KARAKORAM

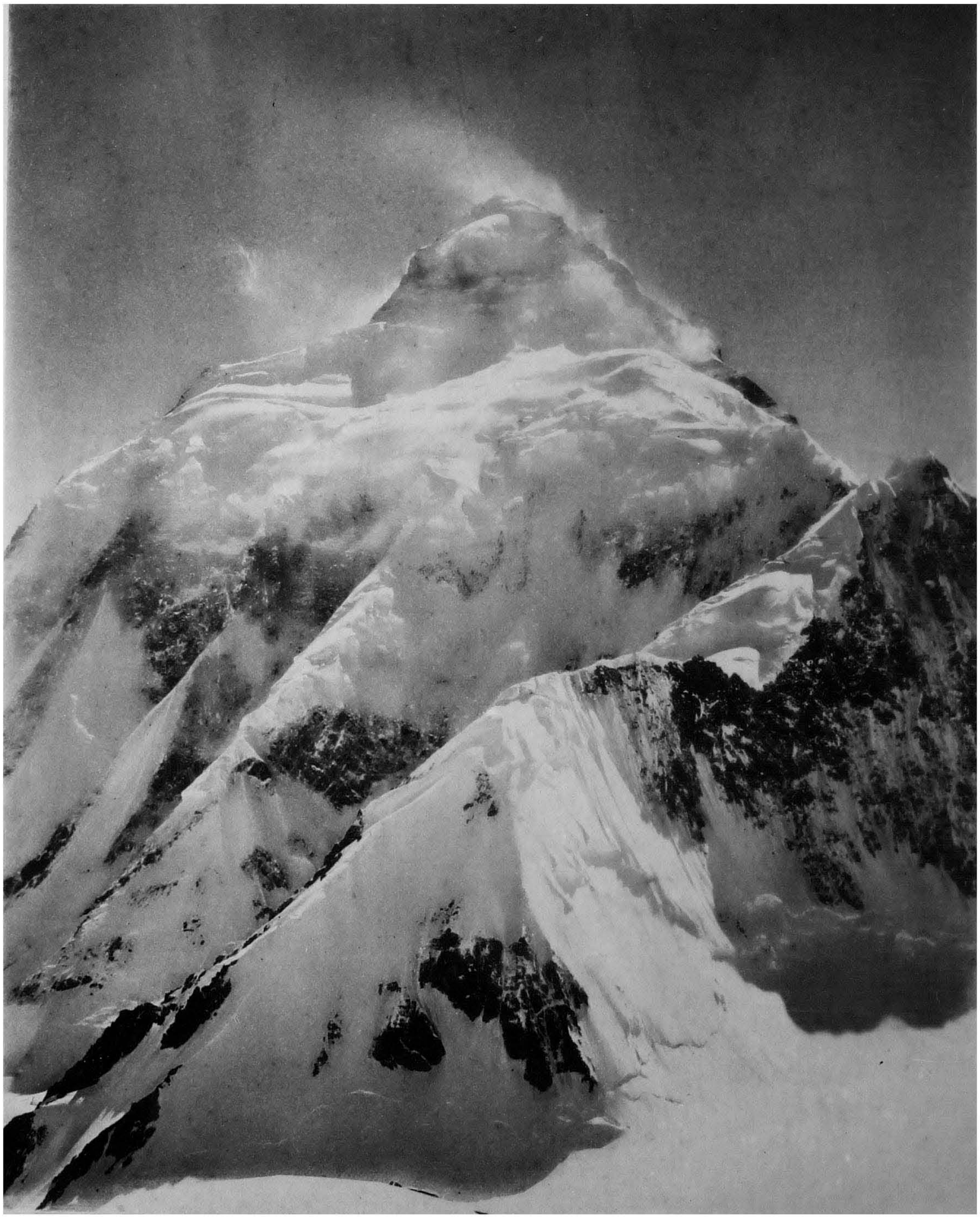
AND

WESTERN HIMALAYA

1909.

PUT INTO ENGLISH BY CAROLINE DE FILIPPI *née* FITZGERALD AND H. T. PORTER.

THE ILLUSTRATIONS FROM PHOTOGRAPHS TAKEN BY VITTORIO SELLA, MEMBER OF THE EXPEDITION.



KARAKORAM

AND

WESTERN HIMALAYA

1909

AN ACCOUNT OF THE EXPEDITION

OF

H.R.H.

PRINCE LUIGI AMEDEO OF SAVOY

DUKE OF THE ABBRUZZI

BY

FILIPPO DE FILIPPI, F.R.G.S.

WITH A PREFACE BY

H.R.H.

THE DUKE OF THE ABRUZZI

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TRANSLATOR'S NOTE.

The thanks of the translator are due and are here gratefully expressed to Cesare Foligno, M.A., J. S. Gamble, C.I.E., F.R.S., F.L.S., and Capt. Howard Knox, who have been so kind as to read various parts of the translation.

H. T. P.

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PREFACE.

Once more I entrust to Cav. Filippo De Filippi, my travelling companion, the complete account of my late expedition. I am grateful to him for undertaking the task, and I hope that his revived memories of our journey may have rendered his labour less burdensome.

The detailed history of our wanderings will explain better than I was able to do in my short lectures before the Italian Alpine Club and the Italian Geographical Society, the difficulties and obstacles which the expedition encountered. The map of the Baltoro glacier which accompanies this volume was planned and executed at the Military Geographical Institute of Florence from photogrammetric panoramas assisted by tacheometer observations taken during the campaign by Ship's Lieutenant Marchese Federico Negrotto Cambiaso. I am glad of this opportunity to express my warm thanks to Ing. Comm. Pio Paganini, the inventor of the photogrammetric method, who has been at all times most generous with aid and advice; to Major-General Ernesto Gliamas, Director of the Military Geographical Institute of Florence; to Lieut.-Colonel Prospero Baglione; to Captain Nicola Vacchelli; to the topographers Fortunato Senno and Giuseppe Galli; and to all others who co-operated in the construction of the map.

Professor Domenico Omodei has once more taken upon himself the wearisome task of calculating and collating the statistics gathered from my meteorological observations, thus increasing the debt of gratitude already incurred by me for his help in former expeditions.

I am likewise most grateful to Ing. Vittorio Novarese, of the Regio Ufficio Geologico, for the geological survey he has written, based upon the observations made by the expedition; and to Professor Romualdo Pirotta and to Dr. Fabrizio Cortesi for their botanical notes upon the plants collected by Dr. De Filippi.

I hope that this book, together with the beautiful photographs taken by Cav. Uff. Vittorio Sella, will succeed in conveying to the reader some portion of the profound impression made upon us by our months of sojourn in the Karakoram. Our work will not have been in vain if it prove to be of assistance to future explorers of that distant and majestic region.

Luigi di Savoia

APPENDICES.

APPENDIX A.

PHOTOGRAMMETRIC SURVEY

On the scale of 1 : 100,000

IN THE

KARAKORAM (WESTERN HIMALAYA),

Comprising Part of the Upper End of the Baltoro Glacier and the Godwin Austen and Savoia Glaciers.

BY

FEDERICO NEGROTTO CAMBIASO,

Ship's Lieutenant.

PHOTOGRAMMETRIC SURVEY.

I.—Selection of the Method followed in the Execution of the Survey.

THE Godwin Austen glacier, the two branches of it which surround to west and east the main mass of K^2, and the buttresses that enclose these, were surveyed by photogrammetry. This special method, invented by the geographer Comm. Pio Paganini, formerly an officer in the Royal Italian Navy, has been adopted by the Military Geographical Institute of Florence for the surveying of high mountains. Thanks to the painstaking studies of many years and to the instruments devised and perfected by Comm. Paganini, his method has attained the highest degree of simplicity and practical utility, and may with advantage replace all other topographical methods in difficult or inaccessible regions. It is especially adapted to steep mountains and large glaciers, to places beyond the frontier or such as are occupied by the enemy; to unhealthy districts; finally, to any place where long and tiresome marches leave little time for surveying with the plane table, tacheometer and theodolite.

In surveying high mountainous regions with the plane table, the Military Geographical Institute has abandoned the use of the tape. The same may be said of the tacheometer, which under the circumstances serves as a theodolite. The points for the survey are always determined by intersection. Then all the directions at points useful for the survey must be observed and noted on the spot, either with the plane table, the tacheometer or the theodolite, and supplemented by numerous sketches to help later in making the map. The method of the plane table, although it has the advantage of enabling one to reproduce natural features on the spot, takes, on the other hand, more time at each station. Moreover, in case of bad weather it is not easy to keep the drawing from being injured in the process of execution, and finally the apparatus is difficult to transport in the high mountains.

With the photogrammetric method all the required directions to the points may be obtained afterwards from the photographs taken from properly chosen stations. The photographic apparatus is provided with special measuring devices to furnish the photographic perspectives with the elements needed for the survey. In the field the only point of similarity between this method and earlier ones is the determination of the stations by taking bearings to surrounding trigonometrical points. This determination may if necessary be made at home with the panoramic views, provided the points are well defined, as is the case in the high mountains, where they usually consist of sharp and conspicuous summits. Thus with the photogrammetric method all that has to be done out of doors is the adjusting of the instrument, the taking of the panoramic views and the noting in the field book the orientation and bearings to the trigonometrical points necessary to determine the station. Other notes may be taken: as of the directions which may help to determine with greater precision such distinctive points as may be useful points of reference for subsequent stations; or to fix the perspective when the number of trigonometric points is insufficient; or to obtain at once a trigonometrical net connected with one or more bases measured directly. This would be necessary in lands where no measurements had previously been taken. The photogrammetric method consists in taking in the field a series of views from different stations, and these pictures serve later as the basis of all those operations which under any other method must be performed on the spot. There is further the advantage that we can determine as many points as we want according to the scale adopted and the amount of detail we wish to give to the map. The Paganini apparatus supplies vertical topographical perspectives, upon which are traced two orthogonal axes. The intersection of these axes coincides with the principal point of the perspective, which by construction is also the meeting of the optical axis of the lens or of the camera with the plane of the image. Of the two perpendicular axes traced on the negative and thence transferred to the positive, one is the line of the horizontal plane which passes through the view-point of the perspective, and thus represents the horizon of the station; the other is the line of the vertical plane which contains the optical axis of the camera; hence also the view-point and the principal point of the perspective itself. This holds good, of course, only when the necessary adjustment of the apparatus is made previously. In order to use the photographic perspectives thus obtained for mapping the ground which they represent, it is necessary to know the distance of the view-point from the plane on which they are formed—in other words, the length of the perpendicular line drawn from the said point to this plane. As in our case we are dealing with photographic perspectives in which the ground shown can be considered to be at infinity,[1] their point of view coincides with the second nodal point of the lens, and the principal focal length of the latter represents the length of the aforesaid distance. The lens

[1] Cf. PAGANINI, *Fotogrammetria.* Milan U. Hoepli 1901.

of the Paganini apparatus is provided with a graduated scale in millimetres and tenths of millimetres, in order that this length may be taken with precision. It is determined once for all at the beginning of work, by bringing into the focal plane distant points and making a series of observations in order to arrive at a mean value approximating the true one. With the help of the graduated scale it is easy to keep this value constant in all the perspectives obtained during the survey. Paganini calls this value the "indicated focal length," to distinguish it from the one determined afterwards at home for the perspectives on paper, which serve for the actual construction of the map. For further particulars the reader is referred to the hand-book mentioned above. This factor is most important because it establishes the relation between the dimensions of the objects and those of the corresponding images on the perspectives. It must be determined therefore with the greatest care and, when necessary, corrected by calculations before setting to work on the survey.

Another element which must be established upon the spot is the orientation of the perspective: that is, the horizontal angle made by the optical axis of the camera (in other words, the perpendicular line from the view-point to the perspective) with the direction to a previously determined point in the field of operations; or, failing this, the azimuth of the optical axis, given by a compass attached to the apparatus. The outdoor work, therefore, is reduced to the following steps: (1) The adjustment of the instrument; (2) the rectification of the level or of the verticality of the axis of rotation; (3) the execution of the panorama (preferably in the first perspective intersecting with the vertical wire some signal point or conspicuous point previously fixed, in order to orientate the panorama with as great precision as possible); and (4) the observations of zenith and azimuth —or of the latter alone, as in the case of the apparatus used by the expedition— of the surrounding trigonometrical points necessary to fix the position of the station, with the addition at most of certain conspicuous points which may later be of value as reference points for locating other stations in cases where geodetic points are unavailable.

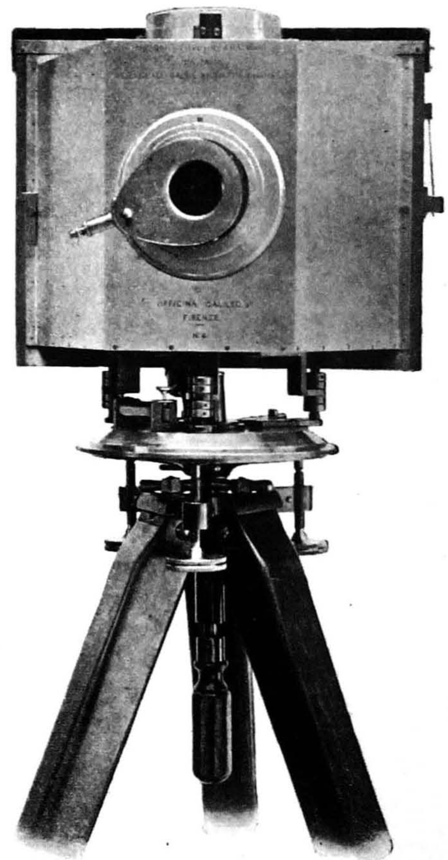
II.—Description of the Apparatus.

Paganini has invented various types of photogrammetric apparatus for the use of the Italian Military Geographical Institute. They are manufactured by the Galileo Company, of Florence. However, when the expedition wished to furnish itself with an instrument, this firm had only one on hand, a model of 1897, arranged by Comm. Paganini for surveys on the scale of 1 : 50,000 and 1 : 100,000 in Erithrea. This model, however, though less in weight, bulk and price, and possessing the greatest simplicity and ease of manipulation, is not altogether adapted for work in very high mountains. We had to content ourselves with it, none the less, as the time was too short for the construction of a new instrument.

Paganini has recently invented a marvellously ingenious one, which unites all the advantages I have mentioned with that of the higher degree of precision possessed by the model furnished with the vertical circle, which was an earlier invention.

The pattern of 1897 has a short focal length (18 centimetres) and takes plates 18 by 24 centimetres (7 by 9½ inches), with the larger side horizontal in order to take in the entire horizon with an equipment of six plates. It may be employed successfully in Erithrea, and has given brilliant results in Russian work in Transbaikalia and Transcaucasia, where the district is less rough and the differences of level less pronounced than in the Alps and the Himalaya. But in the photogrammetric work executed on the Baltoro and Godwin Austen glaciers the panoramic views could not all include the highest peaks, as was, of course, desirable, because the vertical dimension of the plates was too limited to embrace the enormous difference of height between the stations and the surrounding summits. Moreover, the instrument was not furnished with the vertical circle and telescope, as in the other Paganini models; thus the bearings to the most important points had to be taken by means of the vertical wire as seen through the ground glass; and others, as also the heights of the points, had to be determined at home by the co-ordinates x and y of their images measured on the perspectives. These facts simplified the outdoor work very much, but increased the labour afterwards in obtaining the data for the construction of the map. Undoubtedly this apparatus enables the work to be done very quickly on the mountains, and reduces to a minimum the time spent by the operator while exposed to discomfort and bad weather. He must note the indispensable data. These are recorded in a field book, together with such subsidiary observations as sketches to facilitate the locating of the points in the panoramas, names, routes followed, time of exposure and other miscellaneous information. The apparatus has also the great advantage of maintaining unaltered for a long time the adjustments made before beginning work—a fact which contributes much to the success of the observations. A brief description of the apparatus will make this plainer.

It consists of a rigid camera, made of aluminium, in form a right prism, the base of which is an isosceles trapezium. The back of the camera, which is perpendicularly placed upon the largest of the parallel sides of the trapezium, consists of a frame holding the ground glass or the sensitive plate. The front of the camera has fixed at its centre a tube, inside which runs another tube adjustable by means of a screw with a millimetre thread. To this the lens is fixed. A graduated scale in millimetres, which has as origin the focal plane—that is the surface upon which the images are received—is marked externally along the fixed tube, while to the movable tube carrying the lens is attached a ring with a sharp edge which comes into contact with the fixed tube. Thus, turning the inner tube in order to move the lens backward and forward causes the edge of the ring to cut the graduated scale, and thus serves as fiducial line or line of collimation, indicating on the scale itself the distance of the lens from the focal plane. The bevelled edge of the ring is divided into ten equal parts in order to read upon it the divisions of the movable tube—in other words, the tenths of the thread of the screw. This, added to the whole number of millimetres read on the fixed tube, gives in millimetres and tenths of millimetres the distance of the second nodal point of the lens from the focal plane. This value, the "principal indicated focal length," is determined at the beginning of the campaign, and in all subsequent operations care must be taken that the line of collimation of the tube carrying the lens is so adjusted as to give always the same value. This was carefully determined upon the apparatus of the expedition before leaving Srinagar, and gave a result of 180·3 millimetres.



PAGANINI PHOTOGRAMMETRIC APPARATUS, 1897 MODEL.

The objective is a Zeiss anastigmatic and belongs to a special series of wide angulars for photogrammetric work. With a small diaphragm we obtain a clear image 40 centimetres in diameter; with the f–35 diaphragm it produces a clear image free from distortions upon a plate of 20 by 26 centimetres. Thus the plate 18 by 24 centimetres used with this camera took very clear images over its entire surface, even when a large aperture diaphragm was employed; while the luminosity is so great that it is better to use plates of only medium rapidity, or, better still, orthochromatic ones, as we did.

The perspectives thus obtained have a horizontal field of 67° and a vertical one of 54°. In this way, with six perspectives with a displacement of the optical axis of the camera about the vertical axis of the apparatus of 60° for each of them, a panorama is obtained which comprises the whole horizon, plus a narrow vertical band—a horizontal field of 3° 30′ between each one and the next. This vertical band in excess is indispensable, to ascertain the correctness of the panorama, to determine the distance of the point of view from the perspectives, and to join the positives accurately to one another in order to form the panorama. As the vertical field is 54°, one can measure from the perspectives and vertical angles up to 27°. Owing to the enormous differences in level with which the expedition had to contend, a larger vertical field would have been more advantageous. In the new apparatus of Comm. Paganini it is possible to adjust the camera so as to have the larger dimension of the plate (24 cm.) run vertically, giving angles of height or depression up to 33° 30′. To make the entire circle of the horizon eight plates would be necessary, with a horizontal displacement of 45° of the optical axis, giving a vertical band of 4° 30′ between each two contiguous pictures. The new instrument, being capable of reduction to telescope and being furnished with the vertical circle, can, even without the reversible movement I have described, take the angle of peaks whose summits fall outside the upper margin of the plate. This arrangement, too, would have been very useful in the construction of the map.

In all the Paganini apparatus the optic axis of the lens is fixed in a direction perpendicular to the plane of the image. The intersection of the above axis with this plane is marked photographically by the intersection at right angles of two very thin silver hairs stretched before the ground glass on the back of the camera in such a way that they can be easily withdrawn or replaced in case of breakage. The horizontal silver hair, once adjusted, serves, as I have said, to indicate the horizon line upon the photographic perspective. Below the camera are three arms bent at right angles, one anterior and the others posterior. Each has a hole in its end, through which passes an adjustable shaft fixed perpendicularly to the movable plate or alidad of the horizontal circle. The camera can be fixed rigidly at the required position upon the alidad by means of nuts and bolts screwed on to the shafts. This position remains, if possible, invariable throughout all the outdoor work. Its stability is very important, since the said position must satisfy the requirement that the plane containing the optic axis of the camera and the axis indicating the horizon of the station is exactly horizontal as soon as the rotation-axis of the alidad or of the instrument has been vertically disposed. Thus the only adjustment to be made of the instrument in the different stations is to correct the level placed on the alidad, at the same time arranging vertically the rotation-axis of the apparatus.

The azimuthal circle of the apparatus has a diameter of 14 centimetres and its edge is graduated from 0° to 360°, each degree being subdivided into two equal parts, each of which embraces 30′. The vernier is fastened to the movable plate or alidad, and permits us to read the minutes and to appreciate even the 30″. In addition to the three shafts and a level, the alidad is provided with a magnifying lens to use with the vernier and a regulating-screw to use for the small adjustments of collimation. The verticality of the rotation-axis of the instrument is attained by means of three levelling-screws, which pass through the top of the tripod and hold the horizontal circle. This is fixed upon the tripod by means of a clamping-screw with a spring and a handle, which, passing through the head of the tripod from bottom to top, is screwed into a movable support shaped like a half-sphere, fastened by means of a ring under the horizontal circle.

A compass of the Dixey or the Smalcalder type is mounted upon the top of the camera. It can be so adjusted that the vertical visual plane of its bearings coincides with the direction of the optic axis of the camera. Thus it becomes possible to use the compass to orientate the panorama when it is not possible to aim at trigonometric points or at any others of which the position is known. The tripod may be taken to pieces; each foot is in two parts[1] which can be solidly fastened together when the apparatus is set up. We have seen that the most important adjustment consists in fixing the camera upon the alidad in such a way that the plane containing the optical axis and the silver hair which traces the horizon-line upon the perspectives are perpendicular to the rotation-axis of the instrument; and reciprocally, when this rotation-axis is adjusted vertically the plane of the optical axis will be horizontal. In the other apparatus of Paganini this result is attained by means of the telescope of the acclimeter, which may be inverted (pattern 1884), or by the same camera obscura reduced to a reversible telescope (pattern 1889). In the model employed by the expedition the horizontal adjustment is made as follows:—

The three arms of the camera are first placed at approximately the same height upon the movable plate by turning the lower screws with the pins belonging to them, having previously raised the upper ones in order to give free motion to the arms on their respective shafts. Then looking through the ground glass of the camera under the black cloth, and moving to right or left and up or down as necessary, by adjusting the screws, distant points are brought to coincide with the point of intersection of the wires, until by moving the camera in both directions around the rotation-axis, a point is made to run all along the horizontal thread from one extreme to another, without passing above or under the thread. If the rotation-axis is vertical, this coincidence of a point with the horizontal thread in its whole length can only take place when the plane of the optical axis and the wire which traces the horizon-line on the perspective are horizontal. If the plane is not horizontal, and accordingly the plane of the ground glass is not vertical, one observes that in moving the camera to right or left the image gradually diverges from the horizontal wire, describing the segment of a hyperbola either above or below the wire, according as the point cited is situated above or below the horizon.

In practice the following method will secure the horizontal adjustment of the wire and the plane of the optical axis:—

First turn the screws which support the posterior arms of the camera, operating in such a way that by revolving the camera all the way through its field some distant point which is covered by the wire on one of its ends coincides with the other end of the wire. Thus the horizontality of the wire will be fixed. If this point is not on the horizon, it will be seen to describe a curve during the revolving of the camera, passing above or below the intersection of the wires according to the inclination of the optic axis downwards or upwards. The vertex of the hyperbola will be found upon the vertical thread, and it will be easy to estimate the

[1] In the original instrument the feet are in one piece.

convexity of the said curve. Then the screw controlling the anterior arm of the camera will be turned, and the latter raised or lowered until the image of the point is brought to coincide with the intersection of the wires. By making observations of successive points continually approaching the horizon, the right position will soon be arrived at, when all the screws are tightened in order rigidly to maintain it.

III.—Calculations and Construction of the Map.

THE panoramic view obtained under the above conditions gives an image of all the field seen from the station. Together with other panoramic views obtained in like manner at suitable stations, it gives the elements necessary for the execution, on any scale, of the map of that tract of land which they represent. Each perspective of the series is considered separately in constructing the map. The focal distance is equal for all, and all are furnished with the horizon-line and the line of the vertical plane, the latter containing the visual point and the principal point of the perspectives.

Paper positives are used for making the survey, it being possible to allow for the alteration undergone by one single quality of paper and to use a focal length corrected accordingly. This focal length is obtained before proceeding to the survey. It is independent of the "indicated focal length," and is called the "real focal length." All the directions to the points represented in each picture may be easily determined by means of the co-ordinates x and y of their images referred to the perpendicular axes traced on the picture itself, through the following very simple equations:

$$tang\ \omega' = \frac{x}{f} \qquad (1)$$

where f is the real distance of the view-point from the perspective, the orientation of which ω' is known, being an element obtained at the station; and ω' is the angle made by the horizontal direction to a point (x, y) of the perspective with the perpendicular to it from the view-point.

$$tang\ \alpha = \frac{y \cos \omega'}{f}, \qquad (2)$$

where α is the angle that the direction to the image of the point observed makes with its projection upon the horizon, that is to say, with the horizontal direction of the point itself. But also it is

$$tang\ \alpha = \frac{L}{D},$$

where L is the difference of level between the point considered and the station and D the horizontal distance between these points. Hence

$$L = \frac{D\, y \cos \omega'}{f} \qquad (3)$$

After having obtained by formula (1) the bearings of the various points useful for the survey, which are visible on the panoramic views taken from two or more stations, the position of these may be obtained by intersection.

By formula (2) we get their angular elevation; then, having the distance and the difference of level between the points and the station, by means of tables in use at the Military Geographical Institute, one can finally obtain directly the vertical difference by means of formula (3).

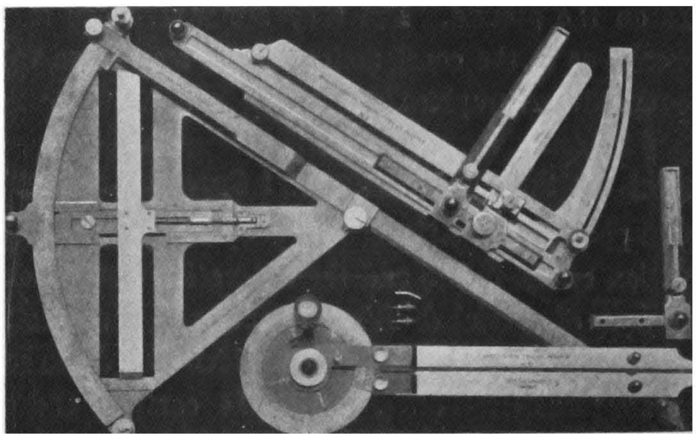
But this is a very long method, and in order to solve the equations given above it is necessary to have the numerical value of the co-ordinates x and y and the distance D. These numerical values are very useful when the survey is on a very large scale, as in civil or military operations; whenever it is a question of data for finding points on the ground. But they are superfluous for a topographical map on a small scale, as in the construction of the map these values would have in any case to be reproduced graphically.

IV.—Simplifying the Survey by means of Special Drafting Instruments.

By the Paganini photogrammetric method adopted by our Military Geographical Institute, the position of the points and their elevation can be taken mechanically and rapidly by means of special drafting instruments, the construction of which is based upon the above formulæ, and upon which the distance D and the co-ordinates x and y are transferred directly with the compass and upon the scale of the map, making it unnecessary to know the numerical value of these measurements.

The construction proceeds in the following manner: the trigonometric points are fixed at the desired scale by means of their rectilinear co-ordinates. Then with the special instrument called by Paganini "*rapportatore ad origine variabile,*" the photogrammetric stations are put in place, as well as whatever other special points have been selected for the purpose of adding to the points of reference in a number proportionate to the scale of the survey. With this instrument the various directions can be traced directly on the transparent paper just as they were read at the time of the outdoor operation on the horizontal circle of the photogrammetric apparatus or the theodolite. With the transparency thus made are placed the stations and the directions from them to the other images necessary to determine further points of reference in addition to the trigonometric ones. With this instrument it is possible to assume any one of the bearings observed as origin of the horizontal circuit and to proceed by degrees, by means of the alidad, to the other readings. In this way is obviated the necessity of all the mathematical calculations to reduce to zero the readings made out of doors, as is the case when the ordinary finders are used—a very long operation when there is a large number of points to be located.

When the stations and all the points intersected by them have been put on paper, we proceed to the determination of the secondary points, or detail, all chosen beforehand for the purpose of the draft. After the various elements of the panoramic views have been corrected, a selection is made from them (taking them two by two, at contiguous stations) of points useful to the survey; either for the purpose of tracing contours, or for determining the lie of various ridges, the direction of streams, the limits of glaciers, bases of rocks, &c. The operation is regulated for the number of points chosen according to the scale that is desired, the precision required, and the time at the disposition of the operator. All these points have been registered in the notebook, according to the station from which they were taken, and marked on the relative panoramic views with numbers or letters written in red ink.



PAGANINI DRAFTING INSTRUMENTS USED IN CONSTRUCTING THE MAP.

The tracing on the design of all directions to these secondary points used to be a very long and monotonous operation and far from accurate. The modern process is quick and simple, thanks to a special drafting instrument based upon the formula (1) quoted above, and called the "graphical sector for the directions to secondary points of the perspective." By its means the horizontal projection of each perspective is traced successively upon the design, carefully orientated, with its principal point at the effective distance from the station point, in such a way that, by transferring with the compass the abscissæ of the various points taken on the views to a scale cut on a metal ruler, the corresponding horizontal directions may be easily drawn by means of a movable plate (or alidad) furnished with a metal ruler, moving about the station point.

With another instrument, specially designed for drawing the elevations, based upon formulæ (2) and (3), differences of level are obtainable, and therefore also the elevations of the stations and of the secondary points of the perspectives. When the apparatus is provided with vertical circle and telescope the angular elevations of the trigonometrical points are read directly on the ground. In this case one obtains the elevation directly from reading the instrument, by means of the distance on the design between the station point and the trigonometrical point of which the altitude is known and from the station point to the observed angle α.

But without the vertical circle the determination of the heights depends upon the value of the abscissæ and the ordinates of the trigonometric points of the perspectives, the height of which is taken with the compass on the perspectives themselves, likewise their graphic distances; so that the differences of level between them and the station point, and also the height of the latter, may be read directly upon the instrument. In the same manner, once the height of the stations is obtained, the difference of level is determined, and therefore the height of the secondary points of the perspective considered useful to complete the survey. As in the case of all the other methods, corrections must, of course, be made of all these apparent differences of level, on account of the refraction of the light and the roundness of the earth. Tables compiled for the purpose are used.

V.—Topographical Work of the Expedition and Construction of the Survey.

In a little more than a month—in other words, from May 25th to July 2nd—the expedition executed twenty-two photogrammetric stations, using 106 negatives. On account of the limited number of plates at our disposal, not all the panoramic views embraced the entire horizon. The region surveyed includes the Concordia amphitheatre of the Baltoro glacier, the Godwin Austen glacier up to Windy Gap and the Savoia glacier, which flows about the western side of K².[1] It was a pity that lack of plates prevented our extending the survey southward, upon the arm of the Baltoro as far as Bride Peak, the ascent of which was one of the aims of the expedition. The work was supplemented, it is true, by compass and tacheometer and with barometrical stations; but among the innumerable peaks of such strange appearance the eye becomes easily confused in passing from one station to another. The numerous sketches taken on the spot did not give all the information really desirable for map-drawing, and are certainly inadequate to give all the characteristic detail of this rugged, broken and largely inaccessible region. Sella's numerous photographs and panoramic views were, on the other hand, of great assistance in making the design, as some of them were taken from high and commanding elevations and under conditions making it possible to determine approximately the photogrammetric elements, so that they served, if not for measurements of altitude, at least for sufficiently exact azimuthal directions. With this end in view, Sella marked his stations by setting up cairns visible from the photogrammetric stations, so that they could be included in the network of stations of reference or geodetic points upon which the survey was based.

It is possible that instead of glass plates we might have used films, which are so much more convenient because of their small bulk and weight. Comm. Paganini, however, does not consider their use advisable, as no good results have been

[1] See the heliotype reproduction of the photogrammetric panorama (S) given on a natural scale as an example of the work done.

obtained with them in three previous campaigns. They easily undergo changes in the celluloid, owing to their sensitiveness to heat, cold, moisture and the chemicals used in developing; so that the image varies in a way which would not be noticeable in ordinary photographic work, but which is sufficient to cause errors in the measurements, which must be corrected to the tenth and hundredth of a millimetre.

The Military Geographical Institute was authorized to execute the topographical representation of the region surveyed by the expedition. It confided the work to Comm. Pio Paganini. The scale chosen for the map was 1 : 100,000. The work proved somewhat arduous, especially at the beginning, on account of the deficiency of well-defined geodetic points, which necessitated referring the survey to several conspicuous points determined by intersection—in other words, concluded from vertices of the secondary triangulation executed for Kashmir, which is, in its turn, connected with the North-western Himalayan series of the primary triangulation of India. A double chain of triangles (quadrilateral and diagonal) of the secondary triangulation of Kashmir extends along the course of the Indus from south-east to north-west, from a point very near its sources to as far as Skardu, where it bends southwards in order to join up with the main system of the Indian survey. From the vertices of this portion of the trigonometric chain (Upper Indus triangulation) were intersected the highest summits of the Karakoram, including the two Masherbrums, Peak No. 8 or Bride Peak, Peak No. 9 or Hidden Peak, Nos. 10, 11 and 12 of the Gasherbrum range, and lastly and highest of all Peak No. 13 or K^2—all these summits surrounding the tract which was to be mapped. But we must consider that these points were intersected at distances of 50 and 100 miles with cross-bearings meeting at acute angles and taken from relatively low points, while there were no signal stations to mark with precision the points aimed at, and thus it was not possible to determine their position otherwise than approximately. However, the following table shows the elements of the points which were used for the purpose in question. It was not always easy to recognize them as they appeared on the perspectives. They were measured also with the tacheometer from several stations, as is shown on the sketch of the triangulation.

Points observed.	Latitudes N.	Longitudes E.G. (old determ.)	Height.	Height.	No. of the determined visuals.		Difference per mile in common sides of triangles.
					Position.	Height.	
			feet	metres			feet
Masherbrum East ...	35° 38′ 36″·4	76° 90′ 57″·9	25,660	7,821·3	9	7	0·4
Peak No. 8 : Bride Peak	35° 36′ 44″·0	76° 36′ 50″·0	25,110	7,653·6	6	4	1·5
Peak No. 9 : Hidden Pk.	35° 43′ 30″·0	76° 44′ 15″·0	26,470	8,068·5	6	4	1·6
Peak No. 10 } Gasherbrum	35° 45′ 31″·0	76° 41′ 42″·0	26,360	8,034 6	6	2	2·4
Peak No. 11 } Gasherbrum	35° 45′ 36″·0	76° 41′ 00″·0	26,090	7,952·3	6	2	2·0
Peak No. 12	35° 45′ 38″·0	76° 39′ 29″·0	26,000	7,924·9	6	2	0·8
Peak No. 13 : K^2 ...	35° 52′ 55″·0	76° 33′ 18″·0	28,250	8,610·7	10	9	2·7

We see that the figures most to be trusted are those for Masherbrum East; the other Peak, or South-east, was omitted because it was invisible from the region surveyed, being masked by the first, which is only about 1,000 feet from it. The tract surveyed was comprised within a square formed by Masherbrum, Bride Peak, Hidden Peak and K². Thus a point was chosen for the origin of the rectilinear co-ordinates which was the approximate centre of this square—that is to say, about at the intersection of the meridian 76° 35′ E. with the parallel 35° 45′. The graduation of the longitude in the final survey was put 2′ 30″ farther east, according to the correction made in 1877 to the longitude of Madras, upon which are based the longitudes of the triangulation of India.

The most distant point, Masherbrum, is about 15 miles from the origin of the co-ordinates; as the origin itself has the latitude of 35° 45′, nearly the same as the southern end of Italy, the elements for the calculation of the rectilinear co-ordinates are already to be found in the appropriate tables.[1] They result from the formulæ:

$$x = I_0 \cos L \,\Delta P''$$

$$y = II_0 \,\Delta L'' + III_0 \,(\Delta P'')^2$$

in which L is the latitude and P the longitude of the point; I_0, II_0 and III_0 are constants which depend upon the origin of the co-ordinates of latitude L and longitude P. The value of these constants is obtained from the aforesaid tables and calculated with the Bessel ellipsoid elements:

$$I = N \sin 1''$$

$$II = \rho \sin 1''$$

$$III = \frac{1}{4} N \sin 2\,L \sin^2 1''$$

N and ρ are respectively the great normal and the radius of curvature of the meridian ellipsis for latitude L. For the points before mentioned, with the relative geographical co-ordinates given by the catalogue contained in Vol. VII (Division E, Group I, No. 13), Triangulation of Kashmir, the following rectilinear co-ordinates were obtained:—

Masherbrum East	x =	− 21333·8	(69992·8)	y =	−	11796·0	(38700·7)
Bride Peak	„	+ 2768·1	(9081·7)	„	−	15285·0	(50147·6)
Hidden Peak	„	+ 13946·2	(45755·2)	„	−	2757·4	(9046·6)
Gasherbrum I.	„	+ 10097·6	(33128·6)	„	+	949·6	(3115·5)
„ II.	„	+ 9042·5	(29667·0)	„	+	1114·0	(36548·5)
„ III.	„	+ 6756·7	(22167·6)	„	+	1173·7	(38507·2)
K²	„	− 2558·1	(8392·7)	„	+	14638·7	(48027·2)

[1] See *Istituto Geografico Militare. Istruzione per la resoluzione di alcuni problemi riguardanti e relazioni di posizione fra punti dati per le loro coordinate geografiche.* Florence, Barbèra, 1896.

Thus it was possible to fix the above points on the drawing on the scale of 1 : 100,000, proceeding afterwards to the necessary adjusting by means of the sides, using the well-known formula :

$$S = \frac{\rho_0 \, \Delta \, L''}{\cos \, \phi} \sin 1'',$$

where the angle ϕ is given by the formula :

$$\tan g \, \phi = \frac{N_0 \cos L_0}{\rho_0} \, \frac{\Delta \, P''}{\Delta \, L''}$$

This formula may also be used for distances over 30 miles. S is the length or side unknown ; $L_0 = L_m + \epsilon$ where L_m is the mean latitude and ϵ a little correction omitted in case of distances under 25 miles. N_0 and ρ_0 are the principal radii of the ellipsoid, in correspondence with latitude L_0. Thus were obtained the following distances :—

K² – Masherbrum East	32424·0	metres	(106377·9 feet)
„ – Bride Peak	30395·0	„	(99721·1 „)
„ – Gasherbrum I	18641·0	„	(61158·1 „)
„ – Hidden Peak	23985·0	„	(78690·9 „)
Hidden Peak – Masherbrum East	36418·0	„	(119481·6 „)
„ „ – Gasherbrum III	8197·1	„	(26893·4 „)
„ „ – Bride Peak	16787·0	„	(55075·4 „)
„ „ – Gasherbrum II	17559·0	„	(57608·3 „)

The circuits of the horizon, executed from different stations and transferred to the drawing by means of the finder, serve also to fix on the design the photogrammetric and tacheometric stations, and also to determine those other significant points which are to be used as points of reference for further stations and for the orientation of the perspectives. This was indispensable, for the photogrammetric stations scattered over the Savoia and Godwin Austen glaciers, not all of which could take in three points of the Indian Triangulation, could by this means be located with sufficient exactness on the drawing.[1]

Two positives were printed of each of the panoramic views, one for composing the panoramas themselves, the other to measure with the compasses the coordinates of the points useful in the survey, after having chosen and distinguished them on the views. The effective distance of the perspective view-point was then determined on the unmounted prints. All these being taken under the same conditions and with a constant indicated focal length, and the same quality of paper being used for printing, always cut the same way of the fibre, the result must be a constant value for the effective distance, in all the printed positives. This value is determined by getting the mean of various measurements made on several

[1] See the sketch of the triangulation, whereon are marked all the points which served for the construction of the survey.

perspectives and for different panoramas[1]. The focal length indicated by the lens in our case was 180·3 millimetres, and the true focal length determined at Florence was 180·6 millimetres. After having chosen and marked in red on the perspectives the various secondary points to be mapped, and transferred their abscissæ upon the sector in accordance with the directions already described, and properly orientated on the drawing, the directions to the said points of the various stations are traced, and by intersection their position in the survey is obtained. Some 300 points were determined in this way.

Finally, in the same way, by carrying the abscissæ and ordinates upon the finder for altitudes the heights of the said points were determined by at least two derivations. With the help of all these points and the stations and references fixed upon the panoramas, it was possible to complete the map, inserting the details and forms of the region—in which the panoramas were of the greatest assistance.

The difficulty of the ground, the scarcity of trigonometric points, the impossibility—owing to the enormous differences of level—of accurately sighting trigonometric summits unprovided with signals, the short time at our disposal, the limited number of photographic plates, all this prevented us from gathering sufficient elements for a true topographical survey. However, we may feel some satisfaction over the result achieved under such conditions. It has at all events sufficient accuracy to serve as point of departure for other explorers making a more extended survey in the same field.

In conclusion, I must express our gratitude to Comm. Paganini, to whose methods and whose instruments we are almost wholly indebted for the work executed on the spot, and to whose experience and assistance we owe the execution of the map. My zeal to make known an admirable topographical method, remarkable for its simplicity and its suitability for high mountain work, has led me to describe it in considerable detail. For, despite the fact that this method has been employed in Italy, with the best results, since 1876, and has been introduced also in certain foreign countries, the English Royal Geographical Society does not mention it, even in its most recent publications (*Hints to Travellers*, 9th ed., 1906; and *Maps and Map Making*, E. A. Reeves, 1910); and, in fact, considers the application of photography to topography to have a very limited and subordinate value. The June number of the *Geog. Jour.*, 1911, has an article by A. O. Wheeler, of the Topographical Office of the Canadian Government, in which full justice is rendered to the photogrammetric method, and which will no doubt contribute toward making it better known in England.

[1] For description of this determination see the monograph already cited and the *Manuale* of Comm. Paganini.

APPENDIX B.

METEOROLOGICAL DESCRIPTION

AND

ALTIMETRIC CALCULATIONS

From Observations made by the Expedition

H.R.H. THE DUKE OF THE ABRUZZI

IN THE

KARAKORAM

AND

WESTERN HIMALAYA.

BY

Prof. DOMENICO OMODEI.

Appendix B.

I.—LIST OF INSTRUMENTS USED.

The expedition was equipped with the following instruments for making the more important meteorological observations, especially those used for computing heights :—

I. One mercurial Fortin barometer, No. 3314, with graduated scale from 240 to 520 millimetres.

Id. No. 3313, with graduated scale from 240 to 520 millimetres.

Id. No. 3312, with graduated scale from 210 to 490 millimetres.

Id. No. 1, with graduated scale from 200 to 400 millimetres.

II. Two aneroid barometers furnished with three graduated scales for altitudes to 29,000 feet.

III. One hypsometer with three pairs of thermometers :—

1st from 58° to 78° in tenths.
2nd ,, 65° ,, 88° ,,
3rd ,, 72° ,, 102° in half-tenths.

IV. Two pairs of thermometers maximum and minimum self-registering.

V. Four mercurial thermometers.

VI. Two standard thermometers.

VII. Four thermometers with bulb blackened in vacuum.

All the above instruments were verified at the National Physical Laboratory at Kew, with the exception of the hypsometers. Of these the pair from 72° to 102° had already been used on the Ruwenzori expedition, and the others were manufactured and corrected in Geneva.

The correction of some of the mercurial Fortin barometers remained uncertain for lack of apparatus with which to compare them at such unusually low pressures; but this was compensated for by making numerous comparisons under low pressures in the mountains. In this way it was possible to use all the barometers.

These instruments, in consequence of their special construction, are very fragile, and unfortunately the damage is not easily discovered by external marks, so that the observations may be very erroneous if not taken with great caution. It is necessary for this reason to submit them to continual comparison in order to give assurance of their regular working. A great many of these comparisons were made both with the barometers and the hypsometers—in fact every time the opportunity arose—and always with reference to No. 3314, of which the exact correction was known. Especial care was taken to preserve this barometer from deterioration.

In order to render the following table more concise, only those results are given which were obtained from the various series of comparisons, some of which were made before the highest ascents, some at the most elevated points and some during the descent.

No.	Dates of comparison.	Number of observations.	Extremes of pressure. mm.	Correction. mm.
	Barometer N. 3313.			
I.	May 13th, 20th, 26th, 27th, 29th and June 2nd	8	from 414·09 to 536·13	+ 1·215
II.	July 19th, 20th, 23rd and 28th ...	8	„ 393·90 „ 471·13	+ 1·205
			Mean	+ 1·215
	Barometer N. 3312.			
I.	May 20th...	3	from 468·99 to 469·32	+ 1·180
II.	July 23rd and 28th	3	„ 468·71 „ 471·30	+ 1·040
			Mean	+ 1·110
	Barometer N. 1.			
I.	May 31st, June 1st, 6th, 8th and 13th	9	from 399·39 to 398·60	+ 1·150
II.	July 8th, 9th and 10th	3	„ 354·47 „ 391·07	+ 1·220
			Mean of means	+ 1·810

The table shows that despite the difficulty of transportation, the correspondence of the barometers was very satisfactory, so that the results obtained are quite reliable. It is important to note that the greatest number of observations were taken with barometers Nos. 3314 and 3313 (No. 3312 was used in the base camp at Rdokass); and that the observations with the hypsometer were always taken at the same time (with two, and sometimes with four thermometers) to avoid all chance of error. The readings of the thermometers (within the limits of approximation of the instrument) were always in accordance with those of the barometers.

Only limited use was made of the aneroids. However, they were compared from time to time with the mercurial Fortin barometers in order to keep them ready in case of need. The experience acquired in Africa on the Ruwenzori, as well as on the present expedition, has positively demonstrated that one cannot rely upon the indications given by the aneroid barometers, however accurate their construction, on account of the unavoidable shaking up they get in transportation. The hypsometer was carried as a substitute for the mercurial barometers in case of breakage, and also for those ascents on which it might not be possible to carry the barometers. The hypsometer certainly gives a less degree of precision than the mercurial barometer. The error of one-tenth of a degree (which is not unlikely to occur owing to the difficulties attending the observations) would cause a corresponding error in the pressure of about two millimetres, an error not possible to the readings of the mercurial barometer.

To ensure the greatest possible degree of accuracy, the use of the hypsometer was constantly associated with that of the mercurial barometers; because, though no doubt the results it gives have a smaller degree of precision, it may be useful in detecting the presence of any disturbing agent in the Fortin barometers—the penetration of an air bubble, for instance, which is the commonest and the most to be feared. With few exceptions, use was made of the sling-thermometers for measuring the temperature of the air. These are certainly preferable to the stable ones, although long usage proved fatal to several of the instruments. They enabled us to obtain the measurement of the tension of vapour and of the humidity of the air, their bulbs being covered with a sheath of cotton soaked in water.

In order to get an approximate idea of the intensity of the sun's heat, thermometers with the bulb blackened in vacuum were used.

In providing the above instruments, the Duke was perfectly aware of the just criticism usually made by scientists upon determinations of this nature. But he contented himself with little, not being able to obtain the best.[1]

The carrying of a meteorological cage would have been difficult, and its advantage was problematical. Therefore the following arrangement was adopted for the exposure and reading of the instruments.

At Rdokass, where the period of the observations was most extended, the instruments were hung on a cross-piece about three feet high, held up by two stakes, while a waterproof cap of convenient height served to protect them from rain and sun at every hour of the day. For the other stations a wooden tripod was employed, covered with a strong canvas cap, under which the instruments were suspended in such a manner as to secure free circulation of air.

The hours of observations indicated in the following tables correspond always to the local time at which the observations were taken in the observatories of India, the data of which were considered as terms of comparison.

[1] On the Ruwenzori expedition the Duke had carried among other instruments an excellent Ångström attinometer, but owing to its bulk and the great difficulty of its management, which required a reflecting galvanometer, he was unable to make use of it as he had hoped.

The greatest accuracy was aimed at in taking the observations—as far as the sometimes very difficult circumstances would permit. The comparison of barometers, which I have described above—which might satisfy the requirements of a laboratory rather than the conditions of an arduous campaign—is sufficient demonstration of the care and circumspection practised. In the tables that follow are given all the observations taken by the expedition from Gund to Tragbal, between April 25th and August 8th.

The readings of the barometers have been corrected for instrumental error, reduced to 0°, and for gravitation; corresponding corrections for all the other readings being made in the same way.

The tables showing the observations as they were entered in the note-book on the spot, though they refer to only a limited period of time, form a valuable and interesting addition to our knowledge of the climatology of these distant and still little known regions.

II.—TABLE OF RESULTS.

A.—From Srinagar to the Baltoro Glacier.

Date. Month.	Day.	Hour.	Pressure, mm.	Instrument used.	Temperature, cent.	Tension of vapour, mm.	Relative humidity.	Temperature. Maximum, cent.	Minimum, cent.	Indicated by the thermometer with black bulb, cent.	Weather notes.
GUND (stay from 11.30 a.m. of the 25th to 7.30 a.m. of the 26th).											
April...	25	4 p.m.	—	—	18·0	6·82	44	20·0	6·5	—	Half overcast sky, cirri-strati.
SONAMARG (from 2 p.m. of the 26th to 6.30 a.m. of the 27th).											
April...	26	4 p.m.	—	—	6·8	6·52	88	—	—	—	Sky covered.
BALTAL (from 10.30 a.m. of the 27th to 2 p.m. of the 28th).											
April...	27	4 p.m.	540·35	Hyps.	4·3	5·52	89	12·0	2·0	—	Sky covered, rain at intervals.
MUTAJUN (from 3 p.m. of the 28th to 4 a.m. of the 29th).											
April...	28	4 p.m.	516·24	Fortin	9·4	2·67	30	11·0	2·0	—	Clear sky.
DRAS (from 10 a.m. of the 29th to 7 a.m. of the 30th).											
April...	29	4 p.m.	—	—	11·5	7·07	70	—	—	—	Sky covered in a.m., clear with strong west wind in p.m.
KARBU (from 2 p.m. of the 30th to 7 a.m. of May 1st).											
April...	30	4 p.m.	—	—	18·0	10·87	71	—	—	—	Partly cloudy, dull, wind S.W. to W. 3.
KARAL (from 12 m. of the 1st to 7 a.m. of the 2nd).											
May ...	1	4 p.m.	—	—	11·0	6·21	63	—	—	—	Clear and calm in a.m., dull, strong S.W. wind in p.m.
OLTHINGTHANG (from 12 m. of the 2nd to 6.30 a.m. of the 3rd).											
May ...	2	4 p.m.	544·45	Hyps.	14·8	8·0	64	18·0	5·0	—	Clear in a.m., overcast in p.m., gusts of wind from W.

A.—From Srinagar to the Baltoro Glacier. (*Contd.*)

Date. Month.	Day.	Hour.	Pressure, mm.	Instrument used.	Temperature, cent.	Tension of vapour, mm.	Relative humidity.	Temperature. Maximum, cent.	Minimum, cent.	Indicated by the thermometer with black bulb, cent.	Weather notes.
TARKUTTA (from 10 a.m. of the 3rd to 6.30 a.m. of the 4th).											
May ...	3	4 p.m.	561·15	Hyps.	16·8	0·96	7	26·0	7·0	—	Clear, gusts from S.W. in p.m.
KHARMANG (from 12 m. of the 4th to 6.30 a.m. of the 5th).											
May ...	4	4 p.m.	565·35	Hyps.	18·9	0·78	5	—	—	—	Clear, gusts in p.m. from W. to S.W.
TOLTI (from 10.45 a.m. of the 5th to 6.30 a.m. of the 6th).											
May ...	5	4 p.m.	569·55	Hyps.	15·8	0·0	0	—	—	—	Clear, gusts from W. in p.m.
PARKUTTA (from 12.30 p.m. of the 6th to 6.15 a.m. of the 7th).											
May ...	6	4 p.m.	—	—	19·5	0·76	4	23·0	5·5	—	Clear and calm early, then half overcast, wind from W. 2, cirri-strati.
GOL (from 10.30 a.m. of the 7th to 3.30 a.m. of the 8th).											
May ...	7	4 p.m.	—	—	17·0	3·17	22	19·7	7·5	—	Overcast in a.m., cum.-strati, wind from W. 4, p.m. clear, wind from W. 2.
SKARDU (from 12 m. of the 8th to 7 a.m. of the 9th).											
May ...	8	4 p.m.	—	—	19·0	2·54	16	—	—	—	Clear and calm.
SHIGAR (from 11 a.m. of the 9th to 6.30 a.m. of the 10th).											
May ...	9	4 p.m.	577·40	Hyps.	22·9	1·19	5	28·5	5·8	54·2	Clear and calm.
KUSHIMUL (from 12 m. of the 10th to 6.15 a.m. of the 11th).											
May ...	10	—	578·63	Hyps.	23·4	0·89	13	30·0	4·0	57·0	Cirri-strati, wind from S.W. 2.
DUSSO (from 12 m. of the 11th to 6.30 a.m. of the 12th).											
May ...	11	4 p.m.	570·03	Hyps.	20·9	2·46	13	23·0	8·0	57·0	Clear, calm, cirri-strati, wind from W. 3.

A.—From Srinagar to the Baltoro Glacier. *(Contd.)*

Date.			Pressure, mm.	Instrument used.	Temperature, cent.	Tension of vapour, mm.	Relative humidity.	Temperature.			Weather notes.
Month.	Day.	Hour.						Maximum, cent.	Minimum, cent.	Indicated by the thermometer with black bulb, cent.	
GOMBORO (from 12 m. of the 12th to 6.15 a.m. of the 13th).											
May ...	12	4 p.m.	560·05	Hyps.	18·4	1·65	10	22·0	—	41·2	Clear, calm, in p.m., ¾ covered, strat.-cum., wind from S.W. 3.
CHONGO (from 11 a.m. of the 13th to 6.30 a.m. of the 14th).											
May ...	13	4 p.m.	532·50	Fortin	12·4	3·06	28	18·5	4·0	42·5	¾ covered, cirri.-cum., wind bet. S. and S.W. 2.
ASKOLEY (from 10 a.m. of the 14th to 6 a.m. of the 16th).											
May ...	14	10	527·64	Fortin	12·9	2·76	24	17·0	2·0	41·0	a.m. ½ covered, cir.-strat. p.m. strat.-cum.
		4 p.m.	526·45	"	9·9	6·76	74				
" ...	15	8	528·43	"	8·9	1·19	14				
		10	528·21	"	12·9	0·68	6	19·5	3·0	50·0	a.m. ½ covered, cirri.p.m.¾,gloomy, gusts from W.
		4 p.m.	528·24	"	10·9	2·38	24				
PUNMAH (from 11.30 a.m. of the 16th to 6 a.m. of the 17th).											
May ...	16	4 p.m.	522·54	Fortin	13·4	3·54	31	19·0	7·0	—	
PAIJU (from 12 m. of the 17th to 6 a.m. of the 18th).											
May ...	17	4 p.m.	508·83	Fortin	12·7	1·81	16	20·5	5·0	59·0	a.m. gloomy, ¾ covered, cir.-cum. Light S W. wind.
Between LILIGO and RHOBUTSE (from 11.30 a.m. of the 18th to 6 a.m. of the 19th).											
May ...	18	4 p.m.	486·87	Fortin	9·9	1·08	12	17·0	0·0	54·0	½ covered, strati, wind from W. 2.

B.—Rdokass.

Date.	Hour of obs. 8 a.m.				10 a.m.				4 p.m.				Weather Notes.
	Pressure, mm.	Temperature, cent.	Tension of Vapour, mm.	Humidity.	Pressure, mm.	Temperature, cent.	Tension of Vapour, mm.	Humidity.	Pressure, mm.	Temperature, cent.	Tension of Vapour, mm.	Humidity.	
May 29	471·34	5·8	2·50	36	471·69	8·8	1·19	14	470·79	9·8	0·50	7	
30	—	—	—	—	472·33	8·8	2·57	30	471·19	10·3	0·49	5	
31	471·51	5·3	1·85	27	472·14	8·3	2·87	35	470·50	11·8	1·27	12	
June 1	469·76	6·8	1·91	25	469·85	11·3	1·57	15	469·32	8·8	2·57	30	
2	469·22	4·8	4·06	62	469·18	5·8	3·86	55	468·34	4·8	4·75	73	
3	468·99	2·4	3·58	65	469·84	5·3	4·15	62	469·67	2·8	3·81	67	Storm ; very cloudy.
4	471·05	6·3	1·26	17	470·81	8·8	0·71	9	470·01	1·73	0·00	0	
5	470·11	3·8	2·12	35	469·49	7·8	0·83	10	467·81	9·1	0·53	6	Fine all day, windy in p.m.
6	468·18	5·3	4·65	69	468·29	7·8	0·37	5	467·66	10·3	0·00	0	
7	469·99	5·8	0·65	9	469·86	7·8	0·00	0	467·86	12·7	0·00	0	
8	469·61	4·3	1·43	23	469·45	8·3	0·00	0	469·17	10·8	0·87	9	Fine, cloudy in p.m.
9	470·06	4·8	1·17	18	470·01	9·3	0·00	0	468·96	12·3	0·00	0	
10	468·77	4·8	1·69	26	468·41	8·3	0·54	7	466·74	9·8	0·59	7	
11	—	—	—	—	—	—	—	—	467·41	7·8	1·79	22	
12	468·59	4·3	2·92	47	469·86	7·3	2·57	33	469·22	9·8	2·47	27	
13	471·86	3·8	4·17	69	472·11	9·3	1·77	20	472·11	10·8	0·87	9	
14	471·65	7·3	2·96	38	471·90	11·8	2·29	22	471·29	10·3	1·67	17	
15	471·53	6·3	2·68	37	471·57	8·3	1·98	24	470·56	12·7	0·24	2	
16	470·53	6·1	2·32	33	470·41	9·3	0·89	10	470·27	5·3	3·28	49	Storm-wind, rain, sleet.
17	469·86	4·3	2·44	39	469·49	8·3	1·49	18	467·24	11·8	1·27	12	
18	468·14	6·8	0·50	7	468·41	9·1	1·21	14	466·53	12·7	0·00	0	
19	467·11	7·3	0·66	8	466·88	9·8	1·47	16	466·00	8·8	2·07	24	Cloudy.
20	466·26[1]	3·8	4·17	69	466·15	7·3	2·57	33	466·26	7·8	2·66	33	
21	468·26	4·8	3·57	55	468·00	8·3	2·36	29	466·88	12·7	0·69	7	
22	468·33	6·3	1·73	24	468·08	10·3	0·78	8	467·66	12·7	0·00	0	
23	468·46	6·3	3·56	50	—	—	—	—	467·11	13·7	0·00	0	Fine.
24	470·22	5·8	2·50	36	470·41	8·3	1·49	18	469·66	14·7	0·00	0	Fine.
25	472·83	5·3	1·85	27	472·90	10·3	0·30	3	471·86	14·7	0·00	0	Fine.

[1] Not included in computing the average, because the corresponding date was lacking for Srinagar.

B.—Rdokass. (*Contd.*)

Date.	Hour of obs., 8 a.m.				10 a.m.				4 p.m.				Weather Notes.
	Pressure, mm.	Temperature, cent.	Tension of Vapour, mm.	Humidity.	Pressure, mm.	Temperature, cent.	Tension of Vapour, mm.	Humidity.	Pressure, mm.	Temperature, cent.	Tension of Vapour, mm.	Humidity.	
June 26	471·51	7·3	1·61	20	471·36	11·8	0·00	0	469·92	16·2	0·00	0	Fine.
27	468·08	7·3	1·61	20	468·01	11·8	0·00	0	466·48	16·7	0·00	0	Fine.
28	466·49	5·3	2·80	42	466·44	5·3	5·16	77	465·81	9·3	3·08	35	Heavy rain during the night.
29	466·47	4·8	4·45	69	466·55	8·8	3·07	36	466·19	11·8	1·27	12	Fine, warm and sunny.
30	—	—	—	—	468·41	5·8	4·86	70	467·91	8·8	4·09	48	Fine.
July 1	468·37	6·8	1·62	22	468·43	10·3	0·78	8	466·80	14·2	0·00	0	Fine.
2	466·81	7·8	1·31	16	467·85	10·8	0·49	5	466·71	14·7	0·00	0	Fine.
3	468·61	6·8	1·91	25	468·81	11·3	0·58	6	467·47	15·7	0·00	0	Fine.
4	469·61	8·3	3·37	41	460·39	12·7	2·82	25	468·56	15·2	0·00	0	Cloudy, rain in evening.
5	469·56	5·8	6·42	92	—	—	—	—	467·51	13·2	2·52	22	Rain in a.m., showers all day, heavy rain at night.
6	468·93	4·8	5·46	84	468·53	7·8	4·18	53	467·79	5·8	5·38	77	Persistent rain all day.
7	467·88	3·8	5·35	88	467·86	5·8	4·86	70	466·98	10·3	2·17	23	
8	466·47	6·3	3·17	44	466·56	6·3	2·68	37	466·37	1·0	4·94	100	
9	469·21	2·4	4·53	82	469·56	5·3	3·77	56	468·99	10·3	1·67	17	Fine.
10	470·26	4·3	2·44	39	470·10	8·8	0·71	9	467·98	13·7	0·00	0	Fine.
11	469·49	6·8	1·91	25	469·40	10·3	1·67	17	467·72	15·7	0·00	0	Fine.
12	468·20	8·3	3·88	47	468·22	11·8	2·29	22	467·75	14·2	2·99	24	Cloudy.
13	468·04	7·3	6·60	86	468·43	9·3	5·40	61	467·99	10·3	5·90	63	Cloudy, slight showers.
14	469·13	8·8	4·09	48	469·11	10·3	4·26	45	469·10	11·8	3·90	37	Cloudy, slight showers.
15	468·49	7·3	5·52	71	—	—	—	—	468·09	12·7	5·02	45	Cloudy, slight showers.

Average of { Pressure ... ... 468·95 mm.
Temperature ... ... 8·6° cent.
Tension of Vapour ... ... 2·14 mm.

C.—Godwin Austen, Savoia and Upper Baltoro Glaciers.

Date. Month.	Day.	Hour.	Pressure, mm.	Instrument used.	Temperature, cent.	Tension of vapour, mm.	Relative humidity.	Temperature. Maximum, cent.	Minimum, cent.	Indicated by the thermometer with black bulb, cent.	Weather notes.
					CAMP II.						
May	24	4 p.m.	434·04	Fortin	3·0	1·34	24	12·0	9·5		Light breeze from N.
					CAMP III.						
May	25	10	416·85	Fortin	1·0	2·39	48	9·0	−10·0	49·0	Clear, N. wind.
		4 p.m.	416·72	,,	0·0	3·13	100				
,,	26	4 p.m.	417·08	,,	1·0	0·77	16	16·0	− 9·0	42·5	Clear, light wind from N.E.
,,	27	10	—		2·0	2·69	51	15·2	− 4·0	44·5	Clear in a.m., partly cloudy in p.m., light wind from S.W.
		4 p.m.	417·60	,,	6·0	0·00	0				
,,	28	8	416·88	,,	− 3·0	0·00	0	15·0	− 9·5	37·0	Sleet. Dull.
		10	417·08	,,	0·5	2·65	56				
		4 p.m.	417·28	,,	− 2·0	3·64	74				
,,	29	8	417·60	,,	− 1·5	2·08	51	12·0	− 6·0	44·0	Wind from S.W. Sleet and hail in p.m.
		10	417·05	,,	5·4	1·39	21				
		4 p.m.	417·55	,,	3·0	2·17	38				
,,	30	8	418·45	,,	0·0	3·96	100	13·5	− 9·5	51·0	Half overcast, wind from S.W., sleet in p.m.
		10	418·41	,,	7·1	4·24	56				
		4 p.m.	418·48	,,	3·0	1·34	24				
,,	31	8	417·50	,,							Clear, very light wind from S.W., partly cloudy in evening.
		10	417·58	,,	3·0	1·34	24	13·0		44·0	
		4 p.m.	437·43	,,	3·0	2·17	38				
June	1	8	416·36	,,							Partly cloudy, S.W. wind, sleet at intervals.
		10	415·88	,,	3·5	1·08	19	17·0	− 4·0	48·0	
		4 p.m.	416·02	,,	3·5	1·91	32				
,,	2	8	415·56	,,	− 1·7	2·32	70	8·0	− 3·0	35·0	Same.
		10	415·33	,,	2·5	2·43	44				
		4 p.m.	414·83	,,	3·5	1·91	32				
,,	3	8	414·80	,,	0·0	3·74	85	13·0	− 5·5	51·0	2–3 in. snow, soon melted. Dull weather and light wind from N.E. in evening. Clear night, with brisk wind in gusts from S.W.
		10	415·25	,,	1·0	3·22	65				
		4 p.m.	415·76	,,	0·0	3·74	81				
,,	4	8	416·10	,,	0·0	4·16	91	12·0	− 9·5	42·5	Fair, calm upper air, S.W. 3.
		10	416·32	,,	3·0	2·17	38				
		4 p.m.	416·50	,,	3·0	0·93	17				
,,	5	8	414·96	,,	2·0	1·04	20	12·0	− 9·0	49·0	Wind S.S.W. Sky half overcast, peaks clear.
		10	415·62	,,	5·1	1·07	17				
		4 p.m.	415·13	,,	2·0	1·04	20				
,,	9	8	416·40	,,				11·0	− 8·3	38·0	Fair, light S.W. wind.
		10	416·50	,,	3·5						
		4 p.m.	416·36	,,		0·29	05				
,,	10	8	414·81	,,	0·0	2·09		10·5	− 4·0	44·8	Fair in a.m., then sky covered, S.W. wind.
		10	414·77	,,	6·1	1·44	20				
		4 p.m.	414·19	,,	4·0	1·64	27				

C.—Godwin Austen, Savoia and Upper Baltoro Glaciers. (Contd.)

Month.	Day.	Hour.	Pressure, mm.	Instrument used.	Temperature, cent.	Tension of vapour, mm.	Relative humidity.	Temperature: Maximum, cent.	Temperature: Minimum, cent.	Temperature: Indicated by the thermometer with black bulb, cent.	Weather notes.
June	11	8	413·90	Fortin	− 2·0	2·39	59	10·0	− 7·0	43·0	
		10	413·72	„	4·0	1·04	27				
		4 p.m.	414·17	„	1·0	1·17	23				
„	24	4 p.m.	417·05	„	7·0	—	—	12·0	− 6·5	39·8	Light wind from S.W., peaks uncovered.
„	25	8	419·46	„	6·0	—	—	10·0	− 6·0	42·0	Fair, calm, very clear atmosphere.
		10	419·56	„	7·0	—	—				
		4 p.m.	419·85	„	6·0	—	—				
„	26	8	418·69	„	8·0	—	—	17·2	− 4·5	49·0	Same.
		10	418·35	„	11·0	—	—				
		4 p.m.	418·60	„	11·0	—	—				
„	27	12	415·16	„	12·0	—	—	15·0	− 8·0	44·0	Fair, calm; in p.m. wind from S.W., fresh high up, peaks uncovered.
		4 p.m.	414·40	„	11·0	—	—				
„	28	8	413·13	„	− 4·0	—	—	5·0	− 3·5	29·0	Sleet, thick fog in valley, peaks covered; light wind from S.W.
		10	413·10	„	1·0	—	—				
		4 p.m.	412·88	„	4·0	—	—				
„	29	8	413·00	„	0·0	—	—	9·0	—	46·0	Snow early in a.m., half-covered sky.
		10	413·18	„	3·0	—	—				
		4 p.m.	413·40	„	5·0	—	—				
CAMP IV.											
May	31	8	391·16	Fortin	− 2·0	1·18	30	—	—	—	
		10	390·85	„	2·0	1·04	20	—	—	—	
		4 p.m.	390·55	„	− 1·0	1·04	24	—	—	—	
June	1	8	389·07	„	− 1·0	1·82	43	—	—	—	
		10	389·78	„	1·0	1·18	23	—	—	—	
		4 p.m.	388·85	„	− 1·0	1·04	24	—	—	—	
CAMP V.											
June	5	4	394·05	Fortin	−3·0	2·86	78	8·0	—	51·0	Sleet; strong tourmente from N. during night.
„	6	8	393·36	„	−8·0	1·39	56	9·0	−15·0	61·0	Sky partly cloudy, light N. wind.
		10	393·42	„	−2·0	3·96	100				
		4	393·82	„	−2·5	2·21	58				
„	7	4	393·17	„	—	—	—	12·0	−13·5	52·0	Light wind from N.N.W.
„	8	8	395·34	„	−5·0	1·27	40	9·0	−15·0	51·0	Clear, light S.W. wind.
		10	395·42	„	−3·0	2·09	57				
SAVOIA PASS (W. gl'cr., W. col.).											
June	7	5.15	349·70	Fortin	−9·0	—	—	—	—	—	

C.—Godwin Austen, Savoia and Upper Baltoro Glaciers. (Contd.)

Date. Month.	Day.	Hour.	Pressure mm.	Instrument used.	Temperature, cent.	Tension of vapour, mm.	Relative humidity.	Temperature. Maximum, cent.	Minimum, cent.	Indicated by the thermometer with black bulb, cent.	Weather notes.
					CAMP VI.						
June	12	10	395·71	Fortin	−2·0	2·34	59	4·0	− 6·0	38·0	Sleet ; dull weather, S.W. wind.
		4	396·04	,,	−3·0	—	—				
,,	13	8	397·37	,,	−1·0	3·43	80	8·0	− 4·5	50·2	Peaks covered ; S.W. wind ; in p.m. wind from N.W. and S.W.
		10	397·65	,,	3·0	2·17	38				
		4	397·94	,,	0·0	3·74	81				
,,	14	8	397·64	,,	2·0	—	—	8·0	− 4·0	—	Calm in valley ; S.W. wind on the heights.
		10	397·88	,,	3·0	—	—				
		4	397·90	,,	0·0	—	—				
,,	15	4	397·53	,,	1·0	—	—	8·0	− 7·0	—	
,,	16	8	397·13	,,	−6·0	—	—	3·0	−10·0	—	Fair and calm ; peaks uncovered.
		10	396·52	,,	8·0	—	—				
		4	396·38	,,	3·5	—	—				
,,	17	8	395·41	,,	−4·0	—	—	13·0	− 8·0	51·0	Sky covered ; light wind from S.W.
		4	395·54	,,	3·0	—	—				
,,	18	8	396·27	,,	−4·0	—	—	12·0	− 7·5	52·0	Fair in a.m. ; light wind from E.N.E. ; in p.m. sky overcast, light S.W.
		10	395·48	,,	−2·0	—	—				
		4	395·09	,,	4·0	—	—				
,,	19	10	394·16	,,	1·5	—	—	8·5	− 7·5	52·0	Wind N.E. and S.W. ; sleet, sky overcast, peaks covered.
		4	393·71	,,	4·5	—	—				
,,	20	8	393·21	,,	−1·0	—	—	8·5	−10·0	55·0	Heavy weather ; calm upper air, light S.W. wind in valley.
		10	393·56	,,	0·5	—	—				
		4	393·41	,,	0·0	—	—				
,,	21	8	394·23	,,	−6·0	2·89	100	8·0	− 9·0	50·0	Light W.N.W. in a.m., peaks uncovered ; p.m. half overcast, light S.W.
		10	394·50	,,	−1·0	1·82	43				
		4	394·15	,,	6·0	0·59	8				
,,	22	8	395·42	,,	−3·0	1·33	36	9·0	− 7·5	46·0	Fair, wind from S.W., colder above.
		10	395·25	,,	1·5	2·12	41				
		4	395·76	,,	0·5	1·04	22				
,,	23	8	394·75	,,	−4·0	1·85	55	9·0	− 8·0	51·0	Sleet ; strong wind, gusts S.W.–S.S.W. ; peaks covered.
		10	395·25	,,	5·0	—	—				
		4	395·44	,,	0·0	—	—				
					SELLA PASS.						
June	15	11.15	353·85	Fortin	−3·0	—	—	—	—	—	
					CAMP VII.						
June	14	4	373·51	Fortin	−6·5	2·04	74	—	—	28·0	Tourmente, strong S.W. ; sky overcast.

C.—Godwin Austen, Savoia and Upper Baltoro Glaciers. *(Contd.)*

Date.			Pressure, mm.	Instrument used.	Temperature, cent.	Tension of vapour, mm.	Relative humidity.	Temperature.			Weather notes.
Month.	Day.	Hour.						Maximum, cent.	Minimum, cent.	Indicated by the thermometer with black bulb, cent.	
June	15	8	373·40	Fortin	−7·0	1·22	46	—	—	60·0	Strong S.W., peaks covered.
		4	373·28	,,	−4·5	1·37	42	—	—	—	
,,	16	10	372·71	,,	−3·0	2·09	57	—	—	—	Fair early, then overcast.
,,	17	4	370·08	,,	−5·0	—	—	9·0	−10·0	—	
		8	—	,,	−9·0	—	—	—	—	—	
,,	18	10	372·18	,,	−7·0	2·67	100	—	—	—	
		4	370·85	,,	−4·0	2·61	77	—	—	—	
,,	19	4	369·43	,,	−6·0	2·89	100	—	—	—	Wind W.S.W.
,,	20	8	369·04	,,	−9·0	2·26	100	—	—	—	
					CAMP VIII.						
June	24	4	360·78	Fortin	−6·0	1·77	61	—	—	—	
					STAIRCASE.						
June	25	1 p.m.	348·30	Fortin	6·0(1)	—	—	—	—	—	
					CAMP IX.						
June	29	4	430·96	Fortin	7·0	—	—	15·0	−2·0	44·0	Wind S.W., half overcast.
,,	30	8	432·34	,,	3·0	—	—	12·0	−5·0	46·0	Sky overcast, wind S.W., snow at intervals.
		10	431·81	,,	2·0	—	—				
		4	431·91	,,	8·0	—	—				
July	1	10	431·33	,,	11·0	5·04	52	16·0	−3·0	47·0	Very fine and calm.
		4	431·33	,,	12·0	3·36	32				
,,	2	8	431·23	,,	4·0	3·54	60	17·0	−4·0	46·0	Fair in a.m., then cloudy, cirri-strati, peaks free, W. wind in upper air.
		4	431·33	,,	15·0	4·85	38				
,,	3	8	432·69	,,	4·0	3·16	52	16·0	−2·0	43·0	Fair and calm; light S.W. above, freshening in p.m. and veering W.N.W.
		10	432·65	,,	11·0	2·83	29				
		4	432·56	,,	14·5	2·87	23				
,,	4	8	433·55	,,	7·0	3·30	44	17·5	−1·5	45·4	Half overcast and cirri-strati in a.m.; strong S.W. above; high peaks covered; overcast in p.m.; gusts from S.W.
		10	434·49	,,	9·0	3·11	36				
		4	434·35	,,	11·5	3·06	30				
,,	5	8	433·01	,,	2·0	3·41	64	11·0	−2·0	42·5	Sleet, peaks covered, S.W. above.
		10	433·27	,,	4·0	5·09	83				
		4	432·95	,,	10·5	6·40	67				
					CAMP X.						
July	1	—	428·30	Hyps.	5·0	—	—	—	—	—	

(1) Uncertain.

C.—Godwin Austen, Savoia and Upper Baltoro Glaciers. *(Contd.)*

Date.			Pressure, mm.	Instrument used.	Temperature, cent.	Tension of vapour, mm.	Relative humidity.	Temperature.			Weather notes.
Month.	Day.	Hour.						Maximum, cent.	Minimum, cent.	Indicated by the thermometer with black bulb, cent.	
					CAMP XI.						
July	7	—	418·34	Fortin	4·0	—	—	—	—	—	Snow at intervals, peaks covered, light S.W.
„	8	—	—	—	—	—	—	—	—	—	Snow at intervals, peaks covered, calm below. Heavy snowfall in evening.
„	9	—	—	—	—	—	—	—	—	—	Sky covered, some peaks free.
„	10	—	—	—	—	—	—	—	—	—	Very fine, evening light S.W., peaks uncovered.
„	11	—	—	—	—	—	—	—	—	—	Very fine, S.W. above.
„	12	—	—	—	—	—	—	—	—	—	a.m. sky half overcast, p.m. overcast. Sleet, wind from S.W.
„	13	—	—	—	—	—	—	—	—	—	Snow during night, snow and sleet day, sky covered, calm.
„	14	—	—	—	—	—	—	—	—	—	Calm low down, sky covered, dull weather, sleet, half clear at sunset.
„	15	—	—	—	—	—	—	—	—	—	Calm low down, sky and peaks covered. Sleet.
„	16	—	—	—	—	—	—	—	—	—	Calm low down; half covered. Cirri-strati. High peaks covered.
„	17	—	—	—	—	—	—	—	—	—	Calm below, mostly fair, peaks partly free. In p.m. clouded over, rain.
„	18	—	—	—	—	—	—	—	—	—	Calm; sky and peaks covered; rain. N.N.E. above.
„	19	—	—	—	—	—	—	—	—	—	Calm, sky and peaks covered. p.m. half clearing. Fine sunset.

C.—Godwin Austen, Savoia and Upper Baltoro Glaciers. (Contd.)

Date. Month.	Day.	Hour.	Pressure, mm.	Instrument used.	Temperature, cent.	Tension of vapour, mm.	Relative humidity.	Temperature. Maximum, cent.	Minimum, cent.	Indicated by the thermometer with black bulb, cent.	Weather notes.
July	20	9.40	417·46	Fortin	7·0	—	—	—	—	—	Snowfall during night and a.m.; low mist, calm.
		10	417·23	"	8·0	—	—				
		12	417·31	"	6·0	—	—				
CAMP XII.											
July	3	4	393·87	Fortin	8·0	4·12	51	19·0	− 6·0	57	
"	4	4	395·37	Hyps.	2·0	4·82	91	22·0	− 1·0	22	Snow all day, W. wind high up; peaks covered; clear below.
"	5	4	393·65	Fortin	7·0	3·20	43	25·0	− 6·0	51	Snow and sunshine at intervals.
"	6	8	—	"	3·0	—	—	22·0	− 6·0	51	
		10	392·98	"	12·0	2·23	21				
		4	392·38	"	7·5	2·90	37				
"	7	8	—	"	7·5	—	—	17·0	− 5·0	49	Intervals of snow and sunshine, clearing at sunset.
		10	392·53	"	11·0	2·83	29				
		4	—	"	8·0	4·22	53				
"	8	10	391·09	"	−2·0	—	—	12·0	− 9·0	—	Snow; calm.
		4	390·30	"	+2·0	—	—			—	
CAMP XIII.											
July	9	5	377·71	Fortin	8·0	0·31	—	16·0	−17·0	51	
CAMP XIV.											
July	10	1.30	354·00	Fortin	1·0	—	—	4·0	−16·0	46	Fair and calm.
		4	354·40	"	3·0	0·52	9				
"	14	10	354·10	"	3·0	2·17	38	4·0	−10·0	60	Wind from S.W.; snow at intervals; sun.
		4	354·35	"	1·0	4·01	81				
"	15	8	—	"	2·0	—	—	3·0	− 8·0	57	Snow; light S.W.; intervals of sun.
		10	354·40	"	1·5	—	—				
		4	—	"	−1·0	—	—				
"	16	8	—	"	0·0	—	—	6·0	− 7·0	58	Light S.W.; peaks covered, clear below; intervals of sun.
		10	353·93	"	5·0	—	—				
		4	—	"	12·0	—	—				
CAMP XV (I).											
July	11	4	342·12	Fortin	0·0	—	—	30	−13·0	51·0	Fair, light S.W.
CAMP XV (II).											
July	17	4	335·74	Fortin	5·0	—	—	—	—	67·0	Cloudy.
NEAREST BRIDE PEAK.											
July	18	2.30	312·33	Fortin	6·0	4·18	57	—	—	—	

D.—Observations Made on the Return Journey.

Date. Month.	Day.	Hour.	Pressure, mm.	Instrument used.	Temperature, cent.	Tension of vapour, mm.	Relative humidity.	Temperature during the 24 hours. Maximum, cent.	Minimum, cent.	Indicated by the thermometer with black bulb, cent.	Weather notes.
CAMP ON N. SIDE OF SKORO-LA.											
July ...	28	4	470·34	Fortin	15·8	1·43	11	—	—	—	Fair, light S.W.
SKORO-LA.											
July ...	29	11	413·27	Fortin	6·4	—	—	—	—	—	Partly fair.
CAMP BETWEEN BURGI-LA AND SKARDU.											
August	1	4	504·63	Fortin	19·4	5·84	35	—	−9·0	—	Storm from S.W. in p.m.
BURGI-LA.											
August	2	9.50	427·65	Fortin	9·4	—	—	—	—	—	
II. CAMP ON THE DEOSAI TABLE-LAND.											
August	3	4	469·81	Fortin	15·3	4·66	36	—	0·0	—	Three-quarters covered, strong S.W.
SARSINGAR.											
August	4	9.50	455·81	Fortin	11·9	—	—	—	—	—	Fair and calm.
STAKPI-LA.											
August	4	12.50	470·61	Fortin	18·9	—	—	—	—	—	
BURZIL.											
August	4	4	505·22	Fortin	19·9	6·77	39·0	—	10·0	—	Fresh S.S.W.
PASHWARI.											
August	5	4	570·07	Hyps.	19·9	—	—	—	—	—	Rain in p.m. Wind S.W.
GURAIS.											
August	6	4	591·28	Hyps.	15·8	11·93	89	—	13·0	—	Showers from S.W., fresh wind.
GORÈ.											
August	7	4	546·42	Hyps.	15·8	10·54	79	—	—	—	Cloudy weather, calm.
RAJDIANGAN PASS.											
August	8	9	497·59	Fortin	12·8	5·02	45	—	—	—	Fair above, mists below.
TRAGBAL.											
August	8	4	540·38	Hyps.	20·9	—	—	—	—	—	Fair and calm.

III.—ALTIMETRIC CALCULATIONS.

Beside the results obtained by his own observations, which are given in the preceding pages, the Duke gathered a very large harvest of data from the meteorological observatories of India, in order to get the terms of reference required for the calculation of the altitudes. As results from the above data, a first base station was fixed at Rdokass, at an altitude of about 13,000 feet, well up on the Baltoro glacier, on which were taken observations of pressure, temperature and humidity for a period lasting from May 29th to July 15th.

Afterwards a second base was fixed at an altitude of about 16,000 feet (Camp III) at the very foot of K^2, beside other secondary ones, in order to secure nearer points of reference for the calculation of the height of the points reached in the various ascents. These calculations were made on the following basis :—

For all the stations before Rdokass and for those from Bride Peak onward the calculation of the various heights was made by comparing them with the simultaneous readings taken at the stations of Leh, Skardu, Gilgit, and in some cases with those taken at Srinagar as well. All observations taken at stations higher than Rdokass (from May 29th to July 15th), which formed the principal objects of the expedition, were compared with those taken simultaneously at Rdokass, except for the two last, after July 15th, when owing to a misunderstanding the observations at Rdokass were discontinued.

For the station near Bride Peak, which was the highest point reached, comparison was made with the readings taken at the four stations of Leh, Srinagar, Skardu and Gilgit.

Of the results given in the foregoing pages, those were especially taken into consideration for which the simultaneous data of reference were secured, these being complete (that is to say, not only the pressure but also the temperature of the air and the tension of vapour were known). In some isolated cases the hour of observation was not the same as that of the reference station ; in this case the readings were compared with those taken at the nearest hour, without attempting to obtain values by interpolation, which would necessarily have been unreliable.[1]

[1] The observations at the most elevated point, near the top of Bride Peak, were taken at half-past two p.m. on July 18th, and for the calculations the comparisons were made with observations taken at 4 p.m. in Leh, Srinagar, Skardu and Gilgit. From the data given by these observatories it follows that on July 18th the pressure for Leh, Srinagar, Skardu and Gilgit respectively was at 10 a.m. 497·15, 623·94, 575·15 and 631·66 millimetres, and at 4 p.m. 493·96, 619·90, 572·20 and 627·78 millimetres. Thus the pressure at 2 p.m. was presumably much higher than at 4 p.m. assumed for the calculations, and hence the altitude of the highest point reached is probably some 66 feet higher than the figure obtained. But this supplementary computation was not made, because it was a question of an isolated observation, and also because little was known of the daily variation of the pressure in those regions.

When all the necessary data were known for the two stations of reference—in other words, the pressure, the temperature and the vapour tension—the well-known formula of Rühlmann was employed to calculate the differences of level:—

$$Z = 18400\,(1{\cdot}00157 + 0{\cdot}00367\,\theta)\left(\frac{1}{1 - 0{\cdot}378\,\frac{\phi}{\gamma}}\right) \times$$

$$\times\ (1 + 0{\cdot}00259\,\cos 2\lambda)\ 1 + \left(\frac{Z + 2z}{6371104}\right) \log \frac{H_0}{H},$$

in which

Z = the difference of level between the two stations;
H_0 = the corrected pressure at the lower station;
H = " " " " upper station;

$\theta = \frac{t_0 + t}{2}$ the mean between the temperature of the air at the lower station and at the upper station;

$\phi = \frac{f_0 + f}{2}$ the mean between the vapour tension at the lower station and that obtained at the upper station;

$\gamma = \frac{H_0 + H}{2}$;

λ = the latitude;

z = the height of the lower station above sea level.

The calculations were made by means of the *Tables météorologiques internationales*, Paris, 1890.

In those cases where only the pressure and the temperature of the air were known, the tension of vapour not being determined, the formula used was that given in the *Annuaire pour l'an* 1909 *publié par le Bureau des Longitudes*, in which are also included some tables that facilitated the calculations. The formula is as follows:—

$$Z = (A^1 - A)\left(1 + \frac{t_0 + t + 1{\cdot}32\,\cos 2\lambda}{1000}\right)$$

in which

$$A^1 = 18382 \cdot \log \frac{760}{H} + \frac{1}{6366000}\left(18382\,\log \frac{760}{H}\right)^2,$$

$$A = 18382 \cdot \log \frac{760}{H_0} + \frac{1}{6366000}\left(18382\,\log \frac{760}{H_0}\right)^2,$$

the symbols having the same meaning as before.

In this approximate formula no account is taken of the humidity of the air, but to make up for this we have assumed 0·004 as the coefficient of expansion of the air instead of 0·00367.

When it is only a question of isolated observations, we consider this formula more than sufficient in consequence of the uncertainty of the law of decrease of temperature with increase of altitude.

For further proof, and to show more clearly the value that we can attribute to the individual observations in the pages that follow, we give in addition to the observations taken by the Duke those obtained simultaneously at the reference stations, drawn as far as Leh and Srinagar are concerned from the data obtained from the central observatory at Simla, and for those of Skardu and Gilgit from the observatory of Srinagar.

It is not necessary to enter here into the value of the barometric method in calculating altitudes. If this method is not on the whole to be compared with the geodetic in precision, still, used with care, it may lead to very satisfactory results.

We give in the following table the measurements obtained by the Duke in 1906 in the Ruwenzori group by means of barometric measurements and those taken two years later with the geodetic method by Major R. G. T. Bright,[1] during the labours of the Boundary Commission for the delimitation of the boundaries of the Congo Free State:—

Mountain.	Boundary commission.		H.R.H.		Differences.	
	Feet. *a*	Metres. *f*	Feet. *c*	Metres. *d*	Feet. *c−a*	Metres. *d−f*
Margherita	16794	5119	16815	5125	+ 21	+ 6
Alessandra	16726	5098	16749	5105	+ 23	+ 7
Elena	16345	4982	16388	4995	+ 43	+13
Savoia	16421	5005	16339	4980	− 82	−25
Umberto	15754	4802	15988	4873	+234	+71
Krepelin	15724	4793	15752	4801	+ 28	+ 8
Weissmann	15163	4622	15299	4663	+136	+41

Practically identical results were also attained in the determination of the altitude of Mount St. Elias:—

Altitude determined by the Duke with barometric method, 18,090 feet.

Id. by Russel (by triangulation), 18,100 feet.

Id. by I. K. MacGrath, U.S. Coast Survey (by triangulation), 18,024 feet.

But there is no doubt that the best results are those obtained from a long series of observations, and that greater uncertainty remains in the case of those based on isolated observations, especially when the tension of vapour has not been determined.

The last table contains a summary of all the altimetric data.

[1] *Survey and Exploration in the Ruwenzori and Lake Region, Central Africa.* By Major R. G. T. Bright, C.M.G., *Geog. Jour.* Aug. 1909, XXXIV, p. 128.

DATA OF OBSERVATION AND COMPARISON.

A.—From Kashmir to the Baltoro Glacier.

No.	Date.		Station of observation.					Simultaneous data of comparison			
	Month and day.	Hour.	Place.	Pressure, mm.	Temperature, cent.	Tension of vapour, mm.	Instrument used for measurement of pressure.	Of the stations of	Pressure, mm.	Temperature, cent.	Tension of vapour, mm.
1	27 April	16	Baltal ...	540·35	4·3	5·52	Hyps.	Srinagar	627·88	20·4	13·26
								Leh ...	495·52	11·3	1·94
								Skardu	574·85	18·6	0·96
								Gilgit ...	633·18	23·3	10·12
2	28 „	16	Mutajun ...	516·24	9·4	2·67	Fortin	Srinagar	628·39	21·7	13·57
								Leh ...	497·50	13·2	1·00
								Skardu	576·63	19·3	0·00
								Gilgit ...	633·33	27·3	3·68
3	2 May	16	Olthingthang	544·45	14·8	8·00	Hyps.	Leh ...	496·10	15·2	0·00
								Skardu	576·43	19·1	0·00
								Gilgit ...	632·72	23·1	1·49
4	3 „	16	Tarkutta ...	561·15	16·8	0·96	Hyps.	Leh ...	495·17	15·7	0·00
								Skardu	576·12	18·1	0·00
								Gilgit ...	632·72	23·1	1·49
5	4 „	16	Kharmang ...	565·35	18·9	0·78	Hyps.	Leh ...	496·34	15·7	0·00
								Skardu	577·26	18·1	0·00
								Gilgit ...	633·92	20·7	2·70
6	5 „	16	Tolti	569·65	15·8	0·00	Hyps.	Leh ...	496·64	15·7	0·00
								Skardu	577·21	18·1	0·00
								Gilgit ...	636·64	19·8	2·30
7	9 „	16	Shigar ...	577·40	22·9	1·19	Hyps.	Leh ...	498·64	15·1	0·00
								Skardu	578·51	23·1	0·00
								Gilgit ...	634·53	29·8	3·27
8	11 „	16	Dusso ...	570·03	20·9	2·46	Hyps.	Leh ...	498·47	17·9	0·83
								Skardu	577·19	23·3	0·05
								Gilgit ...	635·97	31·3	3·05
9	12 „	16	Gomboro ...	560·05	18·4	1·65	Hyps.	Leh ...	497·78	16·7	0·00
								Skardu	576·89	22·5	0·00
								Gilgit ...	634·86	25·8	6·12
10	13 „	16	Chongo ...	532·50	12·4	3·06	Fortin	Leh ...	496·76	17·4	0·00
								Skardu	577·04	20·5	0·00
								Gilgit ...	636·41	22·3	7·42

A.—From Kashmir to the Baltoro Glacier. *(Contd.)*

No.	Date.		Station of observation.				Simultaneous data of comparison of the stations of								
			ASKOLEY.				SKARDU.			GILGIT.			LEH.		
	Month and day.	Hour.	Pressure, mm.	Temperature, cent.	Tension of vapour, mm.	Instrument for measurement of pressure.	Pressure, mm.	Temperature, cent.	Tension of vapour, mm.	Pressure, mm.	Temperature, cent.	Tension of vapour, mm.	Pressure, mm.	Temperature, cent.	Tension of vapour, mm.
11	14 May ...	10	527·64	12·9	2·76	Fortin	577·40	16·2	4·11	635·02	17·7	6·74	498·57	11·3	1·94
		4	526·45	9·9	6·76	„	575·46	19·8	1·60	633·59	22·3	6·86	497·78	7·4	1·99
	15 „ ...	8	528·43	8·9	1·19	„	578·05	12·0	4·71	635·78	19·4	7·15	499·08	4·6	4·24
		10	528·21	12·9	0·68	„	577·85	16·1	3·37	635·92	21·7	6·27	499·05	9·9	3·49
		4	528·24	10·9	2·38	„	576·22	20·5	2·11	633·33	22·4	6·26	497·45	9·4	1·67
	Mean ...		527·79	11·1	2·75		577·00	16·9	3·18	634·73	20·7	6·66	499·99	8·5	2·67

A.—From Kashmir to the Baltoro Glacier. (Contd.)

No.	Date. Month and day.	Hour.	Place.	Pressure, mm.	Temperature, cent.	Tension of vapour, mm.	Instrument for measurement of pressure.	Simultaneous data of comparison: Of the stations of	Pressure, mm.	Temperature, cent.	Tension of vapour, mm.
12	16 May	4	Punmah ...	522·54	13·4	3·54	Fortin	Leh	497·02	12·5	4·90
								Skardu	575·06	19·9	1·54
								Gilgit	632·32	25·6	5·83
13	17 „	4	Paiju... ...	508·83	12·7	1·81	Fortin	Leh	497·71	10·6	1·09
								Skardu	576·48	19·8	1·71
								Gilgit	634·53	22·9	8·03
14	18 „	4	Between Liligo and Rhobutse	486·87	9·9	1·08	Fortin	Leh	498·74	12·1	3·03
								Skardu	576 43	22·8	0·00
								Gilgit	632·90	29·9	4·63

The four tables which follow give the data from observations made May 29th to July 15th at the stations of Srinagar, Leh, Skardu and Gilgit, which served as reference to the observations carried on during the same period at Rdokass (see pages 400–401).

B.—Srinagar.

Hour of observations—	8 a.m.				10 a.m.				4 p.m.			
Date.	Pressure, mm.	Temperature, cent.	Tension of vapour, mm.	Relative humidity.	Pressure, mm.	Temperature, cent.	Tension of vapour, mm.	Relative humidity.	Pressure, mm.	Temperature, cent.	Tension of vapour, mm.	Relative humidity.
29 May	629·30	17·4	11·81	80	629·45	21·3	14·45	77	627·21	29·2	22·38	74
30	—	—	—	—	629·83	24·2	16·88	75	627·62	27·8	20·43	73
31	628·54	18·8	12·57	78	628·64	23·0	15·72	83	625·99	26·8	19·31	74
1 June	627·22	19·7	13·69	80	627·60	21·9	15·05	77	626·12	23·4	16·33	76
2	629·12	16·6	11·87	84	628·58	19·7	12·92	76	628·43	17·9	11·94	78
3	629·60	16·3	12·05	87	629·80	18·8	13·62	84	626·81	24·1	17·29	78
4	628·01	17·7	12·06	80	628·23	21·3	14·29	76	624·85	27·2	20·02	75
5	625·90	19·4	13·10	78	625·64	23·0	15·72	75	624·47	24·8	18·11	78
6	626·12	17·4	11·81	80	626·01	21·6	15·23	79	622·71	26·9	19·63	75
7	624·75	18·6	12·70	80	624·83	23·6	16·72	77	621·95	29·8	22·42	72
8	626·10	19·7	13·22	77	625·79	24·3	16·82	74	623·56	30·1	21·61	68
9	625·79	20·2	13·85	79	625·84	24·6	16·99	74	623·42	30·0	22·93	73
10	624·91	21·3	14·93	79	625·06	25·6	17·62	73	623·79	27·5	21·20	78
11	—	—	—	—	—	—	—	—	625·23	22·6	15·97	78
12	627·52	18·0	12·17	79	627·60	22·4	14·92	74	626·06	28·5	21·59	75
13	629·83	19·7	13·22	77	629·91	24·4	17·29	76	627·77	27·7	20·29	73
14	630·95	20·5	14·14	79	631·18	24·4	17·29	76	627·67	28·9	20·93	71
15	628·74	20·2	13·38	76	628·76	24·7	17·63	76	625·36	30·6	22·75	70
16	627·24	20·5	13·67	76	626·83	21·9	14·57	75	627·23	21·1	13·93	75
17	627·88	16·6	11·45	81	627·60	19·8	13·48	78	624·93	25·7	19·03	78
18	625·90	18·0	12·17	79	625·96	22·2	13·42	67	623·32	28·5	21·99	76
19	624·07	19·7	13·22	77	624·22	22·3	15·51	77	624·62	22·7	15·73	77
20	—	17·4	12·24	83	626·15	21·6	15·41	80	624·03	26·7	17·67	68
21	626·07	19·7	13·69	80	626·12	24·4	16·76	74	623·47	28·8	20·60	70
22	626·12	20·5	14·14	79	626·25	24·8	17·75	76	624·29	28·1	20·83	74
23	627·12	17·2	11·50	79	—	—	—	—	624·95	28·7	21·87	75
24	627·14	20·2	13·85	79	627·19	24·2	17·94	80	625·44	31·1	24·39	73
25	628·16	19·7	12·92	76	627·93	25·3	17·81	74	624·74	32·4	26·04	72
26	626·51	21·3	14·93	79	626·12	26·1	17·50	69	622·95	33·1	26·53	70
27	624·19	22·7	15·90	78	623·96	27·5	19·45	71	620·57	33·7	25·69	66
28	625·18	18·8	13·47	83	625·71	20·0	14·45	83	623·40	24·6	16·63	72
29	624·37	19·7	13·22	77	624·14	23·6	16·55	76	622·23	26·9	19·24	73
30	—	—	—	—	624·64	25·3	17·81	74	621·73	30·3	24·02	75
1 July	623·73	22·4	15·58	77	623·40	26·4	18·79	73	620·20	31·9	25·22	72
2	622·03	22·7	15·40	75	622·08	27·5	19·83	73	619·85	32·3	25·42	71
3	623·81	24·1	16·94	76	624·27	27·7	22·90	83	622·05	31·6	24·97	72
4	625·91	23·3	16·91	80	626·17	28·2	21·17	74	625·03	30·3	22·74	71
5	626·42	22·4	16·60	82	—	—	—	—	624·52	28·9	21·94	74
6	626·91	19·1	13·59	83	627·06	21·4	15·36	81	624·44	25·0	17·09	73
7	626·01	18·0	12·17	79	626·20	20·9	13·42	73	623·30	28·3	19·92	70
8	624·44	17·4	11·81	80	626·91	15·8	11·23	84	627·08	15·7	10·73	81
9	628·84	16·3	11·34	82	628·96	18·6	12·70	80	625·99	25·0	18·17	77
10	627·72	19·4	13·41	80	627·88	22·2	16·04	81	624·09	28·1	21·04	74
11	625·49	21·3	14·93	79	625·52	24·2	16·71	74	623·00	29·3	22·53	74
12	624·49	21·9	13·60	70	624·59	25·7	18·47	75	622·82	26·4	19·17	75
13	624·62	21·1	14·58	79	625·00	26·5	19·30	75	622·90	29·7	21·86	71
14	625·15	22·4	15·58	77	625·25	27·2	20·21	75	623·56	26·7	19·75	76
15	624·80	21·3	14·93	79	—	—	—	—	622·13	28·3	21·10	74

Calculated mean of { Pressure ... ... 625·72 mm.
Temperature ... 23·5° c.
Tension of vapour 16·90 mm.

Leh.

Hour of observations—	8 a.m.				10 a.m.				4 p.m.			
Date.	Pressure, mm.	Tempera-ture, cent.	Tension of vapour, mm.	Relative humidity.	Pressure, mm.	Tempera-ture, cent.	Tension of vapour, mm.	Relative humidity.	Pressure, mm.	Tempera-ture, cent.	Tension of vapour, mm.	Relative humidity.
29 May	501·66	12·7	1·92	17	501·51	16·7	1·44	10	498·54	21·0	0·00	0
30	—	—	—	—	501·79	17·3	1·86	12	499·08	20·5	1·64	9
31	501·13	12·9	2·44	22	500·98	17·7	1·84	12	497·81	21·3	2·70	14
1 June	499·25	13·2	2·26	20	498·90	17·4	2·47	16	496·05	22·4	0·00	0
2	498·98	14·1	3·11	26	498·44	17·3	3·69	25	494·91	23·5	3·12	14
3	497·95	13·5	4·15	36	497·93	14·6	3·25	26	496·61	17·9	3·68	24
4	499·41	11·3	3·40	34	499·20	15·7	2·82	21	499·55	19·1	2·02	12
5	498·03	12·9	3·84	35	497·63	17·8	2·46	16	495·27	21·6	0·00	0
6	496·73	11·8	2·78	27	496·66	17·8	1·56	10	494·40	20·9	1·28	7
7	498·10	14·1	2·57	21	497·98	17·4	1·46	10	494·43	22·3	0·00	0
8	498·10	14·6	1·63	13	498·03	18·9	0·00	0	495·75	22·8	0·00	0
9	498·39	14·6	1·42	11	498·13	19·1	1·91	11	495·27	24·1	1·37	6
10	497·34	14·3	2·99	24	496·94	18·8	1·98	11	494·10	22·7	1·74	8
11	—	—	—	—	—	—	—	—	494·71	20·7	1·76	10
12	497·49	13·8	3·08	26	497·68	19·1	2·84	17	495·87	22·4	0·00	0
13	500·93	13·5	2·94	25	500·93	17·9	1·84	12	498·31	22·9	1·61	8
14	500·77	16·3	3·36	24	500·64	19·5	2·47	13	497·70	23·4	2·79	13
15	500·37	14·3	3·67	30	500·29	18·9	2·85	17	497·25	23·8	0·00	0
16	499·30	13·8	3·63	31	498·95	17·9	2·29	15	496·10	23·5	0·00	0
17	497·39	14·6	3·14	25	494·50	18·2	2·57	16	495·47	19·3	0·65	3
18	497·91	12·7	3·96	36	500·03	17·4	2·70	18	494·98	20·8	2·29	12
19	496·25	12·9	4·51	40	495·51	17·5	5·00	33	494·53	16·4	4·94	35
20	—	9·3	6·00	69	496·43	13·8	5·80	49	494·15	17·9	3·57	23
21	497·73	12·1	4·10	39	497·47	16·0	3·54	26	494·96	22·4	0·00	0
22	498·08	14·6	3·14	25	497·75	18·4	3·38	21	494·76	24·1	2·00	9
23	498·21	13·8	3·97	33	—	—	—	—	495·17	23·5	3·37	16
24	499·76	12·4	2·95	27	499·78	17·3	2·08	14	497·55	23·9	1·13	5
25	501·44	14·1	3·79	31	501·39	19·6	2·06	12	497·81	25·5	2·16	9
26	500·17	14·6	4·16	34	499·66	20·7	2·35	13	496·25	26·7	2·59	10
27	497·17	15·7	4·07	31	496·58	21·0	2·76	15	492·80	25·9	3·07	12
28	495·22	14·6	4·74	38	494·53	20·4	4·24	23	492·29	23·4	4·07	19
29	496·39	13·2	3·99	35	496·35	16·2	3·65	26	493·90	18·7	4·27	26
30	—	—	—	—	496·48	21·2	3·38	18	493·01	23·1	3·61	17
1 July	496·27	15·7	4·42	33	496·27	20·1	3·43	19	492·77	24·3	5·11	23
2	495·47	15·2	5·08	39	495·39	20·4	3·00	17	492·34	24·8	4·13	18
3	496·76	15·7	4·42	33	496·94	19·7	5·92	35	494·38	25·2	5·93	25
4	498·34	17·4	5·43	36	498·00	21·2	5·53	29	495·55	23·5	5·86	27
5	498·20	16·8	5·79	41	—	—	—	—	496·61	22·1	6·44	33
6	497·44	15·7	6·70	50	497·17	19·5	7·09	42	493·82	25·1	5·44	23
7	497·09	14·1	5·04	42	496·66	18·9	5·14	31	493·61	22·7	5·14	25
8	496·22	14·1	5·04	42	495·60	18·5	5·00	32	493·59	19·0	5·96	36
9	498·90	12·4	4·14	38	498·64	16·6	4·82	34	495·44	22·3	4·86	24
10	498·90	12·9	4·51	40	498·59	17·9	4·15	28	495·27	24·0	6·24	28
11	498·13	14·1	4·47	37	497·93	19·9	3·67	21	494·68	23·9	5·62	26
12	497·05	16·3	7·09	51	497·00	18·8	8·45	52	494·20	24·1	6·73	30
13	496·92	15·4	7·63	59	497·19	19·5	8·02	48	496·66	20·6	8·87	49
14	497·98	15·4	2·05	69	498·08	18·8	7·90	49	495·14	23·3	9·68	46
15	497·63	15·2	8·39	65	—	—	—	—	493·87	23·4	8·44	39

Calculated mean of:
- Pressure... ... 497·12 mm.
- Temperature ... 18·3° c.
- Tension of vapour 3·59 mm.

Skardu.

Hour of observations—	8 a.m.				10 a.m.				4 p.m.			
Date.	Pressure mm.	Temperature cent.	Tension of vapour mm.	Relative humidity.	Pressure mm.	Temperature cent.	Tension of vapour mm.	Relative humidity.	Pressure mm.	Temperature cent.	Tension of vapour mm.	Relative humidity.
29 May	580·21	19·6	6·56	39	579·70	22·3	4·99	25	577·23	27·5	1·46	5
30	—	—	—	—	580·61	22·2	5·18	26	577·45	25·3	1·52	6
31	579·58	18·7	6·53	40	579·19	22·3	4·86	24	575·75	27·0	1·25	5
1 June	576·63	18·6	5·19	33	576·84	20·8	4·11	22	575·13	24·9	3·41	15
2	576·84	18·3	6·91	43	576·75	19·5	5·65	34	574·30	24·3	5·50	24
3	577·97	16·3	8·77	64	577·67	20·4	8·16	46	575·28	23·8	3·44	16
4	577·72	19·4	7·28	43	577·32	23·1	5·03	24	573·97	27·7	3·05	12
5	578·07	20·3	5·17	29	575·13	23·8	2·30	10	572·61	26·5	1·17	4
6	574·50	20·1	5·04	29	574·04	23·6	2·04	9	572·09	27·6	3·11	11
7	576·23	19·2	3·26	19	575·72	22·9	2·35	11	572·04	29·7	1·43	4
8	576·23	20·0	3·37	19	575·97	23·7	3·50	16	573·66	29·2	1·46	4
9	576·48	19·9	4·91	28	576·23	23·7	2·49	11	573·31	29·1	2·59	8
10	574·81	19·9	3·43	20	574·46	24·3	3·53	16	571·89	27·9	2·40	8
11	—	—	—	—	—	—	—	—	573·80	23·7	4·21	18
12	576·23	18·8	6·21	38	576·07	23·7	4·14	19	574·53	26·6	1·74	7
13	579·12	20·4	6·28	35	578·81	23·3	4·91	23	576·15	28·7	1·91	6
14	578·67	23·7	4·02	18	578·49	25·2	3·75	16	575·95	27·4	2·56	9
15	578·21	20·4	5·50	31	577·80	24·2	5·03	22	575·69	27·7	3·31	12
16	576·23	20·2	5·36	30	576·28	24·9	4·21	18	574·78	26·3	2·57	10
17	575·46	19·2	5·96	36	575·11	22·6	4·81	23	572·70	27·0	2·94	11
18	574·70	20·8	6·17	34	574·35	24·3	3·78	17	571·32	30·0	3·29	10
19	575·11	21·1	5·72	31	572·16	24·9	4·60	19	570·36	25·5	3·84	16
20	—	21·4	4·00	21	575·36	23·7	5·80	27	573·13	22·6	3·53	17
21	575·72	18·2	7·35	47	575·21	21·9	5·11	26	572·04	28·6	2·63	8
22	575·08	20·4	4·86	27	574·65	24·2	3·20	14	572·85	28·9	1·65	5
23	575·11	22·6	4·42	22	—	—	—	—	573·31	28·2	0·00	0
24	576·88	20·5	3·91	22	576·94	24·7	3·40	15	574·37	30·6	1·42	4
25	579·32	22·2	2·53	13	578·89	25·8	2·61	11	576·15	33·2	0·00	0
26	577·60	23·1	4·25	20	577·11	25·8	1·97	8	573·20	32·2	1·12	3
27	573·74	23·2	3·80	17	573·26	26·9	2·86	11	569·80	31·8	1·50	4
28	572·67	21·3	6·12	33	572·32	23·6	5·00	23	569·70	27·1	3·67	14
29	572·97	21·4	6·87	36	572·66	23·8	5·68	26	570·10	28·1	2·81	10
30	—	—	—	—	574·91	21·5	5·48	29	571·58	28·2	1·55	5
1 July	573·79	21·5	3·82	20	573·48	25·3	3·83	16	570·21	31·6	2·31	6
2	572·52	22·5	4·22	21	572·48	26·3	2·18	8	569·80	33·1	0·00	0
3	573·89	21·9	3·95	20	573·79	26·8	2·40	9	571·38	21·5	8·60	45
4	574·47	24·4	4·78	21	573·97	27·1	5·05	19	572·59	31·3	3·35	10
5	575·26	23·2	4·71	22	—	—	—	—	572·29	29·2	2·81	9
6	575·26	18·2	8·14	52	575·57	19·7	7·23	42	574·35	25·1	5·85	25
7	575·67	16·3	8·63	62	575·82	17·6	7·98	53	572·49	27·3	4·79	18
8	572·77	19·6	6·11	36	573·43	20·3	5·95	34	575·36	16·3	7·72	56
9	578·61	15·6	8·67	66	578·56	17·6	7·46	50	575·13	25·4	3·77	15
10	576·97	19·8	6·12	35	576·68	23·1	4·38	21	573·20	29·8	2·58	8
11	575·26	20·6	4·62	25	574·91	24·3	4·05	18	571·53	32·4	1·82	5
12	573·05	23·4	5·66	26	572·90	28·0	5·92	21	570·87	31·9	2·98	9
13	573·53	23·4	8·01	37	573·66	25·6	8·12	33	572·24	29·3	7·52	25
14	574·40	21·1	6·64	35	574·27	26·9	5·59	21	572·70	26·0	5·86	23
15	573·84	20·8	10·02	55	—	—	—	—	572·54	28·6	5·85	20

Calculated mean of { Pressure ... ... 574·83 mm. / Temperature ... 24·0° c. / Tension of vapour 4·7 mm. }

Gilgit.

Hour of observations—	8 a.m.				10 a.m.				4 p.m.			
Date.	Pressure mm.	Temperature cent.	Tension of vapour mm.	Relative humidity.	Pressure mm.	Temperature cent.	Tension of vapour mm.	Relative humidity.	Pressure mm.	Temperature cent.	Tension of vapour mm.	Relative humidity.
29 May	636·36	26·7	7·30	28	635·80	29·4	5·96	19	632·14	33·6	6·29	16
30	—	—	—	—	636·56	29·9	6·10	19	632·40	34·7	3·46	8
31	634·49	26·1	6·94	28	634·73	29·7	5·33	17	630·47	31·6	8·30	24
1 June	633·28	24·8	8·75	38	632·55	27·7	7·29	26	632·53	25·6	8·72	35
2	634·56	20·3	9·89	56	631·79	21·3	10·15	54	630·87	20·3	14·75	83
3	636·21	18·9	12·80	79	633·26	22·6	10·25	50	631·53	30·2	6·66	21
4	634·56	24·1	10·39	47	633·82	28·1	5·86	21	629·99	34·6	4·12	10
5	632·07	25·7	5·35	22	631·61	29·2	4·47	15	630·24	34·4	4·09	10
6	631·76	27·8	4·62	17	631·30	30·9	2·60	7	628·56	34·3	1·51	4
7	632·37	26·7	5·29	20	631·05	27·6	5·17	19	627·49	36·4	4·26	9
8	632·29	27·2	5·41	20	631·02	31·4	4·00	11	629·30	36·7	3·00	6
9	632·40	28·0	4·23	15	630·92	32·9	3·22	8	628·39	36·1	5·70	12
10	630·47	26·7	9·72	37	629·96	31·8	3·76	10	626·07	33·9	6·74	17
11	—	—	—	—	—	—	—	—	625·72	32·3	5·23	15
12	631·18	27·1	8·10	30	626·78	30·4	5·34	17	624·95	35·7	3·30	7
13	634·63	27·1	8·40	31	632·85	30·9	7·15	22	630·38	35·0	5·43	12
14	634·60	26·7	11·46	44	633·92	32·8	7·25	20	631·30	33·9	5·01	12
15	633·94	27·3	7·98	30	633·36	31·1	7·18	21	629·52	34·4	5·02	13
16	632·45	27·3	9·35	35	630·67	29·9	7·15	23	628·76	32·4	3·97	11
17	631·27	27·2	9·42	35	631·10	30·1	7·95	25	629·16	34·8	4·00	9
18	630·57	27·2	8·04	30	629·24	32·7	6·84	18	625·84	37·6	4·79	10
19	628·25	28·8	6·77	23	626·10	32·4	5·94	16	625·64	33·7	6·23	16
20	—	27·0	8·01	30	628·89	30·2	6·66	21	627·95	29·0	5·16	17
21	631·33	25·6	8·86	36	630·82	29·4	6·55	21	628·20	37·2	3·61	8
22	631·08	27·2	6·42	24	628·73	31·3	5·93	18	627·89	32·3	9·50	27
23	630·87	29·4	8·08	26	—	—	—	—	627·79	34·4	5·48	13
24	633·21	26·6	11·20	43	631·84	30·3	6·15	19	626·98	37·8	3·40	7
25	634·32	26·7	11·14	43	633·74	32·2	4·26	12	630·13	39·2	3·65	7
26	630·64	30·8	5·10	16	630·84	33·9	4·56	11	627·71	40·6	3·76	7
27	627·69	30·0	8·18	26	626·65	34·1	5·35	13	622·97	39·8	4·24	8
28	626·07	30·0	5·88	19	625·14	31·1	5·81	18	623·27	34·9	7·10	17
29	626·47	27·6	6·17	22	628·46	29·2	6·82	22	630·11	32·5	4·36	12
30	—	—	—	—	630·89	30·3	7·21	22	630·97	34·1	7·25	18
1 July	629·65	27·6	5·45	20	628·86	31·8	3·61	10	625·03	37·8	2·16	4
2	628·51	29·0	5·90	20	626·30	32·6	2·98	7	624·01	39·2	4·29	8
3	628·25	29·0	8·32	28	628·18	33·4	3·96	10	625·33	36·8	5·93	12
4	629·32	31·1	7·65	23	629·06	33·0	6·82	18	626·73	36·2	6·13	13
5	630·08	27·9	10·24	37	—	—	—	—	630·23	29·2	5·79	19
6	630·62	24·0	10·76	49	630·57	24·1	11·11	50	628·20	29·4	8·54	28
7	629·35	25·9	9·13	37	629·40	29·6	7·95	26	627·03	30·7	8·53	26
8	629·37	22·2	8·74	44	624·81	17·6	13·61	91	632·77	19·9	13·88	80
9	636·78	19·7	11·72	69	635·06	22·6	12·23	60	630·64	30·8	8·00	24
10	632·16	24·8	9·21	39	631·50	26·4	11·65	45	627·95	34·9	6·77	16
11	629·81	27·6	9·48	34	627·54	29·4	11·29	37	625·61	36·8	0·00	0
12	628·46	27·2	10·67	40	627·84	27·9	12·37	44	627·69	28·3	14·00	49
13	627·89	24·0	12·32	56	622·79	25·0	11·74	43	625·61	36·1	0·00	0
14	629·11	30·5	9·30	29	628·91	34·0	6·21	16	626·65	36·8	5·76	12
15	628·61	27·8	10·95	39	—	—	—	—	629·22	28·2	8·80	31

Calculated mean of { Pressure... ... 629·83 mm.
Temperature ... 30·05° c.
Tension of vapour 7·0 mm. }

C.—Comparison of Simultaneous Observations.

Date.	Hour.	CAMP III.				RDOKASS.				SKARDU.			
		Pressure mm.	Temperature cent.	Tension of vapour.	Humidity.	Pressure mm.	Temperature cent.	Tension of vapour.	Humidity.	Pressure mm.	Temperature cent.	Tension of vapour.	Humidity.
29 May ...	8	417·60	−1·5	2·08	51	471·34	5·8	2·50	36	580·21	19·6	6·56	39
	10	418·05	5·4	1·39	21	471·69	8·8	1·19	14	579·70	22·3	4·99	25
	4	417·55	3·0	2·17	38	470·79	9·8	0·50	7	577·23	27·5	1·46	5
30 " ...	10	418·41	7·1	4·24	56	472·33	8·8	2·57	30	580·61	22·2	5·18	26
	4	418·48	3·0	1·34	24	471·19	10·3	0·49	5	577·45	25·3	1·52	6
31 " ...	10	417·58	3·0	1·34	24	472·14	8·3	2·87	35	579·19	22·3	4·86	24
	4	417·43	3·0	2·17	38	570·50	11·8	1·27	12	575·75	27·0	1·25	5
1 June ...	10	415·88	3·5	1·08	19	469·85	11·3	1·57	15	576·84	20·8	4·11	22
	4	416·02	3·5	1·91	32	469·32	8·8	2·57	30	575·13	24·9	3·41	15
2 " ...	8	415·56	−1·7	2·32	70	469·22	4·8	4·06	62	576·84	18·3	6·91	43
	10	415·33	2·5	2·43	44	469·18	5·8	3·86	55	576·75	19·5	5·65	34
	4	414·83	3·5	1·91	32	468·34	4·8	4·75	73	574·30	24·3	5·50	24
3 " ...	8	414·80	0·0	3·74	85	468·99	2·4	3·58	65	577·97	16·3	8·77	64
	10	415·25	1·0	3·22	65	469·84	5·3	4·15	62	577·67	20·4	8·16	46
	4	415·76	0·0	3·74	81	469·67	2·8	3·81	67	575·28	23·8	3·44	16
4 " ...	8	416·10	0·0	4·16	91	471·05	6·3	1·26	17	577·72	19·4	7·28	43
	10	416·32	3·0	2·17	38	470·81	8·8	0·71	9	577·32	23·1	5·03	24
	4	416·50	3·0	0·93	17	470·01	13·7	0·00	0	573·97	27·7	3·05	12
5 " ...	8	414·96	2·0	1·04	20	470·11	3·8	2·12	35	578·07	20·3	5·17	29
	10	415·62	5·1	1·07	17	469·49	7·8	0·83	10	575·13	23·8	2·30	10
	4	415·13	2·0	1·04	20	467·81	9·1	0·53	6	572·61	26·5	1·17	4
9 " ...	4	416·36	5·0	0·29	5	468·96	12·3	0·00	0	572·31	29·1	2·59	8
10 " ...	8	414·81	0·0	2·09	45	468·77	4·8	1·69	26	574·81	19·9	3·43	20
	10	414·77	6·1	1·44	20	468·41	8·3	0·54	7	574·46	24·3	3·53	16
	4	414·19	4·0	1·64	27	466·74	9·8	0·59	7	571·89	27·9	2·40	8
11 " ...	4	414·17	1·0	1·17	23	467·41	7·8	1·79	22	573·80	23·7	4·21	18
Mean ...		416·05	2·6	2·00		469·74	7·8	1·91		575·32	23·1	4·29	

Camp III (second base-camp).

Date.	Hour.	Srinagar. Pressure mm.	Temperature cent.	Tension of vapour.	Humidity.	Leh. Pressure mm.	Temperature cent.	Tension of vapour.	Humidity.	Gilgit. Pressure mm.	Temperature cent.	Tension of vapour.	Humidity.
29 May ...	8	629·30	17·4	11·81	80	501·66	12·7	1·92	17	636·36	26·7	7·30	28
	10	629·45	21·3	14·45	77	501·51	16·7	1·44	10	635·80	29·4	5·96	19
	16	627·21	29·2	22·38	74	498·54	21·0	0·00	0	632·14	33·6	6·29	16
30 „ ...	10	629·83	24·2	16·88	75	501·79	17·3	1·86	12	636·56	29·9	6·10	19
	16	627·62	27·8	20·43	73	499·08	20·5	1·64	9	632·40	34·7	3·46	8
31 „ ...	10	628·64	23·0	15·72	83	500·98	17·7	1·84	12	634·73	29·7	5·33	17
	16	625·99	26·8	19·31	74	497·81	21·3	2·70	14	630·47	31·6	8·30	24
1 June ...	10	627·60	21·9	15·05	77	498·90	17·4	2·47	16	632·55	27·7	7·29	26
	16	626·12	23·4	16·33	76	496·05	22·4	0·00	0	632·53	25·6	8·72	35
2 „ ...	8	629·12	16·6	11·87	84	498·98	14·1	3·11	26	634·56	20·3	9·89	56
	10	628·58	19·7	12·92	76	498·44	17·3	3·69	25	631·79	21·3	10·15	54
	16	628·43	17·9	11·94	78	494·91	23·5	3·12	14	630·87	20·3	14·75	83
3 „ ...	8	629·60	16·3	12·05	87	497·95	13·5	4·15	36	636·21	18·9	12·80	79
	10	629·80	18·8	13·62	84	497·93	14·6	3·25	26	633·26	22·6	10·25	50
	16	626·81	24·1	17·29	78	496·61	17·9	3·68	24	631·53	30·2	6·66	21
4 „ ...	8	628·01	17·7	12·06	80	499·41	11·3	3·40	34	634·56	24·1	10·39	47
	10	628·23	21·3	14·29	76	499·20	15·7	2·82	21	633·82	28·1	5·86	21
	16	624·85	27·2	20·02	75	499·55	19·1	2·02	12	629·99	34·6	4·12	10
5 „ ...	8	625·90	19·4	13·10	78	498·03	12·9	3·84	35	632·07	25·7	5·35	22
	10	625·64	23·0	15·72	75	497·63	17·8	2·46	16	631·61	29·2	4·47	15
	16	624·47	24·8	18·11	78	495·27	21·6	0·00	0	630·24	34·4	4·09	10
9 „ ...	16	623·42	30·0	22·93	73	495·27	24·1	1·37	6	628·39	36·1	5·70	12
10 „ ...	8	624·91	21·3	14·93	79	497·34	14·3	2·99	24	630·47	26·7	9·72	37
	10	625·06	25·6	17·62	73	496·94	18·8	1·98	11	629·96	31·8	3·76	10
	16	623·79	27·5	21·20	78	494·10	22·7	1·74	8	626·07	33·9	6·74	17
11 „ ...	16	625·23	22·6	15·97	78	494·71	20·7	1·76	10	625·72	32·3	5·23	15
Mean ...		627·06	22·6	16·07		498·03	1·79	2·28		632·09	28·4	7·25	

D.—Comparison of Observations Made on the Godwin Austen, Savoia, and Upper Baltoro Glaciers.

No.	Date.		Station of observation.					Simultaneous data of comparison.			
	Month and day.	Hour.	Place.	Pressure mm.	Temperature cent.	Tension of vapour mm.	Instrument used for measurement of pressure.	Of the station of	Pressure mm.	Temperature cent.	Tension of vapour mm.
	31 May	10	Camp IV ...	390·85	2·0	1·04	Fortin	Camp III	417·58	3·0	1·34
		4		390·55	– 1·0	1·04	„		417·43	3·0	2·17
	1 June	10		389·78	1·9	1·18	„		415·88	3·5	1·08
		4		388·85	– 1·0	1·04	„		416·02	3·5	1·91
			Mean...	390·00	0·2	1·07			416·72	3·2	1·62
	31 May	10	Camp IV ...	390·85	2·0	1·04	„	Rdokass	472·14	1·3	2·17
		4		390·55	– 1·0	1·04	„		470·50	11·8	1·27
	1 June	10		389·78	1·0	1·18	„		469·85	11·3	1·57
		4		388·85	– 1·0	1·04	„		469·32	8·8	2·57
			Mean...	390·00	0·2	1·07			470·45	10·0	2·07
	5 „	4	Camp V ...	394·05	– 3·0	2·86	„	Camp III	415·15	2·0	1·04
	5 „	4		394·05	– 3·0	2·86	„		467·81	9·1	0·53
		8		393·36	– 8·0	1·39	„		468·18	5·3	4·65
	6 „	10	Camp V ...	393·42	– 2·0	3·96	„	Rdokass	468·29	7·8	0·37
		4		393·82	– 2·5	2·21	„		467·66	10·3	0·00
		8		395·34	– 5·0	1·27	„		469·61	4·3	1·43
	8 „	10		395·42	– 3·0	2·09	„		469·45	8·3	0·00
			Mean...	394·23	– 3·9	2·30			468·50	7·5	1·16
	7 „	5.15	Savoia Pass...	349·70	– 9·0	—	„	Rdokass	467·86	12·7	0·00
	12 „	10		395·71	– 2·0	2·34	„		469·86	7·3	2·57
	13 „	8		397·37	– 1·0	3·43	„		471·86	3·8	4·17
		10		397·65	3·0	2·17	„		472·11	9·3	1·77
		4		397·94	0·0	3·74	„		472·11	10·8	0·87
	21 „	8	Camp VI ...	394·23	– 6·0	2·89	„	Rdokass	468·26	4·8	3·57
		10		394·50	– 1·0	1·82	„		468·00	8·3	2·36
		4		394·15	6·0	0·59	„		466·88	12·7	0·69
	22 „	8		355·42	– 3·0	1·33	„		468·33	6·3	1·73
		10		395·25	1·5	2·12	„		468·08	10·3	0·78
		4		395·76	0·5	1·04	„		467·66	12·7	0·00
			Mean...	395·90	– 0·2	2·15			469·32	8·63	1·85
	15 „	11.15	Sella Pass ...	368·85	– 3·0	—	„	Rdokass	471·57	8·3	—
	14 „	4		373·51	– 6·5	2·04	„		471·29	10·3	1·67
	15 „	8		373·40	– 7·0	1·22	„		471·53	6·3	2·68
		4		373·28	– 4·5	1·37	„		470·56	12·7	0·24
	16 „	10	Camp VII ...	372·71	– 3·0	2·09	„	Rdokass	470·41	9·3	0·89
	18 „	10		372·18	– 7·0	2·67	„		468·41	9·1	1·21
		4		370·85	– 4·0	2·61	„		466·53	12·7	0·00
	19 „	4		369·43	– 6·0	2·89	„		466·00	8·8	2·07
	20 „	8		369·04	– 9·0	2·26	„		466·26	7·8	4·16
			Mean...	371·80	– 5·8	2·14			468·88	9·1	1·62
	24 „	4	Camp VIII...	360·78	– 6·0	1·77	„	Rdokass	469·66	14·7	0·00
	25 „	1	Staircase ...	348·30	6·0	—	„	Rdokass	471·86	14·7	—

D.—Comparison of Observations Made on the Godwin Austen, Savoia, and Upper Baltoro Glaciers. (Contd.)

No.	Date. Month and day.	Date. Hour.	Station of observation. Place.	Pressure mm.	Temperature cent.	Tension of vapour mm.	Instrument used for measurement of pressure.	Simultaneous data of comparison. Of the station of	Pressure mm.	Temperature cent.	Tension of vapour mm.
	1 July	10		431·33	11·0	5·04	Fortin		468·43	10·3	0·78
		4		431·33	12·0	3·36	„		466·80	14·2	0·00
	2 „	8		431·23	4·0	3·54	„		466·81	7·8	1·31
		4		431·33	15·0	4·85	„		466·71	14·3	0·00
	3 „	8		432·69	4·0	3·16	„		468·61	6·8	1·91
		10	Camp IX ...	422·65	11·0	2·83	„	Rdokass	468·81	11·3	0·58
		4		432·56	14·5	2·87	„		467·47	15·7	0·00
	4 „	8		433·55	7·0	3·30	„		469·61	8·3	3·37
		10		434·49	9·0	3·11	„		469·39	12·7	2·82
	5 „	4		434·55	11·5	3·06	„		468·56	15·2	0·00
		8		433·01	2·0	3·41	„		469·56	5·8	6·42
		4		432·95	10·5	6·40	„		467·51	13·2	2·52
			Mean...	432·62	9·3	3·74			468·19	11·3	1·64
	1 „	4	Camp X ...	428·30	5·0	—	Hyps.	Rdokass	466·80	14·2	—
	7 „	4	Camp XI ...	418·34	4·0	—	Fortin	Rdokass	466·98	10·3	—
	3 „	4	Camp XII ...	393·87	8·0	4·12	„	Rdokass	467·47	15·7	0·00
	5 „	4		393·65	7·0	3·20	„		467·51	13·2	2·52
	6 „	10		392·98	12·0	2·23	„		468·53	7·8	4·18
		4		392·38	7·5	2·90	„		467·79	5·8	5·38
	7 „	10		392·53	11·0	2·83	„		467·86	5·8	4·86
			Mean...	393·08	9·1	3·05			467·83	9·7	3·39
	9 „	5	Camp XIII	377·71	8·0	0·31	„	Rdokass	468·98	10·3	1·67
	10 „	4		354·40	3·0	0·52	„		467·98	13·7	0·00
	14 „	10	Camp XIV ...	354·10	3·0	2·17	„	Rdokass	469·12	10·3	4·26
		4		354·35	1·0	4·01	„		469·10	11·8	3·90
				358·28	2·3	2·20			468·73	11·9	2·72
	11 „	4	Camp XV (i)	342·12	0·0	—	„	Rdokass	467·72	15·7	—
	17 „	4	Camp XV (ii)	335·74	5·0	—	„	Skardu ...	572·11	30·4	—
	18 „	2.30	Nearest Bride Peak	312·33	6·0	4·18	„	Leh ...	494·99	24·9	10·51
								Srinagar	622·85	29·1	22·65
								Skardu ...	571·45	31·9	7·65
								Gilgit ...	627·08	31·9	14·11

Comparison of Observations Made on the Return Journey.

No.	Date.		Station of observation.					Simultaneous data of comparison.			
	Month and day.	Hour.	Place	Pressure mm.	Temperature cent.	Tension of vapour mm.	Instrument used for measurement of pressure.	Of the station of	Pressure mm.	Temperature cent.	Tension of vapour mm.
	28 July ...	11	Northern camp of Skoro-La	470·34	15·8	1·43	Fortin	Leh ...	497·27	20·7	10·51
								Skardu	573·48	29·2	3·37
								Gilgit ...	628·69	36·2	0·00
	29 „ ...	11	Skoro-La...	413·27	6·4	—	„	Leh ...	497·39	18·4	—
								Skardu	573·73	25·1	—
								Gilgit ...	613·89	32·3	—
	1 August	4	Camp between Skardu and Burgi-La	504·63	19·4	5·84	„	Leh ...	496·92	23·5	8·10
								Skardu	573·84	31·1	6·26
								Gilgit ...	631·23	30·2	12·84
	2 „	9.50	Burgi-La ...	427·65	9·4	—	„	Leh ...	498·45	20·9	—
								Skardu	574·78	28·9	—
								Gilgit ...	630·41	31·9	—
	3 „	4	Chundu-Kut	469·81	15·3	4·66	„	Leh ...	495·02	23·3	8·07
								Skardu	571·65	27·2	6·86
								Gilgit ...	626·30	33·9	7·06
	4 „	9.50	Sarsingar...	455·81	11·9	—	„	Leh ...	497·84	20·6	—
								Skardu	575·11	23·9	—
								Gilgit ...	630·69	29·7	—
	4 „	12.50	Stakpi-la ...	470·61	18·9	—	„	Leh ...	497·84	20·6	—
								Skardu	575·11	23·9	—
								Gilgit ...	630·69	29·7	—
	4 „	4	Burzil ...	505·22	19·9	6·77	„	Leh ...	494·61	22·7	7·59
								Skardu	571·19	30·7	6·35
								Gilgit ...	625·43	35·9	10·91
	5 „	4	Pashwari...	570·07	19·9	—	Hyps.	Leh ...	495·98	21·6	—
								Skardu	573·33	24·4	—
								Gilgit ...	629·29	28·1	—
	6 „	4	Gurais ...	591·28	15·8	11·93	„	Leh ...	494·54	20·1	6·33
								Skardu	572·72	23·0	11·06
								Gilgit ...	610·06	27·9	14·08
	7 „	4	Gorè ...	546·42	15·8	10·54	„	Leh ...	494·69	23·9	6·16
								Skardu	573·68	25·4	9·14
								Gilgit ...	629·98	26·7	15·17
	8 „	8	Rajdiangan Pass	497·59	12·8	5·02	Fortin	Leh ...	497·48	17·9	6·75
								Skardu	575·57	16·1	10·77
								Gilgit ...	622·50	21·2	14·41
	9 „	4	Tragbal ...	540·38	20·9	—	Hyps.	Leh ...	494·33	23·5	—
								Skardu	574·90	27·4	—
								Gilgit ..	629·01	29·7	—

Final Summing-up of Statistics of Height.

No.	Stations.		No. of observations.	Instrument used.	Height above sea level of stations of reference. z metres.	Difference in height between stations of observation and of reference. Z metres.	Height above sea level of stations of observation.		
	Of observation.	Of reference.					$z + Z$ metres.	Metres.	Feet.
1	Baltal	Srinagar	1	Hyps.	1,586	1,266	2,852	2,822	9,259
		Leh ...			3,506	− 716	2,799		
		Skardu ...			2,287	518	2,805		
		Gilgit ...			1,490	1,342	2,831		
2	Mutajun... ...	Srinagar	1	Fortin	1,586	1,527	3,113	3,194	10,479
		Leh ...			3,506	− 309	3,197		
		Skardu ...			2,287	935	3,222		
		Gilgit ...			1,490	1,753	3,243		
3	Olthingthang ...	Leh ...	1	Hyps.	3,506	− 789	2,717	2,758	9,049
		Skardu ...			2,287	487	2.774		
		Gilgit ...			1,490	1,292	2,782		
4	Tarkutta ...	Leh ...	1	„	3,506	− 1,063	2,443	2,493	8,179
		Skardu ...			2,287	225	2,512		
		Gilgit ...			1,490	1,034	2,524		
5	Kharmang ...	Leh ...	1	„	3,506	− 1,110	2,396	2,446	8,025
		Skardu ...			2,287	179	2,466		
		Gilgit ...			1,490	985	2,475		
6	Tolti	Leh ...	1	„	3,506	− 1,162	2,344	2,396	7,861
		Skardu ...			2,287	114	2,401		
		Gilgit ...			1,490	952	2,442		
7	Shigar	Leh ...	1	„	3,506	− 1,258	2,248	2,291	7,517
		Skardu ...			2,287	17	2,304		
		Gilgit ...			1,490	830	2,320		
8	Dusso	Leh ...	1	„	3,506	− 1,153	2,353	2,400	7,874
		Skardu ...			2,287	108	2,395		
		Gilgit ...			1,490	963	2,453		
9	Gomboro ...	Leh ...	1	„	3,506	− 1,006	2,500	2,540	8,333
		Skardu ...			2.287	255	2,542		
		Gilgit ...			1,490	1,089	2,579		
10	Chongo	Leh ...	1	Fortin	3,506	− 588	2,918	2,968	9,738
		Skardu ...			2,287	684	2,971		
		Gilgit ...			1,490	1,525	3,015		
11	Askoley	Leh ...	5	„	3,506	− 451	3,056	3,052	10,013
		Skardu ...			2,287	753	3,040		
		Gilgit ...			1,490	1,501	3,060		
12	Punmah... ...	Leh ...	1	„	3,506	− 422	3,084	3,107	10,194
		Skardu ...			2,287	816	3,103		
		Gilgit ...			1,490	1,643	3,133		
13	Paiju	Leh ...	1	„	3,506	− 185	3,321	3,350	10,991
		Skardu ...			2,287	1,062	3,349		
		Gilgit ...			1,490	1,892	3,382		

FINAL SUMMING-UP OF STATISTICS OF HEIGHT. *(Contd.)*

No.	Stations.		No. of observations.	Instrument used.	Height above sea level of stations of reference.	Difference in height between stations of observation and of reference.	Height above sea level of stations of observation.		
	Of observation.	Of reference.			z metres.	Z metres.	$z + Z$ metres.	Metres.	Feet.
14	Between Liligo and Rhobutse	Leh ... Skardu ... Gilgit ...	1	Fortin	3,506 2,287 1,490	201 1,436 2,261	3,707 3,723 3,751	3,727	12,228
15	Rdokass ... 1st base camp	Leh ... Skardu ... Gilgit ... Srinagar	137	"	3,506 2,287 1,490 1,586	492 1,734 2,540 2,465	3,998 4,021 4,030 4,051	4,025	13,206
16	Camp III ... 2nd base camp	Rdokass Leh ... Skardu ... Srinagar Gilgit ...	26	"	4,025 3,506 2,287 1,586 1,490	994 1,500 2,728 3,464 3,556	5,019 5,006 5,015 5,050 5,046	5,027	16,493
17	Camp IV ...	Camp III Rdokass	4 4	"	5,027 4,025	536 1,535	5,563 5,560	5,561	18,245
18	Camp V	Camp III Rdokass	1 6	"	5,027 4,025	419 1,396	5,446 5,421	5,433	17,825
19	Savoia Pass ...	Rdokass	1	"	4,025	2,347	6,372	—	20,906
20	Camp VI ...	Rdokass	10	"	4,025	1,388	5,413	—	17,760
21	Sella Pass ...	Rdokass	1	"	4,025	2,097	6,112	—	20,053
22	Camp VII ...	Rdokass	8	"	4,025	1,876	5,901	—	19,361
23	Camp VIII ...	Rdokass	1	"	4,025	2,150	6,175	—	20,260
24	Staircase ...	Rdokass	1	"	4,025	2,531	6,556	—	21,510
25	Camp IX ...	Rdokass	12	"	4,025	659	4,684	—	15,368
26	Camp X... ...	Rdokass	1	Hyps.	4,025	715	4,740	—	15,551
27	Camp XI ...	Rdokass	1	Fortin	4,025	905	4,930	—	16,175
28	Camp XII ...	Rdokass	5	"	4,025	1,449	5,474	—	17,960
29	Camp XIII ...	Rdokass	1	"	4,025	1,796	5,821	—	19,098
30	Camp XIV ...	Rdokass	3	"	4,025	2,310	6,335	—	20,784
31	Camp XV (I) ...	Rdokass	1	"	4,025	2,581	6,606	—	21,674
32	Camp XV (II) ...	Skardu ...	1	"	2,287	4,566	6,853	—	22,484
33	Nearest Bride Peak	Leh ... Srinagar Skardu ... Gilgit ...	1	"	3,506 1,586 2,287 1,490	3,932 5,958 5,209 6,023	7,438 7,544 7,496 7,513	7,498	24,600

FINAL SUMMING-UP OF STATISTICS OF HEIGHT. *(Contd.)*

No	Stations. Of observation.	Stations. Of reference.	No. of observations.	Instrument used.	Height above sea level of stations of reference. z metres.	Difference in height between stations of observation and of reference. Z metres.	Height above sea level of stations of observation. z + Z metres.	Metres.	Feet.
34	North Camp of Skoro-La	Leh ... Skardu ... Gilgit ...	1	Fortin	3,506 2,287 1,490	477 1,721 2,549	3,983 4,008 4,039	4,010	13,156
35	Skoro-La ...	Leh ... Skardu ... Gilgit ...	1	"	3,506 2,287 1,490	1,555 2,789 3,658	5,061 5,076 5,148	5,095	16,716
36	Camp between Skardu and Burgi-La	Leh ... Skardu ... Gilgit ...	1	"	3,506 2,287 1,490	134 1,131 1,970	3,372 3,418 3,460	3,417	11,211
37	Burgi-La ...	Leh ... Skardu ... Gilgit ...	1	"	3,506 2,287 1,490	1,300 2,546 3,360	4,806 4,833 4,850	4,830	15,847
38	Chundu-Kut ...	Leh ... Skardu ... Gilgit ...	1	"	3,506 2,287 1,490	451 1,703 2,523	3,957 3,990 4,013	3,987	13,081
39	Sarsingar ...	Leh ... Skardu ... Gilgit ...	1	"	3,506 2,287 1,490	751 1,992 2,813	4,257 4,279 4,303	4,280	14,042
40	Stakpi-la ...	Leh ... Skardu ... Gilgit ...	1	"	3,506 2,287 1,490	485 1,741 2,639	3,991 4,028 4,129	4,049	13,284
41	Burzil	Leh ... Skardu ... Gilgit ...	1	"	3,506 2,287 1,490	− 185 1,080 1,897	3,322 3,367 3,387	3,359	11,021
42	Pashwari ...	Leh ... Skardu ... Gilgit ...	1	Hyps.	3,506 2,287 1,490	− 1,205 50 866	2,301 2,337 2,356	2,331	7,648
43	Gurais	Leh ... Skardu ... Gilgit ...	1	"	3,506 2,287 1,490	− 1,537 276 554	1,969 2,011 2,044	2,008	6,588
44	Gorè	Leh ... Skardu ... Gilgit ...	1	"	3,506 2,287 1,490	− 861 423 1,240	2,646 2,710 2,730	2,695	8,842
45	Rajdiangan ...	Leh ... Skardu ... Gilgit ...	1	Fortin	3,506 2,287 1,490	− 2 1,236 1,920	3,504 3,523 3,546	3,524	11,562
46	Tragbal	Leh ... Skardu ... Gilgit ...	1	Hyps.	3,506 2,287 1,490	− 776 543 1,337	2,730 2,830 2,287	2,796	9,173

D. OMODEI.
Genoa, January, 1910.

Appendix C.

GEOLOGICAL RESULTS

OF THE

KARAKORAM EXPEDITION

OF

H.R.H. The Duke of the Abruzzi,

BY

INGEGNERE VITTORIO NOVARESE,

Of the Italian Geological Survey,

AND

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Formerly of the Geological Survey of India

GEOLOGICAL RESULTS OF THE KARAKORAM EXPEDITION OF H.R.H. THE DUKE OF THE ABRUZZI.

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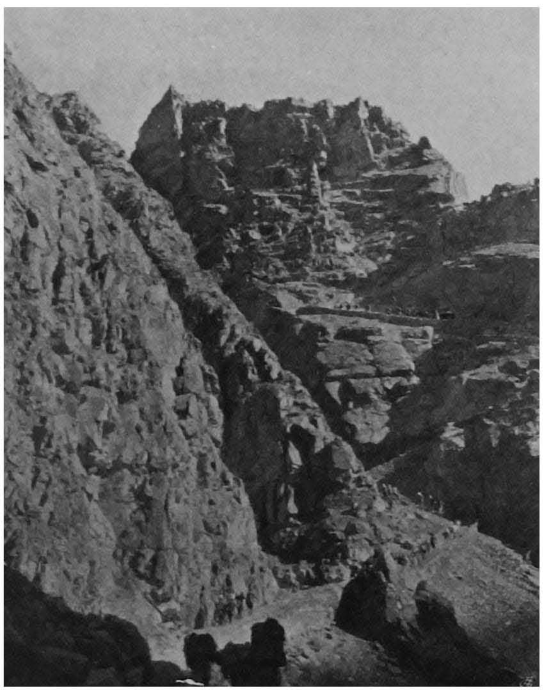


The fundamental outlines of our knowledge of the geology of the Karakoram range and of Baltistan are still, in the main, those drawn by the labours of Col. H. H. Godwin Austen and of R. Lydekker; but though the map published by the latter in 1883, and reproduced on a smaller scale in the second edition of the *Manual of the Geology of India*, published in 1891, was coloured geologically up to the supposed watershed of the Karakoram range, exploration had not in fact been pushed so far and the sources of the Baltoro were, at that time, in every way unknown.

Later explorers had made no noteworthy contributions to the geology of the region if we except the record of limestones on the Crystal Peak and the sedimentary rocks of Golden Throne reported by Sir W. M. Conway; and the good fortune—one may say merit—was reserved for the expedition led by H.R.H. the Duke of the Abruzzi, of collecting observations which are not only new but to a great extent unexpected, because, notwithstanding their importance and obviousness, they had escaped the notice of previous travellers. Moreover, they form a complement to those which were almost simultaneously being made by Dr. Longstaff's expedition at a distance of about 30 miles to the south-east, in the valley of the Siachen glacier, and hence come to throw great light on the nature and constitution of that little-known portion of the heart of the great Asiatic continent.

In working out the geological results of the Italian expedition, the observations and reports made by its several members have been utilised, as well as the lithological material collected by them. The greater part of the specimens, indeed almost the whole, were obtained from the glacier moraines, for the approach to the rock-walls of the Upper Baltoro, though not impossible, is frequently dangerous on account of the avalanches of snow and rocks precipitated at every moment from these precipices, which measure not hundreds but thousands of feet in height. The points where the rocks are directly accessible are therefore somewhat rare, and consequently the specimens collected from rock *in situ* are few in number.

Fortunately the material obtained from the moraines was not fortuitously collected, but the moraines running along a transverse section at the junction of the Upper Baltoro with the Godwin Austen glaciers were consecutively numbered and the more characteristic material collected from each of them. Since it is possible to determine the origin of the material forming the principal moraines in this part of the glacier, a tolerably good idea may be formed of the constitution of the slopes from which each is derived. Further on will be found a list of these moraines and their lithological composition as reported by Dr. F. De Filippi.

The rocks of which specimens were procured belong to the two categories of crystalline schists and sedimentary deposits, with the addition of certain specimens of serpentine. Apart from this last there are no representatives of eruptive rocks, although granite is highly developed in the mountains of the Baltoro valley; evidently the abundance of limestone and other sedimentary rocks attracted and particularly engaged the attention of the Italians.

A.—Schists and Crystalline Rocks.

The specimens of crystalline schists are few in comparison with those of sedimentary rocks, but fortunately the more important of them were collected *in situ*, and the place of origin is consequently known.

Along with the crystalline schists will be described certain specimens of mineral veins, which must traverse them, and the noble serpentine, although this should be associated stratigraphically with the more recent rocks, rather than with the crystalline schists.

I. *Biotite gneiss.*—The specimen was collected by H.R.H. the Duke of the Abruzzi on Bride Peak, from the last rock of the eastern ridge at an altitude of 24,600 feet, on July 18th, 1909.

It is a slightly biotitic gneiss, dark coloured, of fine grain, but not sufficiently so for it to become cryptocrystalline, and showing banded structure. It is probably flaggy, though the smallness of the fragment prevents this being affirmed with certainty. The grain is homogeneous and uniform. The biotite does not form continuous sheets, but appears in isolated flakes. To the naked eye small greenish spots are noticeable, due to amphibole.

Under the microscope the rock is seen to be composed of quartz, felspar, biotite and amphibole, and as subordinate and accessory constituents, sphene, zircon, apatite, as well as occasional calcite.

The quartz occurs in granular aggregates, frequently drawn out in the form of lenticles lying parallel to the foliation; quantitatively it is subordinate to the felspar, and shows neither undulate extension nor mechanical fracture.

The felspar is of two kinds. Orthoclase is the predominant form always slightly opaque through incipient alteration. Cleavage is very distinct and always visible. From a study of the disposition of the cleavage planes and their relative frequency in sections cut parallel or transverse to the foliation it is evident that the individual crystals are arranged with the axis of the two directions of cleavage (001) (010) parallel to the foliation.

The orthoclase individuals have irregular outlines, are always larger than those of quartz, of which they sometimes enclose rounded granules. The maximum dimension of the granules of orthoclase attains 0·6 millimetre, but, on the average, is rather less than half this figure. Small plates of mica are commonly found in the intervals between the separate granules.

The other felspar is marked as albite by its polysynthetic twining and the index of refraction being less than that of quartz. It is very rare in comparison with the orthoclase.

The biotite occurs without any crystal faces, except the basal plane; the flakes have a very irregular outline as seen in a thin section, much elongated in the direction of the basal plane. The maximum dimensions are 0·55 millimetre in the direction of *c* and 0·70 millimetre in the direction perpendicular to this, that is to say, parallel to the basal plane.

The biotite occurs in two sizes. The larger lie along the foliation planes and are arranged in similar orientation. The smaller, which have already been noticed when speaking of the felspar, occur in extremely minute flakes and lying in any direction in the interstices of the aggregate of quartz and felspar forming the ground mass of the rock.

The biotite is brown and exhibits the following pleochroism :—

$$n_p = \mathfrak{a} = \text{pale yellow}$$
$$n_m = \mathfrak{b} = \text{brown}$$
$$n_g = \mathfrak{c} = \text{brown.}$$

There is very little difference between n_m and n_g, the absorption parallel to the basal plane is not great, as the mineral has preserved its transparency and pale brown colour ; it is sensibly uniaxial in convergent light.

The mica in general is quite fresh and shows no sign of chemical alteration or mechanical deformation.

The amphibole has the habit of actinolite, always in rather slender prisms, for the most part grouped in bundles with their axes parallel to the foliation. It is constantly associated with mica, but, notwithstanding this connection, does not seem to be derived from the latter, which, as has been mentioned, is always quite fresh.

The angle of maximum extinction is almost exactly 15°, but not greater. The pleochroism is as follows:—

n_g = $\mathfrak{c}$ = blue green with notable absorption
n_m = $\mathfrak{b}$ = bright green with a slight tendency to brown
n_p = $\mathfrak{a}$ = very pale green
$\mathfrak{a} < \mathfrak{b} < \mathfrak{c}$.

The maximum length of the groups of prisms is 1 millimetre, the mean width of each prism 0·05 to 0·06 millimetre.

Among the accessory minerals sphene is abundant and in comparatively large grains. The calcite is certainly of secondary origin.

The structure of the rock is interesting, particularly as seen in sections perpendicular to the foliation, on account of the regular distribution of the coloured constituents, especially the mica, which is much more abundant than the amphibole, and of a certain uniformity of dimension of the grains of quartz and felspar; this is a type of hornstone structure, characteristic of rocks metamorphosed by contact with granite. In the sections examined no mineral characteristic of contact metamorphism, as, for instance, andalusite, was seen but the structure and character, especially of the biotite, convey the impression of a rock of this character. Should future observation confirm this it will have to be admitted that the granite of the Baltoro neighbourhood is more recent than the crystalline schists which are in contact with, and have been metamorphosed by, it.

II. *Noble Serpentine.*—Typical specimens of this were collected along the whole course of the Baltoro. They were also found in the moraines of the upper reaches and it is probable that it is intrusive in the sedimentary rocks. Lydekker records this mineral as occurring in the Shigar region in the supra-Kuling series, of mesozoic, perhaps upper mesozoic age; it was also determined by Prof. T. G. Bonney and Miss A. C. Raisin[1] in specimens collected by Sir M. Conway from White Fan Pass, a little east of Crystal Peak.

III. *Vein Quartz.*—In variety. Two specimens were collected by His Royal Highness on Bride Peak, along with the biotite gneiss already described, others in the moraines of the Baltoro. The latter enclose pyrites and arsenical pyrites or mispickel; these very common minerals would be of no importance but that they may indicate a possible origin of the gold which near Skardu and elsewhere is found in small quantities in the alluvium of the Upper Indus and its tributaries, possibly in doubly derivative occurrence, as Lydekker found traces of gold workings in the alluvial terraces at about 120 feet above the present level of the Indus. Probably the pyrites of the quartz veins is sufficiently auriferous to give rise on its decomposition to the scanty gold which is met with in these river gravels.

[1] *Proc. Roy. Soc.* LV, p. 486 (1894).

B.—Sedimentary Rocks.

The rocks of palpably sedimentary origin, collected in the Baltoro moraines, fall into two principal groups; one composed of schists and siliceous anagenites,[1] the other of most various limestones, dolomites and calcareous breccias.

The first group contains many types, which, individually, seem tolerably different from each other, but, considered as a whole, yield so many intermediate types as to suggest an origin from one and the same series of strata. The prototype is a rock composed of small rounded fragments of quartz imbedded in a micaceous matrix, and may be described as a reddish violet anagenite with the quartzose component generally of small dimensions, and of white, reddish and greenish colour, imbedded in a distinctly schistose micaceous (sericitic) matrix. With the disappearance of the quartz fragments this rock passes into a thoroughly typical violet-coloured sericite schist. At times the quartz grains increase in size and abundance till the rock, being strongly cleaved, assumes a characteristically gneissose appearance; at others the sericitic cement becomes so cryptocrystalline as to assume a wax-like appearance. Occasionally the whole rock seems to have undergone an alteration which has given it an argillaceous appearance, recalling that of some porphyrites or porphyritic tuffs, which have been altered into argillites.

Less abundant as compared with these rocks, all more or less reddish in colour, are others, quite analogous, of greenish grey colour, which probably alternate with the former because, except for the colour of the micaceous matrix, they consist of the same elements.[2]

The calcareous group presents an extraordinary wealth of varieties and can be divided into three sub-groups: limestones, comprising also dolomites and dolomitic limestones, coloured marbles, and breccias, the latter more abundant than all the other rocks.

The first sub-group includes white, grey and black-banded limestones, and whitish and yellowish dolomites. One crystalline limestone in particular deserves special mention; it is a fine-grained, almost waxy looking limestone, sometimes marbled with fine grey lines, sometimes having the appearance of cipolin, which is probably derived from lenticular masses included in the gneiss or mica schist.

[1] This word, which is not used in England or mentioned in English text books, is in common use by French and Italian geologists for a rock composed of small rounded fragments, or pebbles, of quartz scattered through a fine-grained micaceous matrix. Rocks of this kind are common in the Alps, as also in parts of the Himalayas, and since there is no word in common English use to describe them the term has been retained.—R. D. O.

[2] The rocks described by Prof. F. G. Bonney and Miss Raisin from the collection made by Sir M. Conway under the names of grit, schistose grit, and to some extent quartzite, include many which would here be described as typical anagenites.

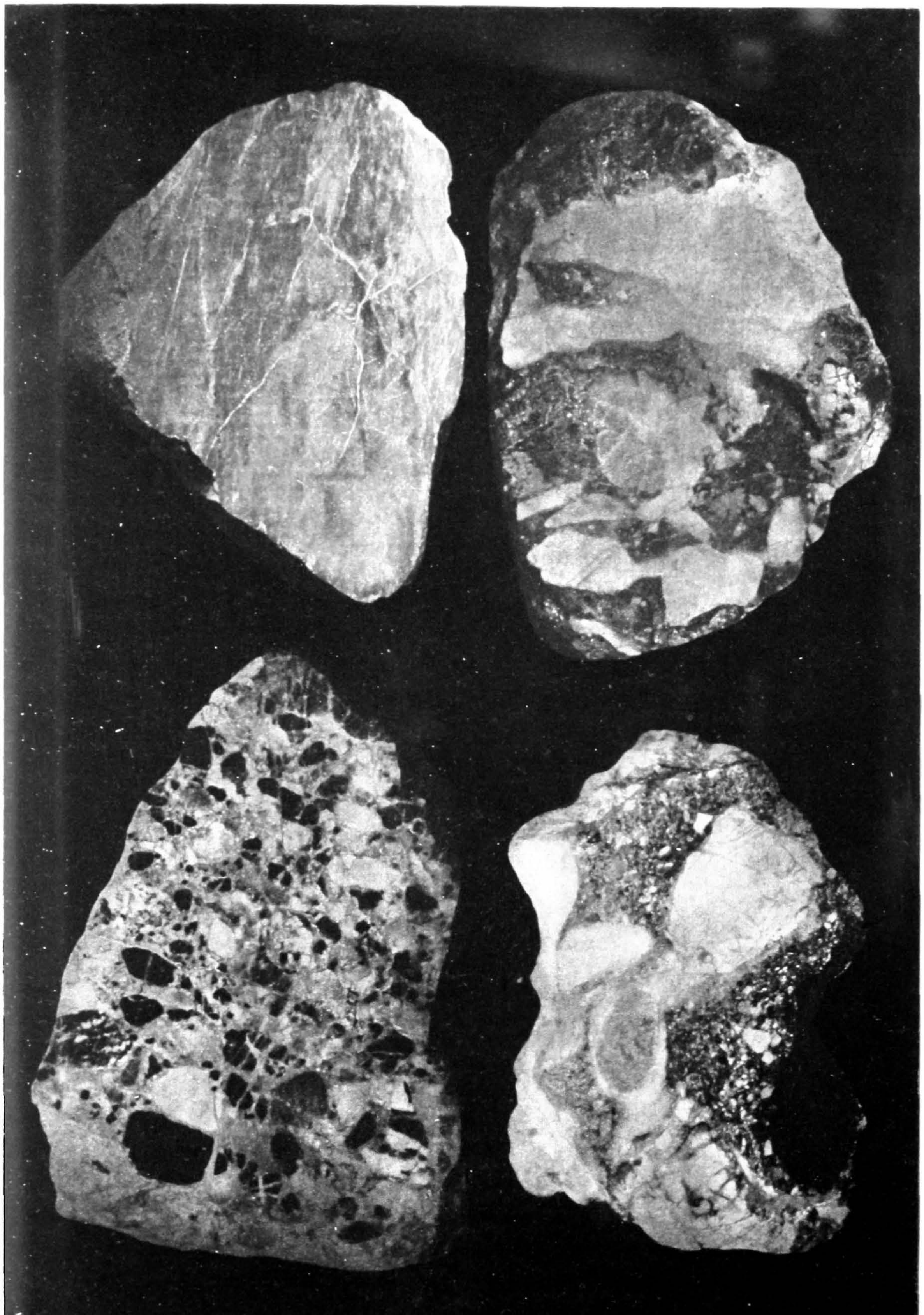
In the group of coloured marbles the prevailing variety is a very beautiful red marble with small white spots, and various other types, all having a red coloured base and white veins.

There comes finally the group of breccias, which presents no small variation, both in the nature of the fragments and in that of the cement, in the colour of one or the other, and so on. Noteworthy is a whole series of breccias of calcareous fragments, bound together by a reddish micaceous substance, quite analogous with the matrix of the anagenites. Better than any description as a help to an appreciation of the range of colours of these breccias, is the fact that they present many analogies with the varieties of marble from the Apuan Alps and other parts of Italy.

Certain specimens, intermediate between the breccias and marbles, are formed of a soft, dark red, calcareous schist, seamed with veins of calcite, which gives place, when associated with white limestone, to a white marble with violet-coloured amygdaloidal patches, and dark red veining, and to a dark red and white marble breccia with green variegation, altogether similar to the *rosso di Lĕvanto;* but while the latter is a typical ophicalcite, as much cannot be said of the Baltoro specimens, in which the green is due to variegation of the schistose portion. It is, however, to be noted that we are not impossibly dealing with an extreme form of true ophicalcite, as fragments of noble serpentine are found in the moraine along with this breccia.

The specimens collected at the camping grounds of the explorers are insufficient for an attempt to arrange the various types in their order of geological sequence. The only hypothesis which can be hazarded is that probably some of the calcareous breccias with micaceous cement come from the contact zone of the schists and anagenites with the limestone and dolomite. In the Apuan Alps very similar breccias (*mischio di Saravezza*) occur at the contact between the lower limestones (*grezzoni*) and the underlying schists, which have been ascribed to the permian, others, on the contrary, occur at the contact of the said *grezzoni* with the zone of marbles, etc. All these breccias appear to be due to mechanical action and are consequently referable to crush breccias.

Owing to the absence of organic remains among the material collected by the Italian expedition, no direct determination of the geological age of the formations is possible, and the only way to arrive at even a very approximate determination is by comparison of the specimens collected with the rocks already studied and known in other parts of the district. According to the work of Lydekker and Godwin-Austen, confirmed by later observation, a great complex of formations occurs in a syncline, between Shigar and Askoley, in Baltistan, and in the range rising west of the Biafo glacier. This complex, formed by alternations of schist, limestone, dolomite containing serpentine, and, according to Col. Godwin-Austen, also quartzites, may well be the equivalent of the formations met with in the Upper Baltoro valley. Mr. Lydekker gives two sections across this formation and mentions



dolomitic limestones, blue and white mottled limestones, pure white and blue limestones with red veins, green and black schists, the latter carbonaceous and calcareous, and so forth, besides brown grits, which may be the reddish anagenites and identical with the quartzites of Colonel Godwin-Austen. In short the rocks are all such as are present in the moraines of the Upper Baltoro glacier. Mr. Lydekker also mentions dolomites and limestones with characteristic red stains, identical with those found in the supra-Kuling series of Chang-cheng-mo.[1] It is not, therefore, too risky to assume that the same formations, but with a much greater development of limestones in comparison with the other rocks, are repeated to the east of K^2 and form the Broad–Gasherbrum–Golden Throne group of mountains.

The beds of the series forming the above-mentioned, so-called[2] Baltistan–Braldoh syncline are ascribed by Mr. Lydekker, on account of their resemblance to other fossiliferous rocks of the district, to his Zànskàr system, named after a district in Kashmir, and attributed to a carbon-mesozoic age. The series which is fossiliferous at Shigar, and comparable with that met with on the Sasser Karakoram track, certainly includes the permian and trias, together with older beds at the base and newer ones above. With all reservation necessary in the present case, we may, provisionally, accept a similar correlation for the sedimentary series of the Upper Baltoro, all the more so as I shall shortly set forth other arguments in favour of this hypothesis.

A sufficiently clear idea of the topographical distribution of these sedimentary rocks in the mountains of the Upper Baltoro may be formed from the series of moraine ridges immediately below the confluence of the Baltoro with the Godwin-Austen glacier, along a line drawn from north to south.[3]

According to Dr. De Filippi the succession is as follows :—

1. A large moraine of granite, gneiss, and crystalline rocks, derived from the range on the left of the glacier from Bride Peak to Masherbrum.
2. Moraine of limestone fragments, rich in coloured marbles and limestone breccias, which have fallen from the western flanks of Golden Throne.
3. Narrow moraine of schistose slaty rocks, which unites with the preceding one a little lower down.
4. A great moraine of calcareous fragments, coloured marbles, breccias and anagenites of various colours, with a predominance of wine red, which descends from Hidden Peak and the southern buttresses of Gasherbrum.

   With this moraine the contribution of the Upper Baltoro ceases and gives way to that of the Godwin-Austen glacier.

[1] *Mem. Geol Surv. Ind.* XXII, pp. 188, 189.

[2] E. Suess, *Das Antlitz der Erde*, III, pt. i, p. 350.

[3] These moraine ridges are very clearly visible in the Panorama M, taken from the rock crest between the Vigne and Baltoro glaciers.

5. Moraine of limestone fragments collected along the slopes of Broad Peak.
6. Median moraine, coming from the southern and western slopes of K^2, the prevailing constituents being granite and crystalline schists with some scattered fragments of limestone.
7. Right hand marginal moraine, with the same composition as the preceding, but becoming richer in limestone fragments below the white limestone peak, which rises to the south-east of Crystal Peak, at the confluence of the Baltoro and Godwin-Austen glaciers.

The observations made by Dr. De Filippi, the beautiful photographs of Vittorio Sella, and the material determined and discussed in the preceding pages, make it possible to draw the outlines of a sketch of the geological constitution of the mountains of the Upper Baltoro and to study their relations to other districts geologically known.

From the end of the glacier near Paiju up to the confluence of the Godwin-Austen glacier, the Baltoro valley is opened through the gneisses and granites of the Baltistan massif, according to the unanimous description of all explorers. It is possible, however, that crystalline limestone might be intercalated in this series of crystalline schists, for Lydekker mentions[1] having met with it in the Hushe valley, which descends southwards from Masherbrum in the heart of the gneissic area.

Certain of Sella's photographs, however, led me to entertain some doubt of the entirely gneissic character of the Lower Baltoro valley. In the preliminary account of the journey, published by the Italian Geographical Society,[2] it is mentioned that the mountains on the right of the Baltoro in front of Rdokass are gigantic, with vertical flanks, and peaks of superb and fantastic forms, sometimes of formidable towers, at others of sharply pointed pyramids. As the photographs and telephotographs show, these irregular forms are confined to the upper parts of the mountains and seem to be the remnants of an enormous, nearly horizontal layer superimposed on the massive gneiss. The forms, in short, of these mountains reproduce the appearance of the dolomitic towers of the Alps, so that it is at least justifiable to doubt whether there may not be, in this part of the Mustagh, the remains of a capping of sedimentary rock regularly covering the gneiss and forming what is known in modern terminology as a "lambeau de recouvrement," composed of dolomites, overthrust on to the gneiss and granites of Baltistan.

Apart from dolomite, the only rock, with which I am acquainted, capable of assuming such forms is the protogene, a special form of granite, of Mont Blanc.

[1] *Loc. cit.*, p. 312.
[2] *Boll. Soc. Geog. Ital.* series iv, XI, p. 444, April 1910.

Since four glaciers descend from the cliffs in question it will be easy for a later examination to confirm or refute this hypothesis by an examination of the moraines.[1]

Ascending the valley, the mountains suggest no change of character till the confluence of the Godwin-Austen glacier is approached. On the right of the Baltoro, opposite and north of Mitre Peak, a marble crag rises from one of the buttresses of Crystal Mountain, and is marked in the map of the Italian expedition by the figure 20088. The peak is most recognisable because the summit, composed of pure white marble, rises from a base of dark-coloured schists. The dip of the schists, though steep, is distinctly eastwards above, but lower down becomes perfectly vertical, where the beds are seen plunging perpendicularly into the Godwin-Austen glacier.

As it was not possible to secure authentic specimens, either of the schists of the base or of the marble, we must have recourse to conjecture. In the material of the moraine the only white marble is a saccharoid limestone of very fine grain, with suggestions of cipolin, derived from the moraine on the Baltoro in direct correspondence with this peak. Is this mass of marble simply a great lenticular inclusion of crystalline limestone in the Baltistan gneiss, like that of Masherbrum, or, does it belong to the overlying group forming the massif opposite to it, from which it seems separated by some local accident of structure or sculpture? The material for answering these questions is not to hand.

West of the marble peak lies a saddle named by Sir W. M. Conway, White Fan pass, beyond which rises his Crystal Peak, not that so named on the Italian map, but one of its minor peaks. Among the specimens collected by Sir W. M. Conway, on the ascent of his Crystal Peak, Prof. T. G. Bonney and Miss A. C. Raisin identified[2] a fine-grained gneiss, a calcitic quartz schist, a dark-coloured mica schist, a dolomite, and a limestone, both crystalline. From the White Fan pass came a mica syenite and a fine-grained crystalline dolomite. All these are rocks of a crystalline series and, except the syenite, of the schistose group. The presence of unaltered sedimentary rocks in the Baltoro moraines, opposite Crystal Peak, led Prof. Bonney and Miss Raisin to propose the hypothesis that sedimentary formations were represented in the rock forming this mountain. Now that we know that sedimentary rocks form the whole of Gasherbrum, from which the greatest part of the moraine material of the Baltoro is derived, Prof. Bonney's conjecture becomes baseless, and the presence of sedimentary rocks in the vicinity of Crystal Peak problematical.[3]

[1] It is worth noting that the illustrations to Sir W. M. Conway's book, and to that of Dr. Jacot Guillarmod, indicate the existence of a very similar feature in the mountains of the Masherbrum range, to the south of the Baltoro valley.—R. D. O.

[2] *Scientific Results*, p. 72.

[3] See, however, the remarks on p. 445.

The formation of schists, anagenites, limestones and dolomites shows up in its full development in the terminal mass, lying between the Godwin-Austen and Upper Baltoro glaciers, which is crowned by the three peaks Broad, Gasherbrum and Hidden, rising to heights of more than 26,500 feet (8,000 metres). The limestones predominate in the high portion of the Broad and Gasherbrum mountains, the base of schists is seen to fringe the foot of these mountains along the whole of the left bank of the Godwin-Austen and eastwards along the right bank of the Upper Baltoro glaciers, to almost opposite Mitre Peak. Beyond this point the limestones extend down to the base, and on the left of the photographic view of Bride Peak from Camp III the mass of limestones, bristling with peaks and pinnacles, is seen to rise from the glacier.

The boundary between the limestones and schists is, consequently, covered by ice in the valley, but certainly rises towards the dip between the calcareous Golden Throne and the gneissic Bride, and probably crosses Chogolisa pass.

Among the specimens collected by Sir W. M. Conway on the second pinnacle of Pioneer Peak, one of the peaks of Golden Throne, is a purple schistose grit with small pebbles, mentioned by Prof. Bonney and Miss Raisin[1], which may be identical with the anagenite of this report.

As appears from specimens collected by His Royal Highness, at a height of 24,600 feet, Bride Peak is composed above of gneiss, and at the base of the granites and granitoid gneisses, so extremely abundant, according to the observations of the members of the Italian expedition, in the moraines of the glacier which descends from this mountain.

In the Upper Godwin-Austen glacier the boundary between the gneiss and the beds of the palæo-mesozoic series must lie to the south of Windy Gap, as the Staircase is made of coarse-grained, light greyish gneiss.

The base of the highest peak of the neighbourhood, K^2, ought, according to the reports of various expeditions, to be formed of light-coloured granites or granitoid gneisses. But the several photographs taken from south, east and west show a well marked stratification with gentle dips of about 15° to 20°, which is greatest in the terminal pyramid; it is probably due to layers of gneiss analogous to those of Bride Peak. Colonel Godwin Austen, who noticed this peculiarity in the photographs brought back by the Italian expedition, expressed the opinion[2] that the stratified summit of K^2 might be more recent than the granite base. I cannot accept this opinion of the illustrious and learned explorer without reservation. The mere fact of superposition is not enough to establish the relative age of two formations in a highly disturbed region, all the more so as the granite may be intrusive.

[1] *Scientific Results*, p. 73.
[2] *Geog. Jour.* xxxvii, p. 26.

The scarcity of specimens obtained from rock *in situ* leaves many questions obscure. Are the schists of the base of Broad Peak the same as those of the Marble Peak? Do they belong to the crystalline schists as Dr. De Filippi believes, or to the palæo-mesozoic series? At present no answer is possible.

One other question remains unsettled, the direction of the dip of the contact between the schists and limestones at the base of Broad Peak. The course of the junction from Windy Gap to the Chogolisa pass, taking into account the difference of level, is nearly north and south, but none of the photographs have enabled the dip to be determined. Taking into account what is seen on the Marble Peak it is probable that the dip is very high and nearly vertical, with a tendency towards inversion to an apparent easterly dip.[1] From Mr. Lydekker's observations we know that at Askoley, in the Braldoh valley, the contact between the sedimentary series and the gneiss of Baltistan hades to the east, that is to say, the gneiss is inverted over the more recent rocks. If this explanation is rejected we must believe that there is a superposition in normal chronological order.

Notwithstanding the great gaps, which yet remain in our knowledge of the geology of the mountains of the Baltoro glacier, one fact of greatest importance has been established. The valley of the great glacier is closed on the north by a very elevated massif, composed of sedimentary rocks of upper palæozoic and mesozoic age, prevailingly calcareous and, therefore, differing widely from the mountains of the rest of the valley, which are entirely, or prevailingly, granitic and gneissic.

This difference explains how the course of the junction between these types of rock has determined that of the longitudinal furrow, formed by two subsequent valleys, which give origin to the bifurcation of the valley into the two branches of the Upper Baltoro and the Godwin-Austen, descending, respectively, from the Chogolisa pass and Windy Gap. The valley of the Baltoro has, therefore, a certain analogy with that of the Upper Aosta, which ends in the two longitudinal valleys of the Allée Blanche and Ferret, meeting at Entrêves, at the foot of Mont Blanc, to form the strictly transverse valley of the Dora di Valdigne. Geologically and lithologically the Baltoro valley is, to a certain extent, the opposite of the Aosta, because, while the latter is formed of schistose limestone rocks and shut in by a granite mass, the former is cut through granitic and gneissic mountains

[1] The view of Bride Peak in the photographs, and the course of the boundary from the Chogolisa Pass along the whole of the lower part of the Godwin Austen glacier, seem to indicate a well-marked easterly or, more precisely, north-easterly dip. If this dip remained unaltered the boundary should rise along the base of K^2 to the Savoia pass. That the boundary is found at Windy Gap, much further east, indicates a stratigraphical disturbance, either fracture or secondary fold, causing either bodily displacement or a local change of dip, and determining the abrupt bend to the north-eastwards of the course of the upper Godwin-Austen glacier.

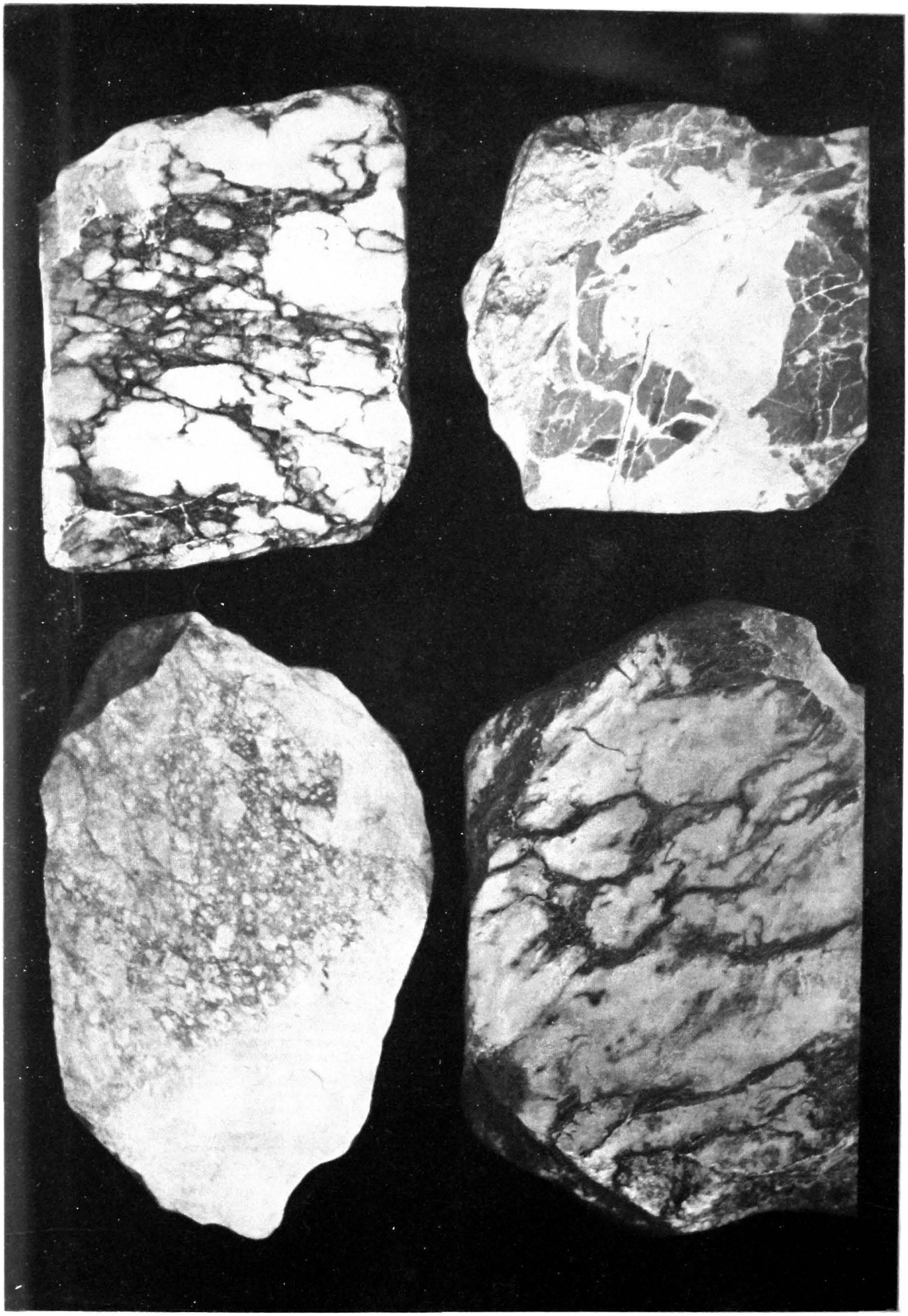
and closed by a mass of schists and limestones, which ought to be named after the Broad Peak, as this rising to 27,133 feet forms the highest point, rather than the customary Gasherbrum, which will be retained as it has become established by use.

From the distribution of morenic material in the glaciers of the group it seems fairly probable that the terminal peaks of Broad, Gasherbrum IV, Hidden and Golden Throne are all formed of limestone and dolomite. They will consequently be the first peaks of over or near 26,500 feet known to be formed of sedimentary rocks, whereas the loftiest summits previously known are composed of granitic, gneissic rocks, or else formed by volcanic cones. Allowing for difference of scale, the Broad group may be taken to represent, in the Karakoram, the Grand Combin, in the Alps—the only peak formed of sedimentary rocks (mesozoic calcareous schists of Piedmontese facies) which rises above 13,000 feet.

If we regard the general geological structure of the region, as shown by geological maps and descriptions, the discovery of the great mass of limestones of the Upper Baltoro appears clearly as the continuation, and harmonic complement, of the structural outlines which had been suggested, but left uncertain, by earlier exploration to the south-east. For a long time the presence of palæo-mesozoic rocks in the Chang-cheng-mo-Karakoram region of Eastern Ladakh has been known; they have been described by Dr. Stoliczka in 1878, and at a later date by Mr. Lydekker, who found dolomites with upper trias fossils. This palæo-mesozoic area forms an elongated strip running north-westwards parallel to the direction of the gneissic mass of Baltistan. It had been traced to Sirsil, between the Nubra and Shyok valleys, on the road to the Karakoram pass, but its ultimate course and end remained unknown. The calcareous dolomitic mass of Gasherbrum lies approximately on the north-west prolongation of this band, and the discovery, by Dr. Longstaff, of limestone in the median moraine of the upper Siachen glacier, at a place intermediate between Sirsil and the Upper Baltoro, is a weighty argument in favour of the continuity of this band of mesozoic limestone for some 90 miles, through a region which is yet unexplored, even geographically.

The importance of this discovery is not merely geological but also, and principally, geographical. The course of the watershed, between the Indus valley and the closed drainage area of Turkestan, from the Mustagh to the Karakoram pass, was uncertain and badly known, in spite of certain peaks having been trigonometrically fixed, as it had been barely seen and never crossed by the explorers who followed each other at long intervals.

The Italian expedition obtained, from Windy Gap, on 15th June, 1909, the first view over the unknown country east of the mountains bounding the Baltoro glacier, and saw, to the left of Gasherbrum, not the valley of the Oprang tributary of the Yarkand, seen a few days previously by His Royal Highness from the Savoia



pass to the west of K 2, but another valley, with a glacier draining to the south-east.

Almost simultaneously, on 16th June, 1909, Dr. Longstaff crossed the presumed watershed by the Saltoro pass and descended onto a glacier which, a couple of months later, was suspected on the suggestion of Colonel Burrard to be the upper portion of the Saichar or Siachen glacier, previously known only at its lower end, and believed to have a length of about 20 miles, instead of the 45 miles it is now known to reach. The source of the Siachen is thus pushed back to an untraversed pass, seen by Dr. Longstaff from an estimated distance of 12 miles, and supposed to be the same as that reported, from the northern side, at the head of the Urdok glacier by Sir F. Younghusband, in his exploration of the Oprang valley in 1889; a pass which seems to lie in about the same latitude as Golden Throne. In the mountains to the east of this pass, to which Dr. Longstaff gave the name of Younghusband, he noted the very lofty peak of Teram Kangri, whose height, estimated approximately at 27,610 feet, makes it one of the loftiest mountains of the world.[1]

Finally he noticed that the moraines on the left of this upper Siachen glacier, like those on the right of the upper Baltoro, were full of marbles and calcareous breccias, and saw, some ten miles off, the rocks of Teram Kangri gleam white, where not covered with snow; facts which led him unhesitatingly to the conclusion that this superb mountain was formed of limestone. This statement, which might appear rash, if unsupported, attains a certain probability from the observations and records of the Italian expedition in the Gasherbrum massif.[2] The mountain mass of Teram Kangri lies about south-east of Broad Peak, and on the line joining this with the limestone band recorded between the Nubra and Upper Shyok valleys and from its eastern declivities by Mr. Lydekker, to the south of the Sirsil or Sasser pass.

This unexpected extension of the Siachen glacier to the vicinity of the mountains at the head of the Baltoro gives great importance to the observations of the Italian expedition, whether from Windy Gap or the Chogolisa pass, as has already been briefly referred to in the addresses given by His Royal Highness and published in various scientific periodicals.[3]

As regards Windy Gap, this has already been dealt with. The camp on the Chogolisa pass commanded the valley of the Kondus, a glacier which was seen to intervene between the Baltoro and the recently discovered Upper

[1] More recent and rigid measurements by the Indian Trigonometrical Survey have reduced this figure. The final calculations are not complete but the height has been determined as about 24,489 feet, a figure which can be relied on to within 100 feet.—*Geog. Jour.*, XXXIX, Jan. 1912, p. 72.

[2] Dr. Longstaff has recognised Teram Kangri in a photograph, taken on 22nd June, 1909, by Vittorio Sella from Windy Gap. *Geog. Journ.*, January, 1911.

[3] *Rivista del Club Alp. Ital.* XXIX, pp. 26–35 (1910); *Boll. Soc. Geog. Ital.* ser. v, XI, pp. 454 and 460 (1910).

Siachen. The valley of the Kondus, dominated by the peaks K^7, K^8, K^9, winds tortuously, first to the east, then to the north, passing round the bases of Golden Throne and Hidden Peaks. This last is not the most easterly peak of the Gasherbrum group, for eastwards of Hidden Peak rises another, and only to the east of this does a deep gap form the true limit of the Gasherbrum massif, taken in a wide sense, and the head of the Kondus glacier. The Italian expedition believed that this was in truth the pass at the head of the Urdok glacier, seen from the Oprang side by Younghusband, and for this reason.

Beside this depression another was seen, formed by a low ridge, separating the Kondus from a wide, glacier-filled valley further east, which is probably none other than the Upper Siachen. The low crest just mentioned rises rapidly towards the south into the high mountains between the Kondus and the supposed Siachen, and to the east into other lofty mountains, which should be the easterly or northerly continuation of Teram Kangri, if not this mountain itself.

From the saddle at the head of the Kondus it seems possible to descend to the Oprang basin, and probably into the Urdok valley.

If the map accompanying Dr. Longstaff's account of his expedition is compared with the representation of the Kondus valley, which has just been set forth, it is evident that there are no irreconcilable differences. The Kondus and Siachen glaciers end in two depressions, separated by a low crest, which, seen from a distance, might be superimposed on each other by an effect of perspective, so as to give the impression of a single valley, especially from the relatively low point where Longstaff was upon the Siachen, at about 16,000 feet, an impression less probable from the camps of His Royal Highness on Chogolisa, at an elevation of 22,000 feet, equal to, if not greater than, that of the pass in question. From this it follows that the westernmost extremity of the Siachen valley will not communicate directly with the Urdok, but only with the Kondus, whose head intervenes, so to speak, between the valleys of the Siachen and Urdok; and that the pass seen by Sir F. Younghusband lies between this latter and the Kondus valley.

A discovery so important as that of the greater extension of the Siachen has given wide field for conjecture and hypothesis, and to considerable divergence of interpretation, a thing which is natural in view of the many uncertainties still existing. Dr. Longstaff, and still more distinctly Dr. Neve, his companion in part of the expedition, have expressed in their writings the opinion that the Siachen communicates with the Baltoro directly over a saddle at the base of Hidden Peak, or to the north of it, in the same way that the Biafo glacier in Baltistan communicates with the Hispar. In the first place this supposed continuity of the two glaciers does not exist. South of the Broad massif the Kondus glacier, as has been mentioned, is insinuated between them. The valleys which descend to the east and north of the massif are tributaries of the Oprang, either by means of the Gasherbrum glacier of Younghusband, or by the Urdok; consequently there can be no direct connection between the Siachen and Baltoro glaciers. Yet, broadly speaking, the notion implied by these authors might be extended across the gap formed by the Upper Kondus, and it might be maintained that the Baltoro and Siachen, in spite of a brief interruption, lie in the same tectonic furrow and so preserve the analogy desired by Dr. Longstaff. But not even in this way is it correct, for the Biafo-Hispar system is formed by two longitudinal valleys draining in opposite directions, in a furrow which is orographically, and geologically, a single well-marked feature. The Siachen-Baltoro system, on the other hand, would consist of a longitudinal valley draining to the south-east, joined by a series of gaps and valleys, found along its prolongation to the north-west, with the distinctly transverse valley of the Lower Baltoro. The supposed analogy therefore does not exist, even on this hypothesis; on the contrary, it is obvious that the Siachen furrow continues into the Urdok across the two contiguous saddles.

From the observations made by the two expeditions it results that the course of the water parting between the Indus and Yarkand basins is very different from what had been believed and shown on maps.

The Karakoram, like the Himalaya, of which it is the western portion, consists of a series of chains parallel to each other, and also approximately parallel to the course of the geological zones and leading tectonic features, ill-known as yet, of the whole great system. The rivers flow in open valleys between these chains; and narrow, deep-cut channels, frequently reduced to impassable gorges, by which the rivers pass from one valley to the next, sever the chains in pieces. Consequently, although the lines of peaks appear continuous on the map and exhibit a sensible parallelism, the principal watershed, and many of the secondary ones, have a very different course, proceeding by stretches as they pass from one range to another by means of transverse ridges, which separate the divergent slopes of each of the furrows contained between a pair of ranges.

On the whole then, as this passage of the watershed from one chain to the next takes place for long stretches in a regular manner, always from a more forward range to one further back, the complex course of the line of watershed cuts, at a very acute angle, the general direction of the ranges, so that it is easy, in ill-known parts of the system, to confound two quite distinct members with each other and regard them as only one. Just this confusion was made in all maps anterior to 1910 in the country between the Upper Baltoro and the Karakoram pass.

The discovery of the Upper Siachen, and of Teram Kangri, has shown the existence of a great longitudinal furrow, occupied by a glacier, and of a chain, parallel to that, well known and fixed, which runs from K^2 to Hidden Peak and, up to now, was called the main range of the Karakoram. The ridge by which the watershed crosses from this to that of Teram Kangri is formed by that saddle between the head of the Kondus and the Siachen which was seen from Chogolisa. The chain of K^2 is truncated by the Kondus valley, whose tortuous course in the upper part indicates a breach of continuity, filled with ice, but where this disappears, exhibiting itself as one of those impassable gorges in which the Karakoram is rich. It is probable that the continuation of the chain of K^2 is that in which the peaks K^9 and K^{10-11} are found, these latter over 25,000 feet in height, and in the Saltoro chain to K^{12} and beyond.

It is natural to enquire what may be the influence, on the morphology of the region, of the junction between the crystalline and sedimentary rocks, which, in the Upper Baltoro valley, determines the furrow extending from Windy Gap to the Chogolisa pass. Probably it crosses the Upper Kondus valley and cuts the ridge between this and the Siachen to the east of K^{10-11}, which present themselves, orographically, as the homologue of Bride Peak, in secondary alignment parallel to the principal range, and, geologically, as the continuation of the crystalline axis of K^2. If the depression along the plane of contact continues farther to the south-east, it should cross the Siachen valley and the Murgisthang pass, to reach the known boundary on the Sasser pass. It is evident therefore that, although this contact determines many and important orographical details, it does not correspond to any great valley, and still less to a furrow of primary rank, as is the case in the Biafo-Hispar valley.

In conclusion it is certain that the water parting between the Indus and the Central Asian drainage, after passing the peaks of K^2, Broad, Gasherbrum and Hidden, turns eastwards to a parallel range which bounds the Siachen on the east and probably culminates in Teram Kangri. A good part of this range was already known, for it runs from the Sasser pass, for more than 100 miles south-eastwards to the Pangong Lake, and is cut through by the precipitous gorge of the Shyok, in the reach which lies above the sharp elbow formed by this river, a little below its junction with the Chang-cheng-mo. The range of K^2 runs south-west of this, and although the complexity of its geological composition—for granites, schists and various sedimentary rocks take part in it—has a very sensible influence in multiplying and increasing the accidents of relief, it has not rendered less evident the orographical continuity, which is obvious enough in many parts.

The two chains of K^2 and Teram Kangri, are, therefore, well distinct, and the resemblance between the Karakoram and the double chain of the Hindu Kush, already suspected by some, has a real basis. The latest discoveries have revealed the importance of the Teram Kangri range, which is promoted from the position of a secondary spur of the presumed watershed range, to that of a primary range of the system. The continuation of this range, to the northwards, is certainly that row of peaks, which the Italian expedition observed from Windy Gap, and which will now become the object of fresh journeys of exploration.

Geological Survey Office, Rome, *July*, 1911.

Having been asked to undertake the translation and revision of the Appendix dealing with the geological results of the expedition made by His Royal Highness the Duke of the Abruzzi to the Karakoram, I find little left to be done as regards the latter half of the task. The facts, as set forth by Ing. Novarese, may be accepted, the interpretation follows, for the greater part, with logical certainty. Only in two parts of any importance do I find myself unable to accept unreservedly the opinions expressed in the note. The first of these concerns the limestones of Crystal Peak and the hills eastwards of it. In the note they are regarded, with very little hesitation, as belonging to the older gneissic series, and as lenticular inclusions in it. This interpretation is not impossible, but it seems to me that insufficient weight has been given to earlier observations, and that the case for regarding the limestones as belonging to the sedimentary series, either as a continuation of the Gasherbrum exposure or as an outlier, is stronger than is represented by the text. Sir W. M. Conway, in the description of his expedition, expressly states that on the descent from his Crystal Peak he came upon "a new set of rocks which gave a fresh character to the ridge separating the Baltoro and Godwin-Austen glaciers." These rocks are described as granites and hard limestones, light grey, buff and white in colour, of which seams were found in the rocks lower down the valley but here forming the mass of the mountains. His next camp up the glacier was pitched on a fan composed of fragments of white marble.[1] In the description of the rocks collected *in situ* on these hills it is stated that no record was kept of the order in which they were collected, but of the specimens one is described as gneiss, one as mica schist, and five as various forms of limestones; the other specimens are one of syenite and one of quartz associated with limestone breccia.[2] It may be noticed that the gneiss and mica schist were both collected on the ascent of Crystal Peak, and that these rocks are unrepresented in the collection from the White Fan pass; moreover, from the latter locality came a greyish crystalline limestone, veined with noble serpentine, recalling the presence of similar rocks among the moraine débris derived from the Gasherbrum group of mountains, and the occurrence of serpentine among the sedimentary rocks on the slopes of Mango Gusor.[3]

These facts render it at least possible that we have to deal with an exposure of the limestone series, penetrated by intrusive veins of syenite and gneissose granite, such as is not uncommon in the Himalayas. It may be that the boundary, between the areas occupied mainly by crystalline and by sedimentary rocks, after running down the Upper Baltoro valley, crosses the main glacier and passes up onto the mountains north of it, thence, turning north-eastwards near the Crystal Peak, it

[1] *Climbing in the Himalayas*, etc., pp. 465 ff.

[2] PROF. T. G. BONNEY and MISS A. C. RAISIN. *Proc. Roy. Soc.* LV, p. 486; also in W. M. CONWAY, *Climbing in the Karakoram Himalayas*, vol. II, Scientific Results, p. 73.

[3] *Mem. Geol. Surv. Ind.* XXII, p. 189.

would run down to the valley of the Godwin-Austen glacier, striking it near the sharp bend and following the general course of the upper part of this valley. As an alternative the Crystal and Marble Peak exposure of limestones may be an outlying area of sedimentary rocks, but in either alternative there is the possibility, which should be investigated by future travellers, of the occurrence of sedimentary limestones in the hills north of the Baltoro glacier.

The second point, on which something more remains to be said, is the minor classification of the mountain ranges. The view advocated by Drs. Longstaff and Neve is rejected on the ground that there is no structural continuity between the Siachen, Baltoro and Biafo valleys, such as would give them a geological unity and justify the mountains on either side being regarded as forming two separate ranges; but, if this argument is allowed to prevail, it would equally militate against the view which regards the mountains on either side of the Oprang-Nubra trough as forming a pair of parallel ranges, for this orographical depression certainly does not follow, but runs obliquely to, the general strike of the leading feature in the geological structure of the district, namely, the Karakoram syncline of sedimentary rocks.

This argument is not, however, final, for the movements of elevation, which have given rise to the mountains, were spread over a long period, and it may well be that the latest of them, those which determined the rows of peaks as they now stand, did not exactly follow the earlier ones, by which the leading features of geological structure were marked out. Moreover, the case for the classification adopted in the note is stronger than is there set forth, for not only is the Oprang-Nubra trough similar to the much larger depression formed by the Sutlej and Sanpo valleys on the northern side of the Himalayas, but there is an apparent connection between the two, for the former is continued south-eastwards by the Shyok valley up to the elbow, where it bends from a southerly to a north-westerly course, and thence by the lower part of the Pangong Lake to the Upper Indus, and by this to the Sutlej valley. To the south-east this line of valleys has been held to be sufficient reason for separating the Himalayas, on the south, from the mountains to the north, so that if Ing. Novarese errs in separating the Teram Kangri peaks from those of the K^2 and Gasherbrum group, he errs in good company. And if this view is accepted, then the series of peaks, labelled K with a number by the Survey of India, can no longer be regarded as belonging to the same range that is crossed by the Karakoram pass, and a different name, Mustagh for choice, would have to be given to them and to the mountains which have been repeatedly described as the Karakoram Himalayas.

It is, however, by no means certain that this view of the grouping of the peaks into ranges is correct. It is natural for geographers to seek a parallelism between the minor members of a great chain of mountains and the general direction of the whole, and the intricacy of the valley systems, cut back at times along the strike-line between minor ranges, and at others across and through them, makes it not impossible to find justification for dividing the mountain chain, as a whole, into a series of parallel ranges, running along the length of the chain. Yet, although it may be possible to adopt a nomenclature expressing this view, it does not follow that the names represent what really occurs in nature, and there is another aspect of the case which is at least equally worthy of consideration, that the individual members of the chain are ranged not along, but obliquely transverse to, the general direction of the whole, much like the arrangement of the individual birds in a flock of wild geese, or the individual regiments of an army ranged in echelon.

The study of areas of structural elevation, on a smaller scale, and of less complication, than a mountain range, shows that the principal anticline is often crossed by minor ones, ranged obliquely to it, so that the margin of the area of uplift is marked by a series of open folds, all pitching in the same direction and advancing one beyond the other. It is not unnatural to suppose that a similar feature may be found on a larger scale in great mountain ranges, and on this view the Teram Kangri and Gasherbrum peaks would fall into the same range, continued probably to K^2, and the Mustagh Peaks. Nor would the interruption of the range by the deep gap between Teram Kangri and Gasherbrum, or by the Godwin-Austen glacier valley between that and K^2, affect the structural unity of the range, for it must be remembered that the peaks are peaks because the agencies of denudation have not yet had time to remove them, though they have removed all the surrounding rock; on the other hand the peaks owe their elevation to the fact that the rock of which they are composed has been uplifted, and where we find a group of peaks rising much above those by which they are surrounded, we may conclude that this great elevation is due to the fact that the last episode, in the general uplift of the mountains, was a more rapid and greater upheaval of the particular region in which the high peaks are found.

It might be, of course, that there were two neighbouring areas of such special elevation, one marked by the Teram Kangri group of peaks, the other by the K^2, Broad, Gasherbrum and Hidden Peaks, and that between them lay a zone of lesser uplift. A more probable case, however, is that these two groups of very high peaks form parts of the same general area of special, recent, uplift, and this special upheaval may have determined the position of the watershed, which crosses the Oprang-Nubra trough. If this is the case, K^2 and the Mustagh Peaks are restored to that group of ranges crossed by the Karakoram pass, which together have come to be known as the Karakoram mountains.

That such widely divergent views of the classification of these mountains can be put forward, without any possibility of even indicating which is likely to be ultimately accepted, shows how little is really known as yet, and how much remains to be done before the structure of this region can be rationally discussed, much less said to be properly understood.

Horsham, *February 20th*, 1912.

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ROCK SPECIMENS COLLECTED ON THE BALTORO MORAINES.

PLATE I.

Fig. 1. Rose-coloured, veined limestone.

Fig. 2. Many-coloured breccia of limestone fragments and sericitic cement.

Fig. 3. Many-coloured breccia of limestone fragments and yellow calcareous cement.

Fig. 4. As Fig. 2, with the fragments more scattered and subordinate to the matrix.

PLATE II.

Fig. 1. Brecciated violet-coloured limestone (*pavonazetto*). The deeply coloured portion is schist.

Fig. 2. Marble blotched with red.

Fig. 3. Rose-coloured limestone (*persichino*), minutely brecciated.

Fig. 4. Brecciated violet limestone with greenish tinting. The deeply coloured part is a reddish violet schist; the green coloration is due to infiltration of the part originally white.

Appendix D.

BOTANICAL REPORT

BY

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AND

Dr. F. CORTESI

UPON THE PLANTS GATHERED BY THE EXPEDITION.

APPENDIX D.

BOTANICAL REPORT

UPON THE PLANTS GATHERED BY THE EXPEDITION.

I.—LIST OF PLANTS GATHERED.

A.—Braldoh and Biafo Valleys.

EPHEDRA pachyclada Boiss.
Salix sp.
Clematis orientalis L. var. ?
Berberis vulgaris L. var. *aetnensis* Presl.
Cheiranthus himalayensis Camb.
Cleome sp. ?
Saxifraga imbricata Royle.
Colutea arborescens L. var. *nepalensis* L.
Astragalus sp.
Chesneya cuneata Benth.
Caragana polyacantha Royle.
Oxytropis microphylla DC.
Papilionacea, sp. indet.
Myricaria elegans Royle.
Hippophäe rhamnoides L.
Daphne oleoides Schreb.
Primula farinosa L.
Macrotomia perennis Boiss.
Nepeta discolor Royle.
Lonicera microphylla Willd.
Erigeron andryaloides C. B. Clarke.
Anaphalis virgata Thoms.
Artemisia sp.
Artemisia sp. aff. *Absinthium* L. ?
Chondrilla graminea Benth.

B.—Lower Baltoro and Rdokass.

Poa sp.
Festuca sp.
Lloydia serotina Rchb.
Oxyria digyna Hill.
Silene Moorcroftiana Wall.
Lychnis apetala L.
Stellaria graminea L. var. *montioides* Edgew. & Hook. fil.
Delphinium Brunonianum Royle.
Papaver nudicaule L.
Sedum aff. *atropurpureum* Turcz. ?
Potentilla albifolia Wall.
Potentilla sericea L. var. ?
Potentilla sp. ?
Astragalus Candolleanus Royle.
Oxytropis lapponica Gaud.
Oxytropis lapponica Gaud. var. *humifusa* Kar. et Kir.
Epilobium latifolium L.
Pirola rotundifolia L.
Primula farinosa L.
Gentiana aquatica L. var. ?
Gentiana detonsa Fries.
Gentiana sect. Comastoma sp.
Lonicera asperifolia Hook. fil. & Thoms.
Codonopsis ovata Benth.
Aster heterochaeta Benth.
Allardia nivea Hook. fil. & Thoms.
Chrysanthemum tibeticum Hook. fil. & Thoms.
Taraxacum officinale L.
Taraxacum officinale L. var. *eriopodum* DC.

C.—Upper Baltoro (above 15,000 feet).

Carex atrata L.
Lychnis apetala L.
Isopyrum grandiflorum Fisch.
Braya uniflora Hook. fil. & Thoms.
Saxifraga flagellaris Willd. var. *mucronulata* Royle.
Saxifraga imbricata Royle.
Potentilla fruticosa L. var. *pumila* Hook. fil. forma *grandiflora*.
Potentilla ochreata Lehm. ?
Mertensia primuloides Clarke.
Nepeta longibracteata Benth. ?
Leontopodium alpinum L. var. *nivale* Ten.
Allardia tomentosa Dcne. ?
Allardia vestita Hook. fil. & Thoms.
Sedum Rhodiola DC.

D.—Skoro-La.

Cystopteris fragilis Bernh. ?
Chenopodium album L.
Polygonum viviparum L.
Oxyria digyna Hill.
Silene Moorcroftiana Wall.
Lychnis nigrescens Edgew.
Cerastium trigynum L.
Cerastium vulgatum L. var.
Delphinium Brunonianum Royle.
Aconitum Napellus L. var. *rotundifolium.* Hook. f. & Thoms.
Arabis ?
Sedum Rhodiola DC.
Sedum Eversii Ledeb.
Saxifraga sibirica L.
Saxifraga flagellaris Willd. var. *mucronulata* Royle.
Potentilla multifida L. var. *angustifolia* Lehm.

Potentilla ochreata Lehm.
Potentilla bifurca L. var. *Moorcroftii* Wall.
Potentilla indica Th. W.
Rosa macrophylla Lindl. var. *minor* Lindl.
Oxytropis lapponica Gaud. var. *typica.*
Oxytropis mollis Royle.
Geranium pratense L. ?
Geranium sp.
Epilobium latifolium L.
Bupleurum longicaule Wall var. *himalensis* Klotsch.
Primula farinosa L.
Gentiana aquatica L. var.
Gentiana sp.
Pleurogyne carinthiaca L.
Mertensia tibetica Clarke.
Myosotis sylvatica Hoffm.
Thymus Serpyllum L.
Pedicularis pectinata Wall.
Pedicularis bicornuta Kl.
Lonicera microphylla Willd.
Valeriana dioica L.
Aster sp.
Leontopodium alpinum L. var. *nivale* Ten.
Erigeron alpinus L. ?
Anaphalis nubigena DC.
Tanacetum sp.
Artemisia sp.
Chrysanthemum Stoliczkae C. B. Clarke.
Saussurea Schultzii Hook. f. ?
Taraxacum officinale L. forma.

E.—Deosai Tableland (14,000 feet).

Carex nivalis Boott.
Polygonum affine Don.
Rumex sp.
Cerastium trigynum L.
Ranunculus nivalis L.
Thalictrum minus L. ?
Aconitum Napellus L. var. *multifidum* Hook. fil. & Th.
Papaver nudicaule L.
Corydalis ramosa Wall. var. *glauca* Hook.
Draba glacialis Adams.
Chorispora sabulosa DC.
Sedum Rhodiola DC.
Sedum aff. *atropurpureum* Turcz. ?
Saxifraga flagellaris Willd. var. *mucronulata* Royle.
Potentilla argyrophylla Wall.
Oxytropis sp.
Geranium aconitifolium L'Hérit. ?
Bupleurum falcatum L. var. *nigrocarpum* Jaquem.
Primula purpurea Royle.
Gentiana sp.
Swertia pedunculata Royle.
Eritrichium sp.
Stachys tibetica Vatke.
Thymus Serpyllum L.
Veronica alpina L.
Pedicularis pectinata Wall.
Pedicularis bicornuta Kl.
Pedicularis cheilanthifolia Schrenk.
Pedicularis rhinanthoides Schrenk.
Campanula modesta Hook. fil. & Thoms.
Aster himalaicus Clarke.
Leontopodium alpinum Cass. var. *nivale* Ten.
Anaphalis nubigena DC.
Tanacetum sp.
Senecio aff. *tibeticus* Hook.
Cremanthodium aff. *Decaisnei* Clarke.
Jurinea macrocephala Benth.
Saussurea sp.
Crepis glomerata Dcne. ?

II.—CLASSIFICATION OF SPECIMENS.

Polypodiaceae.

Cystopteris fragilis Bernh. ? Ascent of Skoro La, north side; 10,000–13,000 feet.

Gnetaceae.

Ephedra pachyclada Boiss. Between Dusso and Askoley, Braldoh valley (8,000–10,000 feet); 11–14th May, 1909.

Poaceae.

Poa sp. Rdokass; 13,025 feet; June–July, 1909.

Festuca sp. Rdokass; 13,025 feet; June–July, 1909.

Both these grasses are represented by fragmentary specimens, without rhizomes or basal leaves.

Cyperaceae.

Carex atrata L. Vigne glacier, at about 16,500 feet; 15th July, 1909.

This species is not indicated for the region in the publications of previous explorers.

Carex nivalis Boott. W. Hunter Workman and F. Bullock Workman: "The Call of the Snowy Hispar," p. 286. Deosai tableland; 14,000 feet; 2nd–3rd August, 1909.

The Workman expedition found this species (which is common in the Himalaya, Western Tibet and the Karakoram) on the Hispar glacier, between 13,000 and 15,500 feet.

Lloydia serotina Rchb. Sir W. M. Conway: "Climbing and Exploration in the Karakoram Himalayas, Scientific Reports," p. 83; W. Hunter Workman and F. Bullock Workman, op. cit. p. 286. Rdokass; 13,025 feet; June–July, 1909.

Allium odorum Linn. (No. 70 without locality !).

Conway (loc. cit.) cites for the Baltoro valley *A. senescens* Miq. = *A. tuberosum* Roxb. Our plant is without doubt *A. odorum* L., with the characteristic oblique rhizome covered with numerous whitish fibres, finely reticulated.

Salicaceae.

Salix sp. ind. Askoley; 15th June, 1909.

The leaves of this willow are covered with rounded reddish galls. It may be the species of *Salix* cited by Conway (p. 83) and by the Workmans (p. 286) as *Salix*, not determinable, gathered on the Hispar glacier at 13,000 feet.

Chenopodiaceae.

Chenopodium album L. Ascent of Skoro La, north side; 10,000–13,000 feet; 28th July, 1909.

Polygonaceae.

Polygonum viviparum L. Conway, p. 83. Ascent of Skoro La, north side; 10,000–13,000 feet.

Among the numerous examples of this species are some which may easily be referable to a minor form.

Polygonum affine Don. Conway, p. 83. Deosai tableland; about 14,000 feet; 2nd–3rd August, 1909.

Oxyria digyna Hill. Conway, p. 83; Workman, p. 287. Moraine of the Baltoro, below Rdokass; 16–17th May, 1909. Ascent of Skoro La, north side; 10,000–13,000 feet.

Rumex sp. Deosai tableland; about 14,000 feet; 2nd–3rd August, 1909.

In the absence of mature fruit a more precise identification is not possible.

Dianthaceae.

Silene Moorcroftiana Wall. Conway, p. 78. Moraine of the Baltoro, below Rdokass, 20th July, 1909; and ascent of Skoro La, north side, 10,000–13,000 feet, 28th July.

Lychnis apetala L. Conway, p. 78. Rdokass, 13,025 feet; Vigne glacier, at about 16,500 feet; 15th July, 1909.

Lychnis nigrescens Edgew. Ascent of Skoro La; between Askoley and the foot of the Skoro La glacier; 9,500–12,800 feet; 28th July, 1909.

Cerastium trigynum L. Conway, p. 78; Workman, p. 287. Deosai tableland; about 14,000 feet; 2nd–3rd August. Ascent of Skoro La, north side; 10,000–13,000 feet; 28th July, 1909.

Cerastium vulgatum L. var. ? Ascent of Skoro La, northern slope; 28th July, 1909.

A fragmentary specimen; referable to one of the numerous forms of *C. vulgatum*.

Stellaria graminea L. var. *montioides* Edgew. & Hook. fil. Rdokass; 13,025 feet; June–July.

Ranunculus nivalis L. Deosai tableland; ca. 14,000 feet; 2nd–3rd August, 1909.

Isopyrum grandiflorum Fisch. Conway, p. 78. Rocks at the head of the Baltoro; western spur of Gasherbrum; 18,000 feet; 27th June, 1909.

A diminutive form, doubtless referable to this species, which is found at great heights, Conway's expedition having gathered it at some 16,000 feet above sea level.

Thalictrum minus L. ? Deosai tableland ; about 14,000 feet ; 2nd–3rd August, 1909.

Fragmentary specimen, only showing foliage.

Clematis orientalis L. var. ? Braldoh valley, among the stones of.

From the shape of the leaves this would appear to be *C. orientalis*, which is, however, a variable and polymorphous species.

Delphinium Brunonianum Royle. Conway, p. 77. Rdokass; 13,025 feet; June–July, 1909. Ascent of Skoro La, north side; 10,000–13,000 feet; 28th July, 1909.

A beautiful plant with large fine blue flowers, quite worth cultivating for ornamental purposes.

Aconitum Napellus L. var. *multifidum* Hook. fil. & Thoms. Deosai tableland ; about 14,000 feet ; 28th July, 1909.

Var. *rotundifolium* Hook. fil. & Thoms. Conway, p. 77. Ascent of Skoro La, north side ; 10,000–13,000 feet.

Berberidaceae.

Berberis vulgaris L. var. *aetnensis* Presl. pro specie. Braldoh valley between Dusso and Askoley ; 7,900–10,000 feet ; 11–14th May, 1909.

This specimen is doubtless to be referred to the form described by Presl, with the leaves obovate mucronulate, spinulose-serrulate, with the nervation prominent on the under side.

Papaveraceae.

Papaver nudicaule L. Conway, p. 77. Rdokass, 13,025 feet ; Deosai tableland, about 14,000 feet.

The specimen from the Deosai tableland is more hispid than those gathered at Rdokass.

Meconopsis aculeata Royle ? Rajdiangan or Tragbal ; 8th August, 1909.

The determination of this species is doubtful, because its characteristics do not fully correspond with those of *M. aculeata*, particularly with regard to the shape and appearance of the fruit, which seems similar to that of *Meconopsis sinuata*. With more abundant material for purposes of comparison we should have been able to decide if this form should be considered a new one.

Dr. De Filippi says the plant is common within a limited area, where it is called "Blue Poppy."

Corydalis ramosa Wall, var. *glauca* Hook. Deosai tableland; about 13,000–14,000 feet.

Cruciferae.

Draba glacialis Adam. Conway, p. 78. Deosai tableland ; about 14,000 feet.

Chorispora sabulosa DC. Conway, p. 78. Deosai tableland; about 14,000 feet.

Cheiranthus himalayensis Camb. Between Dusso and Askoley, Braldoh valley; 7,900–10,000 feet.

Arabis ? Ascent of Skoro La, north side; 10,000–13,000 feet.

Braya uniflora Hook. fil. & Thoms. Rocks at the head of the Baltoro, about 18,000 feet, 29th June, 1909; and Vigne glacier, 16,500 feet.

Capparidaceae.

Cleome, ? Braldoh valley, between Dusso and Askoley; 7,900–10,000 feet.

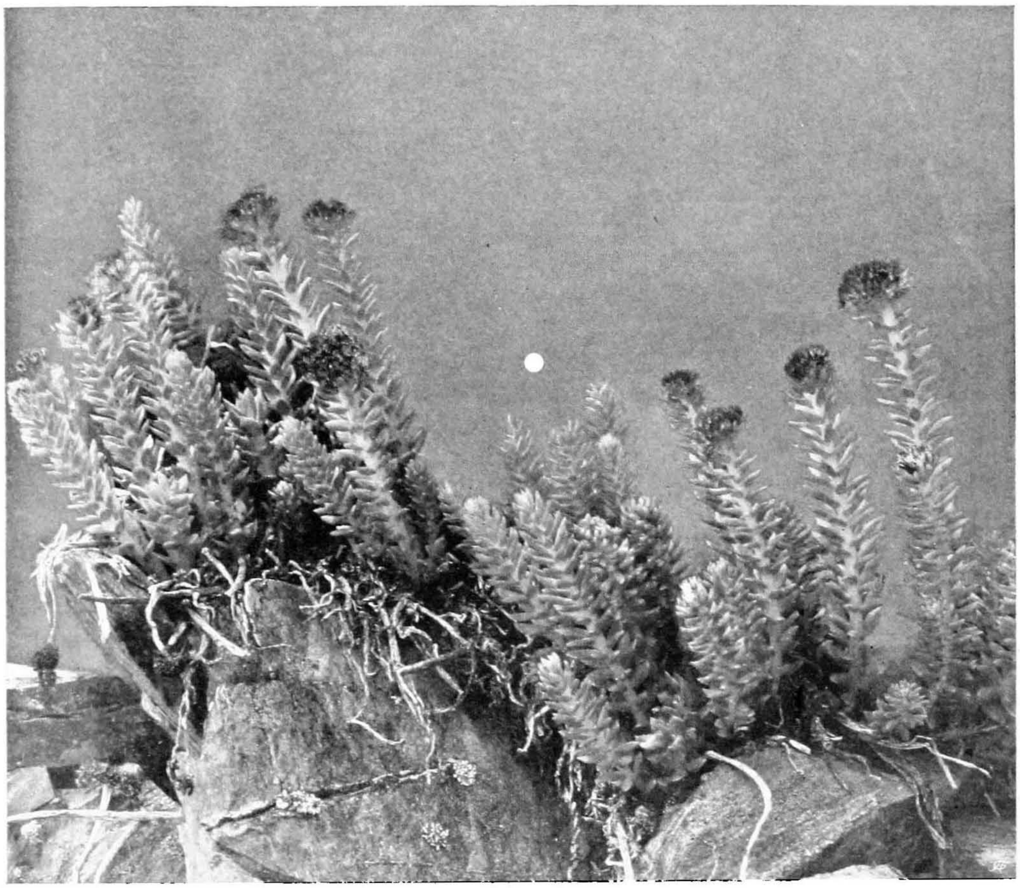

FIG. I.—SEDUM RHODIOLA DC.
[Gathered at the end of the right-hand spur of the Vigne, 16,500 feet.]

Crassulaceae.

Sedum Rhodiola DC. Workman, p. 287. (Pro sphalm. *S. Rhavialɑ* et *S. Rhadiola.*) Ascent of Skoro La, north side, 10,000–13,000 feet; and Deosai tableland, about 14,000 feet; *fl. et fruct.*

Among the specimens gathered at Skoro La is one with a fasciation of the apex of the axis of the inflorescence and of the inflorescence itself. This beautiful plant is shown in Fig. I, as photographed.

Sedum sect. *Rhodiola* aff. *atropurpureum* Turcz. ? Rdokass, 13,025 feet; Deosai tableland, about 14,000 feet.

Our specimens are probably closely related to, if not identical with *Sedum atro-purpureum* Turcz, of Central Asia. We have no means of comparison to settle the matter with certainty.

Sedum Ewersii Ledeb. Conway, op. cit., p. 80. Ascent of Skoro La, north side; 11,000–13,000 feet.

Cotyledon aff. *spinosa* L. (Without locality!)

Cotyledon ? (Above Paiju.)

A single rosette of large fleshy leaves, much deteriorated by treatment with alcohol and hot water. Would appear to be a *Cotyledon*.

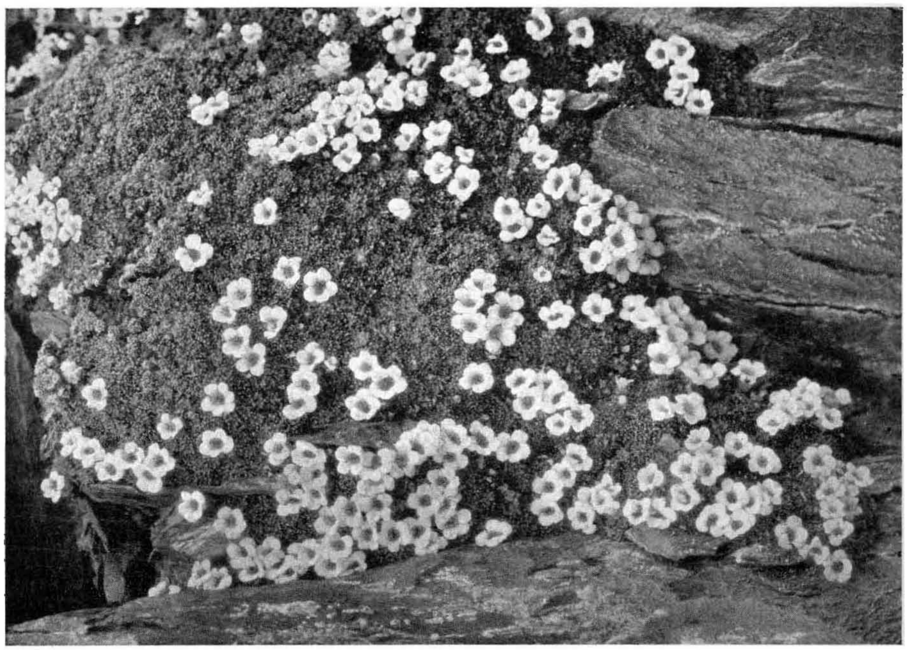

FIG. II.—SAXIFRAGA IMBRICATA ROYLE.

[Gathered on the rocks of the western spur of Gasherbrum, about 18,000 feet.]

Saxifragaceae.

Saxifraga sibirica L. Conway, p. 79. Ascent of Skoro La, north side; 11,000–13,000 feet.

Saxifraga imbricata Royle. Conway, p. 79. Braldoh valley, between Dusso and Askoley; 7,900–10,000 feet; according to photograph also on western spur of Gasherbrum, 18,000 feet.

The example representing this species in the collection is very poor, but it is supplemented by the fine photograph here reproduced (Fig. II).

Saxifraga flagellaris Willd. Conway, p. 79. Var. *mucronulata* Royle pro sp. Ascent of Skoro La, north side, 10,000–13,000 feet; Deosai tableland, 14,000 feet; moraine of the Baltoro, between 11,000–13,025 feet.

Our example must be referable to Royle's variety, on account of the ciliated and subspinulose edges of the leaves.

Rosaceae.

Potentilla fruticosa L. var. *pumila* Hook. fil. Conway, op. cit., p. 79; Workman, op. cit., p. 287; Th. Wolf: "Monogr. der Gattung Potentilla," p. 59. Vigne glacier; about 16,500 feet.

FIG. III.—POTENTILLA FRUTICOSA VAR. PUMILA HOOK. FIL.
[Gathered at the end of the right spur of the Vigne, ca. 16,500 feet.]

The example consists of a small fragment, but the identification is assisted by the fine photograph (Fig. III). According to what Wolf says in the Monograph cited above, the plant in the photograph having the flowers with long peduncles, must be referable to *P. fruticosa* var. *pumila* Hook fil. forma *grandiflora* Th. W.

Potentilla argyrophylla Wall. Conway, p. 79; Workman, p. 287. Deosai tableland, about 14,000 feet, 2nd–3rd August, 1909; Tragbal pass, 8th August, 1909.

Potentilla sericea L. var. ? Conway, p. 79; Workman, p. 287. Rdokass.

Our example, which is very poor, must surely be referable to a variety of this species, probably to *dasyphylla* Ledeb.

Potentilla multifida L. var. *angustifolia* Lehm. Skoro La, north side; 9,500–12,800 feet.

Potentilla ochreata Lehm.? Vigne glacier; about 16,500 feet. Ascent of Skoro La; 10,000–13,000 feet.

Potentilla bifurca L. Conway, p. 79; var. *Moorcroftii* Wall. Ascent of Skoro La, north side; 10,000–13,000 feet.

Potentilla indica Th. W. Between Askoley and the foot of the Skoro La glacier; 9,500–12,800 ft.

Potentilla albifolia Wall. = *Sibbaldia potentilloides* Camb. Baltoro moraine, between 11,000–13,025 feet; also below Paiju, about 11,000 feet.

Potentilla sp. Vicinity of Rdokass camp, 13,025 feet.

Posa macrophylla Lindl. Conway, p. 79; var. *minor* Lindl. Ascent of Skoro La; 9,500–13,800 feet.

Phaseolaceae.

Colutea arborescens L. Conway, op. cit., p. 79; var. *nepalensis* L. Between Paiju and valley of the Punmah; 25th July, 1909.

Astragalus sp. Paiju; about 11,000 feet.

Specimen imperfect and without fruit.

Astragalus Candolleanus Royle = *A. Royleanus* Bunge. Conway, p. 79. Rdokass; 13,025 feet, between Askoley and half-way between Korophon and Bardumal.

Chesneya cuneata Benth. Conway, p. 79. Between Askoley and half-way between Korophon and Bardumal.

Caragana polyacantha Royle. Conway, p. 79. Braldoh valley, between Dusso and Askoley; 8,000–10,000 feet.

Oxytropis lapponica Gaud. Bullock Workman, p. 287; var. *typica*? Ascent of Skoro La, north side; 10,000–13,000 feet.

Var. *humifusa* Kar. et Kir. Rdokass, 13,025 feet.

Oxytropis mollis Royle. Ascent of Skoro La, north side; 10,000–13,000 feet.

Oxytropis microphylla DC. Braldoh valley between Dusso and Askoley, 8,000–10,000 feet; between Askoley and half-way between Korophon and Bardumal.

Oxytropis sp. Deosai tableland; about 14,000 feet.

Phaseolacea. Braldoh valley; 8,000–10,000 feet.

Example with leaves only, not determinable. Perhaps *Astragalus*.

Geraniaceae.

Geranium pratense L. ? Conway, p. 78. Ascent of Skoro La, 10,000–13,000 feet.

Geranium sp. Conway, p. 78. Ascent of Skoro La, 10,000–13,000 feet.

Geranium aconitifolium L'Hérit. ? Deosai tableland, about 14,000 feet.

Tamaricaceae.

Myricaria elegans Royle. Conway, p. 78. Biaho valley, between Paiju and the Biafo glacier, 10,000–10,650 feet, 26th July, 1909.

Elaeagnaceae.

Hippophäe rhamnoides L. Conway, p. 83. Valley of the Braldoh, between Dusso and Askoley.

Our specimens with thorny branches confirm once more the variability and polymorphism of this species.

Thymelaeaceae.

Daphne oleoides Schreb. Conway, p. 83. Valley of the Braldoh, between Dusso and Askoley, 8,000–10,000 feet.

Lythraceae.

Epilobium latifolium L. Rdokass, 13,025 feet; ascent of Skoro La, north side, 10,000–13,000 feet.

Apiaceae.

Bupleurum falcatum L. var. *nigrocarpum* Jaquem ? Conway, p. 80. Deosai tableland, about 14,000 feet.

Without specimens of fruit it is impossible to differentiate this from the similar species *B. diversifolium* Rochel.

Bupleurum longicaule Wall. var. *himalense* Klotsch. Ascent of Skoro La, north side, 10,000–13,000 feet.

Without fruit.

Apiacea sp. Deosai tableland, about 14,000 feet.

Apiacea sp. Rdokass, 13,025 feet.

Specimen with leaves only, noted in journal, No. 8A, as having *reddish flowers.*

Pirolaceae.

Pirola rotundifolia Linn. Rdokass, 13,025 feet, June–July, 1909.

Leaves only.

Primulaceae.

Primula purpurea Royle. Conway, p. 91; Workman, p. 287 (sub. *P. nivalis* Pall. var. *macrophylla* Pax). Deosai tableland, about 14,000 feet.

Specimens with simple floral or double superposed umbels.

Primula farinosa L. Conway, p. 81. cites the var. *caucasica* Reg. Between Dusso and Askoley, about the camp; Rdokass, 13,025 feet; ascent of Skoro La, north side, 10,000–13,000 feet.

Androsace villosa L. Conway, op. cit., p. 81. Rdokass, 13,025 feet; between Dusso and Askoley, Braldoh valley, 8,000–10,000 feet.

Androsace mucronifolia Watt. Deosai tableland, about 14,000 feet.

Plumbaginaceae.

Acantholimon lycopodioides Boiss. Conway, p. 81. Between Askoley and half-way between Korophon and Bardumal.

Example consisting only of rosettes of foliage.

Gentianaceae.

Gentiana aquatica L. var. ? Rdokass, 13,025 feet.

Must be referable to one of the varieties of *G. aquatica*; *G. pymaea* Clarke and *G. humilis* Stev. are also very closely related to the species, and possibly belong to it as varieties.

Gentiana decumbens Linn. Ascent of Skoro La, north side, 10,000–13,000 feet.

Gentiana detonsa Fries. = *G. barbata* Froel. Rdokass, 13,025 feet.

Gentiana Sect. *Comastoma*. Rdokass, 13,025 feet.

We have here a very interesting plant related to *G. falcata* Turcz, and to the two species described by Murbeck (*Oest. Bot. Zeitschr.*, 49, 1899, p. 241) under the names *G. Hedini* and *G. cordisepala*. Ours is probably a new form.

Gentiana sp. Deosai tableland, about 14,000 feet.

Gentiana sp. Ascent of Skoro La, north side, 10,000–13,000 feet.

Pleurogyne carinthiaca L. Conway, p. 82. Ascent of Skoro La, 10,000–13,000 feet.

Pleurogyne sp. Rdokass, 13,025 feet.

Swertia petiolata Royle. Deosai tableland, ca. 14,000 feet.

Boraginaceae.

Macrotomia perennis Boiss. Conway, p. 82 (sub *M. endochroma* Hook. fil. & Thoms). Between Askoley and half-way between Konophon and Bardumal.

Onosma echioides L. Conway, p. 82. (Sine loco !)

Erytrichium sp. Conway, p. 82. Deosai tableland.

Absence of fruit prevents the precise determination of this plant.

Mertensia tibetica Clarke. Ascent of Skoro La, north side, 10,000–13,000 feet.

Mertensia primuloides Clarke. Vigne glacier, about 16,500 feet.

Myosotis sylvatica Hoffm. Ascent of Skoro La, north side, 10,000–13,000 feet; Rdokass, 13,025 feet.

Actinocarya tibetica Benth. ? Rdokass, 13,025 feet.

Lamiaceae.

Stachys tibetica Vatke. Conway, p. 82. Deosai tableland, about 14,000 feet.

Nepeta discolor Royle. Conway, p. 83. Between Askoley and half-way between Korophon and Bardumal.

Nepeta longibracteata Benth. ? Vigne glacier, about 16,500 feet.

The identification is somewhat doubtful, as the dimensions, particularly of the leaves, are smaller than those given in the descriptions we have consulted. Perhaps we have to do with a form of the species.

Dracocephalum heterophyllum Benth. ? Deosai tableland, about 14,000 feet.

Thymus Serpyllum L. Conway, p. 82. Deosai tableland, about 14,000 feet; ascent of Skoro La, north side, 10,000–13,000 feet; Vigne glacier, about 16,500 feet.

Scrophulariaceae.

Veronica alpina L. Deosai tableland, about 14,000 feet.

This species is not given in the *Flora of British India*, nor in later authors already cited; thus it is a new addition to the flora of the region. However, it is certain that we have here to do with *V. alpina* L., our specimen being very closely related to the forms of this species found in northern Europe (Norway, &c.).

Pedicularis bicornuta Kl. Ascent of Skoro La, 10,000–13,000 feet.

Pedicularis pectinata Wall. Conway, p. 82. Deosai tableland, about 14,000 feet; ascent of Skoro La, 10,000–13,000 feet.

Pedicularis cheilanthifolia Schrenk. Workman, p 287. Rdokass, 13,025 feet. Deosai tableland, about 14,000 feet.

Pedicularis rhinanthoides Schrenk. Deosai tableland.

Orobanchaceae.

Orobanche sp. aff. *Hansii* Kern. Conway, p. 82. (Sine loco.)

Caprifoliaceae.

Lonicera microphylla Willd. Conway, p. 80. Valley of the Braldoh, between Dusso and Askoley, 8,000–10,000 feet.

Lonicera asperifolia Hook. fil. & Thoms. Rdokass, 13,025 feet.

Possibly a distinct form of this species, but lack of material for comparison prevents certitude. Used for firewood on the expedition.

Valerianaceae.

Valeriana dioica L. Conway, p. 80. Between Askoley and the foot of the Skoro La glacier, 9,500–12,800 feet.

Campanulaceae.

Codonopsis ovata Benth. Rdokass, 13,025 feet.

Campanula modesta Hook. fil. & Thoms. Deosai tableland, about 14,000 feet.

Asteraceae.

Aster heterochaeta Benth. Bullock Workman, p. 288. Rdokass, 13,025 feet.

Aster himalaicus Clarke. Deosai tableland, about 14,000 feet.

Aster sp. Ascent of Skoro La, north side, 10,000–13,000 feet.

Possibly a smaller form of the preceding.

Leontopodium alpinum Cass. Conway, p. 80; Workman, p. 288; var. *nivale* Ten. Ascent of Skoro La, north side, 10,000–13,000 feet; Vigne glacier, about 16,500 feet; above Rdokass, about 14,750 feet; Deosai tableland, about 14,000 feet.

On the grounds given by Dr. Karl von Keissler in *Aufzählung der von E. Zugmayer in Tibet gesammelt Phanerogamen* (*Ann. KK. Naturhist. Hofmuseum von Wien*, Band XXII, 1907, p. 27) the forms of this species examined by us must be ascribed to var. *nivale* Ten. *Syll. Fl. Neapol.*, p. 426, and are closely related to the forms found in the high Apennines (Gran Sasso, Majella, &c.).

Erigeron alpinus L. ? forma. Ascent of Skoro La, north side, 10,000–13,000 feet.

Erigeron andryaloides Clarke. Conway, p. 80. Between Askoley and half-way between Korophon and Bardumal.

Anaphalis virgata Thoms. Conway, p. 30. Paiju–Punmah.

Anaphalis nubigena DC. Conway, p. 80. Ascent of Skoro La, 10,000–13,000 feet; Deosai tableland, about 14,000 feet.

Tanacetum sp. Between Askoley and the foot of the Skoro La glacier, 9,500–12,800 feet.

Tanacetum sp. Deosai tableland, about 14,000 feet.

Artemisia sp. Valley of the Braldoh, sandy soil.

Artemisia sp. aff. *Absinthium* L. ? Valley of the Braldoh between Dusso and Askoley, sandy soil.

Artemisia sp. Ascent of Skoro La, north side, 10,000–13,000 feet.

Chrysanthemum tibeticum Hook. fil. & Thoms. Rdokass, 13,025 feet.

Chrysanthemum Stoliczkae Clarke. Conway, p. 81. Ascent of Skoro La, north side, 10,000–13,000 feet.

Cremanthodium aff. *Decaisnei* Clarke ? Deosai tableland, about 14,000 feet.

Senecio aff. *tibeticus* Hook. Deosai tableland, about 14,000 feet.

Allardia vestita Hook. fil. & Thoms. ? Vicinity of Rdokass, about 16,500 feet; 2nd July, 1909, in leaf; Vigne glacier, about 16,500 feet, in flower.

Allardia nivea Hook. fil. & Thoms. Moraine of the Baltoro below Rdokass, 4th July, 1909.

Allardia tomentosa Dcne. ? Vigne glacier, about 16,500 feet, 15th July, 1909.

Jurinea macrocephala Benth. Deosai tableland, about 14,000 feet.

Saussurea Schultzii Hook. fil. ? Ascent of Skoro La, 10,000–13,000 feet.

Saussurea Jacea Clarke ? Gorge of the Punmah; 26th July, 1909; between Askoley and half-way between Korophon and Bardumal, in leaf.

Saussurea sp. Deosai tableland, about 14,000 feet.

Crepis glomerata Dcne. ? Deosai tableland, about 14,000 feet.

Taraxacum officinale L. forma. Conway, p. 81. Ascent of Skoro La, 10,000–13,000 feet.

One of the many high-mountain forms of this ubiquitous and polymorphous plant.

Taraxacum officinale L. var. *eriopoda* DC. Rdokass, 13,025 feet.

Chondrilla graminea Benth. Bullock Workman, p. 288; var.? Between Paiju and the Punmah.

Must be a variety of this species which is cited tentatively by the Workmans.

Lactuca tatarica C. A. Meyer. Conway, p. 81; Workman, p. 388. (Sine loco.)