also made a careful study of the Kara-Kash valley. Personally I believe that this big valley also was modelled by the action of the Ice Age glaciers, but unfortunately we have no direct means of proving this assumption. In such a dry continental region no striated boulders are preserved, and you can often only judge from the shape of the valley's trough and from the presence of old shoulders, which are frequently very faintly indicated, what was the former extension of the glaciers. Unfortunately, the lower part of the Kara-Kash river between Alinazar Qurghan and its exit from the Kunlun Mountains, for a length of some 40 miles, is absolutely unknown, and it is very likely that big terminal moraine deposits may be piled up there.

In the upper part of the Kara-Kash we saw wild yaks, big black beasts, as well as herds of antelope, but not a single wild donkey. I think that the wild donkeys only live on the high plateaux over 16,000 feet. The Qirghiz people had already left the upper grazing-grounds in the valleys. Only after crossing a side spur running down fron the Kunlun range did we meet a small Qirghiz settlement near Kengshewar. The good nomads were rather astonished when we approached their yurts. But as soon as they learned that we were peaceful travellers, the headman led us into his yurt, where he gave us milk, bread, and butter. He afterwards told us that they had been much astonished at seeing our party coming from the east, which was a no-man's land. They remembered quite well that some twenty years ago a sahib, who had had frozen feet, had come from that direction. So they had not forgotten Sir Aurel Stein's party, which passed this spot in 1908.

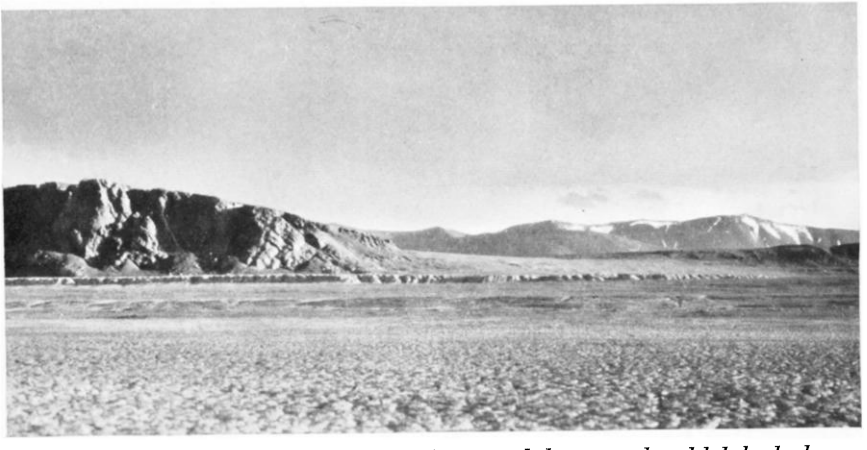
We stopped some days in the desolate, dirty, custom serail of Suget Qaraul on the Karakoram road. Here we were able to hire a camel caravan, which, led by two of our best and trustworthy Ladakhi coolies, was sent back to the Aksai Chin to fetch the luggage we had to leave behind. Needless to say, the owner of the camels had never heard the names of the Lingzitang, Aksai Chin, or Khitai Dawan. Afterwards our clever assistant caravan-bashi, Zabur Malek, who went with the camel caravan, told me that they had taken another direction after leaving the Upper Kara-Kash valley. They did not cross the Khitai Dawan as we had done, but passed round to the west and south of it. When coming down from the Khitai Dawan I had seen in the distance a blue sheet of water bordered by beach-lines. The camel caravan went along this lake, met with fresh-water springs, and reached the depot safely. So they did not have to cross the mountains lying between the Aksai Chin and the Khitai Dawan. The road they took seems to be a particularly easy one leading from the Upper Kara-Kash valley directly up on to the big plateaux. There are several smaller lakes in this part of the westernmost edge of the Aksai Chin. I think the only European who ever followed this road was Johnson, although it is often difficult to find one's way through his reports. Hayward in 1868, as well as members of the Yarkand Mission, followed the westernmost main branch of the Kara-Kash down to the junction of the eastern tributary valley.

When in October 1927 we went on from Suget Qaraul into Chinese Turkistan, we made for the Sanju pass, which, in spite of its mean height (16,500 feet), is much more difficult than any other pass we had to cross. I even think that the ill-famed Saser pass is not much more difficult. The Sanju pass has been crossed by many Europeans, and the topography of this region is now well known. Some geographical facts however might be summarized here. In the valley leading down from the pass to the foothill region of the Kunlun marks of former glacial action can be seen at several places. The big well-preserved boulder deposits which are situated in the upper part of the valley give an idea of the former extension of the glaciers. Unfortunately our ride down to Sanju Bazar was carried out in such a hurry, pressed upon us by the orderlies of the Chinese authorities, that we had not enough time to study properly the lower part of the valley. As the Sanju river had not too much water in it, we could follow the direct path leading through the big gorge which the river has cut through the mountains. In one day's march we had to cross the river more than twenty-five times. As soon as the summer floods, caused by the melting of the snows in the mountains, are coming nobody can traverse these gorges, and caravans have to cross the range by the Chuchu Dawan.

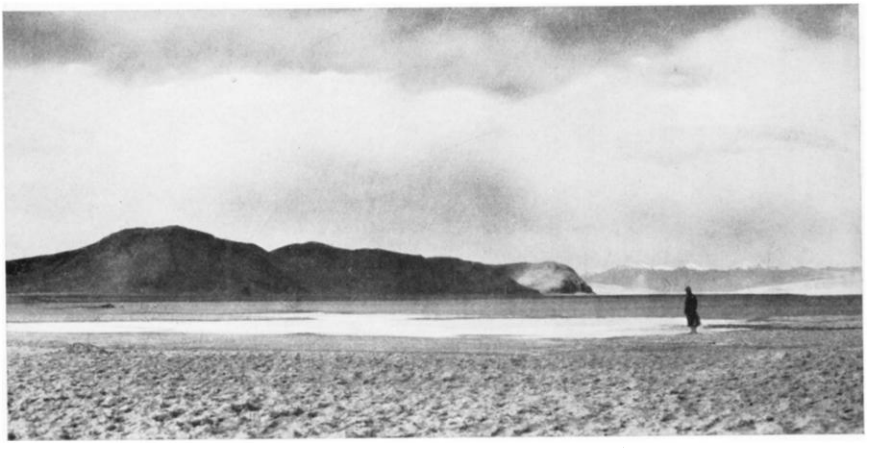
I spent the winter months of 1927–28 in the great Taklamakan Desert of Chinese Turkistan, engaged in geographical and archaeological studies. I shall not dwell on these subjects here. I paid a visit to the small deserts west of the Yarkand Darya, and I also visited the strange Mazar Tagh near Maralbashi. The hills which interested me most were the small ridges south of the Yarkand Darya. I found that their structure was rather complicated, and that they consisted of limestones, deep red quartzites, as well as younger volcanic rocks which had been intruded into red sandstone changing it into quartzite. The limestones which form steep cliffs in the Chokh Tagh are probably of Palaeozoic Age. Formerly it was generally believed that an unbroken range crossed the Western Taklamakan from these desert ranges directly to the Mazar Tagh on the Khotan Darya. But Sir Aurel Stein has proved that there is no connecting link between these desert hills, although he believes that formerly there probably was such a range, which has been destroyed by wind-erosion. But the geological structure of the Khotan Mazar Tagh, which consists of younger Tertiary rocks, points to a more independent range, the more so as the strike of the rocks deeper in the desert turns more east–west.

I studied some very remarkable landscapes in the southern part of the Taklamakan between the Yarkand and Keriya Darya. It is the land of withering rivers. Among high belts of sand-dunes you often meet with old river-beds bordered by rows of dead trees and tamarisks. Formerly the rivers coming down from the Kunlun Mountains penetrated farther into the desert. The Keriya Darya once joined the Tarim, and the Niya further east, which once watered the old settlement of Niya, now ends some 70 miles to the south of the ruins. The same applies to other rivers. These rivers often also submerged the southern border of the sea of sand during extraordinary floods. This is proved by extensive clay deposits which can often be traced deep into the heart of the desert. A section near the famous Rawak Stupa showed me that such an inundation had taken place here after the third–fifth centuries A.D., because

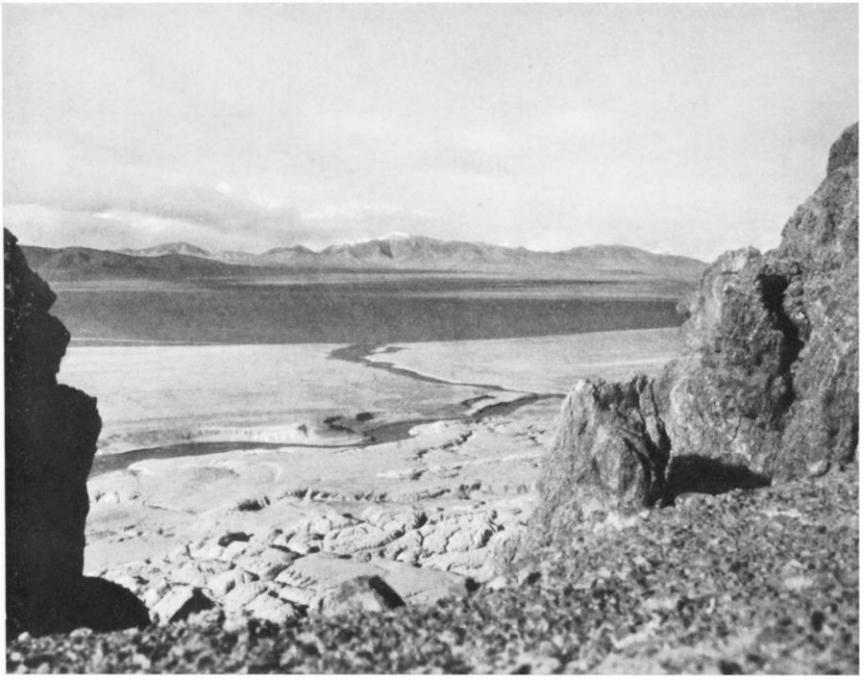
Glaciated range south-east of Tomar



Looking south from the Sirigh Jilganang lake over the old lake bed



Large salt lake on the Aksai Chin from southern shore: Kunlun in distance



The Sirigh Jilganang lake from the south: clay deposits in foreground

Old clay deposits of the Sirigh Jilganang lake

the corresponding culture deposits of pottery debris, Chinese coins, bones, and beads are buried below clay layers. These layers were deposited during an inundation by the Yurungqash Darya. The old dry bed of this river can still be seen some 4 miles to the east of the ruin. After that high flood the river changed its bed, shifting it some 12 to 14 miles to the west.

When returning from Chinese Turkistan in July 1927 I crossed the Kunlun with Dr. de Terra by the Kilian Dawan, which is to the west of the Sanju pass, while Bosshard returned to Europe via Russia with the heavy luggage and our collections. The valley of the Kilian river everywhere, especially in its upper part, shows marks of former glacial action. The valley has a beautiful trough form, in places resembling our famous Alpine valleys. The river often runs in a deep gorge cut in black slates and metamorphic rocks. The valleys also to the south of the Kunlun, which we entered after crossing the Kilian Dawan, were bordered by well-preserved rock terraces, which must have been modelled by former glacial action.

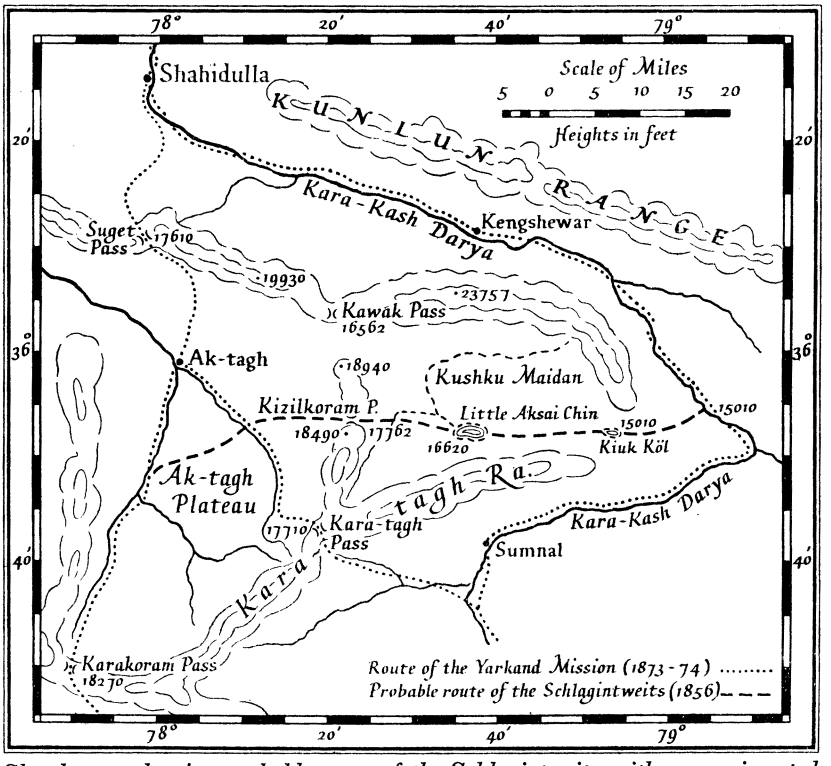
On July 22 we reached Suget Qaraul again, and from here we started for the Karakoram road. Although we generally followed the Karakoram road we were able to explore some hitherto largely unexplored regions north-west of the Karakoram range. I visited the plateau of Ak-tagh, and reconnoitred the region to the west of the Kara-tagh pass. Only Hayward and members of the Yarkand Mission have crossed this pass, which is situated in a range bordering the Upper Kara-Kash valley in the west, and which stretches east-north-east to west-south-west. The strike of the rocks in these regions is quite extraordinary because it is contrary to the strike of the main ranges. Our geological studies showed us that a younger folding has taken place in the sedimentary filling of Cretaceous and Tertiary rocks, and that the pressure was contrary to that which folded the Kunlun and the Karakoram ranges. I searched in vain for the lake which was seen by members of the Yarkand Mission when they went from the Kara-tagh pass to Ak-tagh. Probably the lake has dried up in the meantime. I believe that my countrymen, the Schlagintweits, were the first Europeans to cross the big plateau which is bordered in the north by the so-called Ak-tagh range, in the east by the Kara-tagh range, and in the south by the Karakoram. What they called the Little Aksai Chin is probably the Kushku Maidan of the maps of the Survey of India. It is still a puzzle to me what these explorers meant by the Kizilkoram pass, which is said to lie in a dark red range. I suppose this pass is to be found in a range which separates the Kushku Maidan from the plateau of Ak-tagh. The Schlagintweits mention that the Kizilkoram range branches from the Kara-tagh, the last name meaning the "Black Range." When I approached the Kara-tagh in September 1928 I had to climb a range consisting of red brecciated rocks, and this range perhaps finds its continuation in the north. The two lakes which the Schlagintweits mention, the Little Aksai Chin lake and the Kiuk Köll (the Blue Lake: Turki, Kök Köl), must be situated on the Kushku Maidan.

I have tried on the sketch-map overleaf to give an idea of the topography of those regions according to the descriptions which we find in the reports of the Schlagintweits. It is a pity that they have not published any detailed maps of their journeys. All we can do is to interpret their reports and to try to enter their observations on our maps. Their original diaries are stored in the

library at Munich, and I hope to examine them some day to see whether they contain any unpublished material.

I have not very much to say about the Karakoram road. In general I can confirm Prof. Dainelli's view about the former extensive glaciation of those regions. Big glacier streams once ran through the broad valleys of the Upper Indus district. We were held up in the Shyok valley for one day owing to the news that the ice-dam of the Chong Kumdun glacier, which had dammed up the Upper Shyok, was broken. But it was only a false alarm, and we could cross the river the next day safely by the ferry boat working there.

The rocks in this region are often deeply disintegrated. Boulders can be seen



Sketch-map showing probable route of the Schlagintweits, with names inserted from their reports

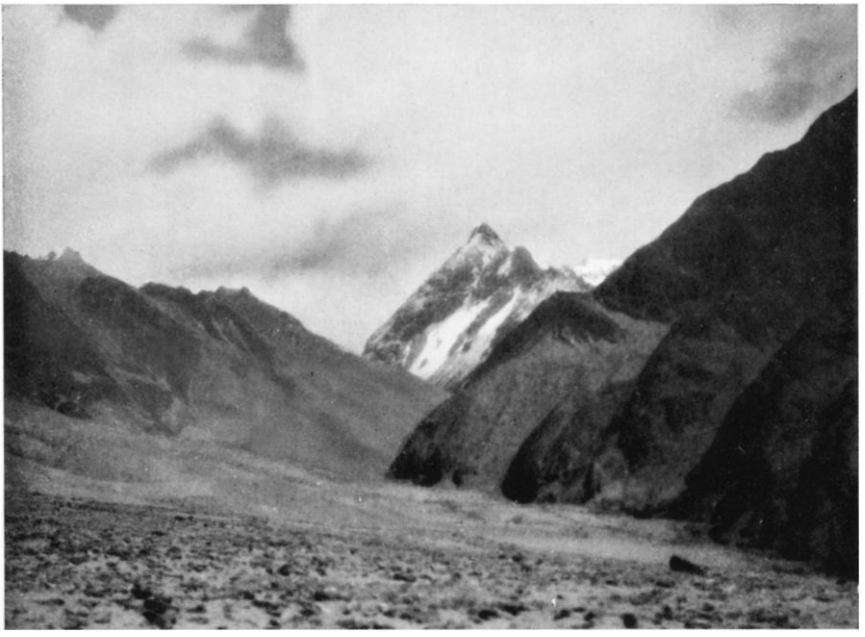
of which only the outer crust is left. Often the cavity was large enough to give shelter to our dog, who was always looking out for a shady place. Coming from the barren and high Karakoram regions we were much impressed by the beautiful Nubra Valley with its small picturesque villages. There are numerous small monasteries in the Nubra–Shyok Valley, and many of them are more or less unknown. I am sure that on old "mani" walls slabs of slate could be picked up bearing inscriptions which could tell us something about the ancient history of Baltistan and Ladakh.

After having spent more than eight months among the Turki population of

Peak 21,750, Kunlun, from ridge above Haji Langar

Kunlun from valley leading south from Peak 21,960 to salt marsh of the Aksai Chin

The upper Kara–Kash valley west of Abdul Ghafur Langar, and snow peaks of the Kunlun



Peak, probably 20,530 of Indian Survey Sheet 51 (Yarkand), in Kunlun north of Gulbazar Mazar

Looking up the Kara-Kash at great bend above Abdul Ghafur Langar

Chinese Turkistan we were rather glad to be back again in Ladakh. I personally like the Ladakhis more than the Turkis; they are always cheerful and always willing to work, they never or rarely complain, and they can stand the greatest hardships. The Turkis, on the other hand, are not so willing to work. Their struggle for life is not so hard, and they need not work so much in order to get their living.

On August 17 we were again in Leh, where we found the necessary rest after the long journey. Here I should like to mention an ancient monastery in Ladakh, which is situated at Basgo. In this monastery there are beautiful wall-paintings, and every traveller will be impressed by the huge statues of the Champa or Buddha Maitreya. Another spot worth seeing in the Upper Indus valley is Saspul, where there are beautiful old frescoes in small caves cut into the rocky cliffs. Several of these paintings are beautifully done, and the art-loving traveller should not miss a visit to these caves which are quite near to the bungalow.

On the last stage of our journey we were able to gather more observations about the morphology and geology of the country traversed. When one day the comprehensive scientific results of my expedition have been worked out and are properly published, I hope to be able to return to Central Asia to start special systematic investigations. There is an immense territory still to be explored, not so much from a topographical as from a geological and geographical point of view.

I should like, in closing, to express my deepest gratitude to the Government of India and to all the British officials who gave me so much help during my expedition.

DISCUSSION

Before the paper the PRESIDENT (Colonel Sir CHARLES CLOSE) said: To-night we are to listen to a lecture by Dr. Emil Trinkler, who is a Fellow of the Society and has often studied in our House. He is known to us for his journeys in Afghanistan and, more lately, for his researches and explorations in the Karakoram and Western Kunlun. He was accompanied on his journeys by Mr. Bosshard and Dr. De Terra, neither of whom, I regret to say, is with us this evening. Dr. Trinkler, you may remember, contributed a valuable paper on the Glaciation of the Tibetan Plateau in the recent March number of the *Geographical Journal*.

Dr. Trinkler then read the paper printed above, and a discussion followed.

The PRESIDENT: We are honoured to-night by the presence of H.E. the German Ambassador, who has kindly consented to say a few words.

H.E. THE GERMAN AMBASSADOR (Dr. FRIEDRICH STHAMER): I wish to thank you for the cordial reception which you gave my countryman, Dr. Trinkler, and for the great approval you showed of his lecture as well as for the interest with which you followed it. I venture to say that we were all very interested in what we have heard to-night and that we were highly impressed by the picture which Dr. Trinkler drew of those unknown regions, regions which emulate in grandeur and picturesqueness the Alps, which you probably all know, and regions which would be worth a visit if they were not so distant and if they afforded the comfort to which modern people are accustomed.

I wish also to express my thanks to the Royal Geographical Society for having invited Dr. Trinkler to come to London to lecture on his experiences. It is the privilege of the Society to hear lectures by explorers, scientists, and members of

geographical societies all over the world, because the character of this Society and its work is international and embraces the whole world. It is interested in the experiences of and explorations by any expert from any nation. I am especially glad to put on record that Dr. Trinkler is not the first German scientist to lecture on his experiences, but is one in the list of many German explorers who have visited London at the invitation of the Royal Geographical Society. I may mention Dr. Filchner and Mr. Rickmers, who, in turn, explored the same or contiguous regions as Dr. Trinkler, and who gave us an insight into the life and customs of the people of Central Asia.

I am glad that my countrymen have been the guests of the Royal Geographical Society, and I know that is a sign of the extremely good relations which exist between your Society and my country. I may refer also to the visit which was paid three years ago to the Geographical Society of Berlin on the occasion of its centenary, and I hope that members of this Society and of my country will take part in the centenary of the Royal Geographical Society which is to take place in London this year. I thank you very much for your attention.

Sir FRANCIS YOUNGHUSBAND: I think we should, in the first place, remember that the first Europeans to explore the region that has been described this evening were the two brothers Schlagintweits, countrymen of the lecturer. They were very remarkable men, and had in other parts of the Himalaya made some original surveys, and brought back some beautiful pictures which are now to be obtained in colour prints published during the 1850's. Probably the reason why the records of that part of their explorations which has been described this evening have apparently not been preserved is because one of them was murdered in Central Asia. He was the first European to cross the Karakoram Mountains into the plains of Turkistan, but he lost his life in Kashgar. As I say, they were two very remarkable men, and on an occasion such as this we ought to remember the services they rendered to geographical science.

I have not myself been to the eastern part of the region the lecturer described. I crossed the Karakoram Pass in the years 1889 and 1890, and I could see from it the kind of country which Dr. Trinkler traversed in the journey he has described this evening. Certainly a more desolate and depressing region you could hardly imagine. It is not only very bare but, being at the height of 16,000 to 18,000 feet, it seems more desolate, because you feel in a very depressed state of mind on account of the altitude. Nevertheless, as Dr. Trinkler has said, you do on special occasions find real beauty there. Such occasions are sunsets, when the light slanting across the mountains and valleys has the most marvellous effects both of colour and of light. It is well that a traveller like Dr. Trinkler has taken the trouble to describe such a scene to us.

Also what is remarkable in that mountainous region and, again, also in the desolate region of the Taklamakan, which Dr. Trinkler afterwards traversed, was the extraordinary stillness, especially at night when you get out under the stars. It is then that you feel the wonderful stillness and silence impressed upon you and producing an effect which it does not produce in anything like the same degree in Europe.

Dr. Trinkler went to that region especially to see what the Ice Age was like; and any one who has been in that part of the mountains can see the way that the ice covering there has moulded the mountains and broadened out the valleys. But what has often puzzled me is why in that region of the Karakoram and away to the east there are rounded mountains and great broad open valleys, and again in the Pamir region, away farther to the west and north, you see the same thing, and yet in the middle, between these two regions, round K_2, you find deep-cut valleys and steep hillsides. It is very difficult to understand why in that gap of about

200 miles there should be mountains and valleys of such a different type. I do not know that the explanation has yet been given.

There is a lot, as you can see from the maps, still to be done; and we hope that Dr. Trinkler will be going to that region again, as he has suggested this evening. One of the things that impressed me was the way in which he overcame his transport difficulties with the aid of sheep. I have had sheep in that region, but rather for supply purposes than for transport. Somehow or other sheep do manage to pick up food in those desolate regions, and after several weeks they are still quite good eating. Dr. Trinkler was, apparently, able to use them as useful transport animals for weeks and weeks together.

I should also like to agree with the lecturer in what he said with regard to the cheeriness of the Ladakhis as compared with the Turkis of Turkistan, the latter being a very amiable type of people, but not very cheerful or very willing to work hard. On the other hand, the Ladakhis, in my experience, have been cheerful and very delightful people to have with one. Any one who wants to know their character and habits of life and their customs cannot do better than read a most interesting and entertaining book by one of themselves, entitled 'The Servant of Sahibs.' That book is written by a caravan boy, Ghulan Rasal, who started with me in 1890 and who was afterwards with many Europeans and Americans and was persuaded by Mr. Barrett, an American with whom he travelled in those regions, to write his experiences. The book is written in a most wonderful pigeon-English, but is most entertaining. I recommend all travellers who are able to get it to read it because they will not only learn something of Ladakhis' ways and customs but also what the Europeans appear like in the eyes of the Ladakhis. That they will find in good strong colours.

The PRESIDENT: Dr. Trinkler tells me that there is still a brother of the two brothers Schlagintweits alive in Germany, and I understand it is his desire to try to find if there are not some records left amongst the family papers from which he could reconstruct some portions of their many journeys which are at present obscure. It would certainly be interesting and important for the study of that part of Central Asia if we could discover their diaries.

The lecturer is one of a number of distinguished explorers who have been to that part of Asia, and I feel that bit by bit we are getting to know something about it. We have had several lectures upon the subject, and Dr. Trinkler's is not the least important. We have had, for instance, a lecture recently by H.R.H. the Duke of Spoleto and an afternoon lecture by Colonel Schomberg on country a little farther north. I feel that one day we shall get a complete synthesis of that country based, I hope, on Dr. Trinkler's work, and on the labours of those other explorers whose names I have mentioned, and their predecessors.

It must not be supposed that it is possible to go into that country and start exploring without any previous study. You need to know, first of all, how to make a map; you need to be a bit of a geologist and to know some of the languages. To give you some idea of the sort of study necessary, I gathered from Dr. Trinkler that he began studying Tibetan when he was thirteen years of age. I think I am safe in saying that there are very few present who studied Tibetan at as early an age as that. Then you have to get accustomed to all sorts of strange food, and Dr. Trinkler tells me that the meat of wild donkeys is admirable: quite equal to English beef. I have not been able to make the comparison, but it must be admitted that explorers are sometimes very hungry.

We thank the lecturer sincerely for his lecture, and are glad that the Government of India was able to afford him facilities. The results have fully justified their action, and we shall look forward to Dr. Trinkler's detailed publications on the journeys that he has made.