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## EXPEDITION TO SPILLIMACHEEN MOUNTAINS, SEPTEMBER, 1910—PHOTO-TOPOGRAPHICAL SURVEYS.

By ARTHUR O. WHEELER.

THE following note, dealing with the technical part of the work, is written to supplement the account prepared by Dr. Longstaff of a short expedition to the Spillimacheen mountains of British Columbia made by the doctor and myself on behalf of the Alpine Club of Canada during the month of September, 1910.

For a number of years, as Topographer of the Department of the Interior of Canada, I had been in charge of a photo-topographical survey of the Main and Selkirk ranges of the Rocky mountains, within what is known as the Railway Belt of British Columbia—a tract of land extending for 20 miles on either side of the line of the Canadian Pacific railway through the province named.

The Spillimacheen mountains lie between the Columbia river on the east and the Beaver river, Duncan river, and Howser and Kootenay lakes on the west. They are an outlying group of the Selkirk range on the eastern side of its main watershed. From high peaks in both the main range of the Rockies and the Selkirk range I had frequently gazed on the Spillimacheen mountains, and seen wide snowfields and glaciers, with most interesting-looking peaks, pyramids, towers, and pinnacles rising from their midst. I had also heard of wonderful waterfalls and amphitheatres at the heads of the many deep valleys by which the region is intersected. Rumours had reached me of 12,000-foot peaks—an altitude not great as the high mountains of the world go, but great for the Selkirks—to be found there. A long-standing desire to visit these mountains was brought to a focus by the collaboration of Dr. Longstaff, and an expedition was arranged to begin soon after the Alpine Club of Canada's annual camp, held at Consolation valley, and a short expedition made after it by a chosen few should be over.

It was intended to ascend the Columbia river, from its intersection with the railway at Golden, to the mouth of the Spillimacheen river, and then by the middle branch of that stream to the summit of the group and across the same to the Duncan river; then up the Duncan and down the Beaver river to the railway at Bear Creek station, keeping, if possible, to the high slopes above timber-line along the western side. Unfortunately, the routes across these mountains by both the middle and south branches of the Spillimacheen were reported closed for pack-animals by fallen timber and bridges washed out, so we were forced to go still farther south and attempt the passage by Bugaboo creek. This route was reported feasible by the best authorities on the subject in the Columbia valley above Golden. The Selkirks, however, are a very uncertain quantity, and Dr. Longstaff has told you how we fared.

My previous photo-topographical surveys had been carried on the

east to cover the Dogtooth range, lying north and east of the north branch of the Spillimacheen river, and on the west along the summit of the Selkirk range as far as the northern extremity of the Spillimacheen mountains, which that summit overlooks (see accompanying map). It was now attempted to carry a survey, using photographic methods, across the Spillimacheen mountains, *viâ* Bugaboo creek and pass, to the Duncan river, and then northward to connect with previously established stations of the Selkirk and Dogtooth ranges of which the position and altitude were known, thus fixing the position and altitudes of the present survey.

The use of the method of photography as applied to measurement by means of perspectives, was first conceived by the late Colonel A. Laussedat of the Institute of France and Director of the Conservatoire National des Artes et Métiers, as far back as 1849. To Major-General Annibale Ferrero, Director of the Geographical Military Institute of Italy, is due the credit of initiating the ordnance photographic surveys of the present day. Their execution was carried out by the celebrated engineer, L. Pio Poganini, with a staff of able assistants, about the year 1876. Its application to Canadian topographical surveys, upon which it has been most extensively used, is due to Dr. E. Deville, Surveyor-General of Dominion Lands, who, in 1895, published a concise and valuable work upon the subject, entitled "Photographic Surveying." Unfortunately, the book is out of print, and a most complete and ready reference to the history and theory of this section of the science is thereby lost to the scientific world.

The Canadian field-equipment consists of a plain fixed-focus camera, and an ordinary 3-inch circle transit-theodolite, with vertical circle attached to the telescope. A short, stout tripod is adapted to receive either. Each instrument weighs about 20 lbs., the camera including one dozen glass plates and holders, and is carried separately. The camera is an oblong aluminium box cased in wood. Cross levels are attached to the metal box in two positions, which for the sake of recognition have been called the "horizontal" and "vertical." The levels are adjusted by foot screws on the tripod. Plates are used, the size being  $6\frac{1}{2}$  by  $4\frac{3}{4}$ . Films have been tried, but are too subject to distortion when passing through the developing process to give sufficiently accurate results. In the horizontal or longer position the lens covers  $56^\circ$  of arc, and seven plates are required to complete a circuit. In the vertical or shorter position the lens covers  $37^\circ$  of arc, and eleven plates are used. There are instruments in use for this method of surveying that combine the transit-theodolite and camera in one piece, but they are cumbersome and difficult to pack to the summits of high mountains; others use the magnetic needle and register its readings upon the photographs obtained, thus giving them direction. Such an instrument as the latter would be useless in the Canadian rockies, owing to local attraction from scattered iron masses.

It is necessary that the photographic work be based upon a plan of triangulation, which may be carried to any degree of accuracy. In quick exploration and reconnaissance surveys the triangulation and photographing can be carried along together. Altitude is obtained by reading the angles of elevation or depression between stations, and either starting from or connecting with known points. To orient, or obtain the direction of a view, the azimuth or angle must be read between some fixed point and a point in the view which will be clearly discernible on the working print. It is absolutely essential that views be taken on plates in a vertical position; it is, therefore, necessary that the levels on the camera be in perfect adjustment. The focal length of the camera is marked on the edge of the metal-box against which the plate presses and is registered on every view taken.

As the whole reduction of the perspectives obtained to a ground plan is dependent upon the focal length of the camera used, this registering is very necessary. Notches in the edge of the box also register the horizon and principal lines of the perspective.

Practically speaking, the views obtained are perspectives, from which, by the rules of geometry and perspective, the general topographical features embraced may be projected upon a ground plan. It is necessary that such features can be seen in at least two views taken from stations some distance apart, and of which the position and elevation above a given datum, generally sea-level, have been or can be ascertained from the triangulation. A topographical map usually consists of contour-lines, representing the projection on the plan of imaginary lines following the inequalities of the surface at given intervals of altitude. A sufficient number of points along the ridges and dividing watercourses, or other suitable places of the area embraced by the views, are identified in the photographs to enable contours to be drawn at the required equidistance. On the plan the points are placed in position by projecting thereon the traces of the horizon and principal lines of the two or more views employed, and the lines of sight from each camera station to the said points projected on the horizontal traces. The intersection of the projections of the lines of sight fixes the position of a point. The altitudes of the points are based upon the elevation of the stations from which the views are taken, and are obtained directly from the photographs. The horizon line, which is registered on every view, corresponds to the altitude of the station. The elevation of any point in a photograph is proportional to its height above or below the horizon line, and the distance its projection falls within or beyond the trace of that horizon line. When the distance becomes so great as to make curvature and refraction appreciable factors corrections must be applied, but it is not, generally speaking, practical to map by this method at so great a distance. The method is very similar to that of the plane-table, but has some strong advantages. With the plane-table most of the plotting is done in the

field, with the camera altogether in the office; with the plane-table one station is occupied at a time, with the camera views from both stations before you, and thus you practically occupy both stations at once. This last is a very important factor in the identification of points. Photographs, however, give but a weak representation of Nature's contrasts, even at their best. Those who have climbed high mountains and know the climatic conditions there, will readily appreciate the ease and facility of taking a round of photographs and reading a number of angles as compared with the delicate drawing operations required for a plane-table. I may add that during fifteen years of experience I have found that very few photographs are obtained with the Canadian equipment that cannot be used for mapping purposes, and those only when the atmosphere is thick with smoke from forest fires, as is frequently the case in the Canadian rockies. Storms and clouds will occasionally prevent the successful occupation of a station, and necessitate a second or even a third ascent, but such occurrences are infrequent.

The above are the fundamental principles of the method. Numerous geometrical constructions, however, assist in obtaining elevations along ridges and definition of figures in planes parallel or inclined to the ground plane. They require the use of perspective instruments, such as the centrolinead, the perspectograph, the perspectometer, and the photograph board. For the most part they can be dispensed with. The accuracy and detail of the mapping is dependent on the precision of the base triangulation, the number of the camera stations, and the scale of the map.

While adapted to all classes of country where there are sufficiently defined contours and contrast of features to show clearly on a photograph, the method is best of all suited to the delineation of rugged, snow-clad mountainous country, where access is difficult and ordinary methods would be impossible.

The method is especially suited to geographical exploration and quick reconnaissance surveys of required areas. Surveys of this character may be carried up valleys of main waterways and extended over important lake basins. While an exploration party with its attendant machinery is slowly making headway up a valley, commanding points along its margin may be occupied by the camera and transit, and by such means a quick triangulation carried up it, the photographs gathering all the requisite topographical information more accurately than by actual exploration. It is, of course, essential to have either a starting-point or closing point; but this is equally necessary for any other method. Similarly a lake basin or any desired area can be mapped, provided there are points of sufficient altitude bounding or within the area to display it in detail to the camera. It may be contended that the occupation of each camera station will entail an arduous climb; that is a small matter to any one desirous of mapping a given area of country.

Two persons only are necessary for the camera and transit work, and one may be a porter to help carry the instruments. It has also been contended that the sides of mountain valleys are often too precipitous to permit of the camera seeing into them, on account of the necessity for the plate being vertical when exposed. It is seldom, however, that stations cannot be found to give a raking view. A strong point in favour of the method is that altitude is carried by angles of elevation and depression from point to point, read back and forth between the stations, and all others are taken direct from the photographs. The photographs, moreover, furnish the best possible permanent records from which to study at your ease the country passed through, when far away from it. From them by the above methods can be obtained an immense amount of most valuable information, such as the height of surrounding peaks (especially referred to below), the length, width, and fall of the glaciers, the drop of waterfalls, the depth of precipices, the dip and thickness of strata, the altitude of timber and permanent snow-line, the course and fall of streams, the area of lakes, snowfields, etc., and the processes employed by Nature in carving out the terrain from the original upland.

I wish to refer briefly to two instances where photo-topographic methods are of special use: (1) The method of squares is particularly adapted to the delineation of lakes, or of rivers, large and small, flowing through bottom lands that may be heavily timbered and inaccessible to travel except by the waterway itself. From camera points above such valleys bird's-eye views can be obtained where all the windings and side channels, islands, and other details are shown as on a map. The perspective of a series of squares is drawn upon the photograph covering any section of a stream or lake, and a corresponding series of squares drawn in proper position on the plan. The channels, islands, etc., are then drawn at sight, square by square. It will readily be seen that such a delineation could not be obtained by ordinary methods of traverse, except at a great expenditure of time and money, as it would be impracticable in a rapid survey to follow every channel or delineate every island where there were many. The advantage, moreover, of being able to do all this at your leisure in a comfortable office is obvious. (2) The possibility in mountainous tracts of obtaining from photographs, taken as explained, a fair estimate of the height of surrounding peaks is one upon which I desire to lay particular stress. When making a photographic survey of the Selkirk range adjacent to the Canadian Pacific railway, I had occasion to take a series of views from commanding points in which a number of the highest peaks of the adjacent main range of the Rockies were identified. Among these were Mounts Columbia, Bryce, Lyaill, and Forbes. As a matter of experiment, it was endeavoured to compute from the photographs the altitude of the peaks named, the methods employed being the same as those used in the

ordinary reduction of altitudes for points when drawing contours. The results were as follows: Mount Columbia, 62 miles distant, computed from photographs at four different stations, gave a mean altitude of 12,723 feet, with a range of 261 feet; Mount Bryce, 58 miles distant, a mean of six computations, showed a result of 11,685 feet, with a range of 235 feet; Mount Lyall, 52 miles distant, from four stations gave 11,459 feet, with a range of 271 feet; Mount Forbes, 50 miles distant, from four stations, gave 12,069 feet, with a range of 355 feet. In each case the extreme distance apart of the computing stations was a little over 18 miles. The wide range may be accounted for by the fact that the lines of sight were oblique, and consequently a greater difficulty met in plotting their position accurately at so long a distance.

It may be mentioned that before making the above computations the same method was tried upon Mount Chancellor, 45 miles distant, and directly opposite the base. Chancellor had been established by the Topographical Survey at 10,780 feet. It was now computed from four photographs with a mean result of 10,751 feet and a range of 41 feet, or 29 feet less than the established altitude. The lines of sight, however, in this case provided a sharp-cut intersection. While I do not hold that results so obtained can be considered of absolute value, they give a fair approximation as primary estimates for peaks of which the height has not been or cannot be established by accurate triangulation methods.

These were the methods used upon our expedition to the Spillimacheen mountains. Dr. Longstaff has shown how circumstances combined to prevent a successful termination. Owing to such circumstances, we were unable to connect the survey made with definitely fixed points. However, all was not quite lost, and the data obtained will permit of a map that will be a useful guide for the future. It has established the connection between Bugaboo and Howser creeks, and shows the position and extent of most of their tributaries. It further establishes the position of the headwaters of the south branch of the Spillimacheen river. Of all this there has been heretofore a most hazy idea. Even the local guides at the mouth of Bugaboo creek could give us no definite information, and that fact contributed largely to our failure to accomplish our primary object.

On the other hand, the results are tentative. I was unable to obtain a definite point from which to carry the altitudes, and therefore had to assume one. My observations during previous Selkirk surveys had placed the average timber limit at 7300 feet, so I set the lowest part of the Bugaboo pass at 7160 feet—an altitude not very far astray, one way or the other. As a working base the distance between two stations, occupied on either side of the pass, was set at  $1\frac{1}{2}$  mile. This seemed to agree with our distances as estimated by travel. It means that all stations and the topography mapped from them are placed relatively in

proportion to the length of that base, but subject to its error. Altitudes are obtained by angles of elevation or depression from the several stations and by the relative heights above or below the horizon lines of the photographs used, but for accuracy are subject to the true distance from such stations; they are, therefore, not absolute.

From the data used the peaks were found to be, for the most part, between 9000 and 10,000 feet, but a few of the highest exceeded that altitude. One, Eyebrow peak, computed from photographs, gave an altitude of 11,489 feet, which, if true, would establish it the second highest peak in the Selkirks computed by trigonometrical methods. Of this altitude I have considerable doubts, although to reduce it would shorten the distance from the observing stations, and consequently the length of the assumed base, a reduction that would be at variance with the length of our estimated stages of travel.

Dr. Longstaff has set before you the claims of the area from alpine and hunting points of view. The above notes are intended to give an idea of the aims of the expedition in the interests of geographic research, and of the methods employed with that end in view. I regret I am not able to furnish a map of the country surveyed in time for Dr. Longstaff's paper; but Canada at the present moment, and particularly the west of it, is in a high state of development, and there have been many calls upon my time professionally.

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## CAPTAIN SCOTT'S ANTARCTIC EXPEDITION.

By Sir CLEMENTS R. MARKHAM, K.C.B., F.R.S.

THE letters received from Captain Scott and the members of his expedition have relieved us of much anxiety. Very excellent winter quarters have been established at Cape Evans, with eighteen ponies in good condition, two motors, and thirty-one dogs. The house was built, all stores landed, and the *dépôt* party had started by January 26 for a journey of two months, with eight ponies. We must wait for a year before we can receive news of the results of a great enterprise. This Society takes a very special interest in the expedition, because it is the necessary complement of our own most successful venture, and is commanded by our own carefully selected and well-tried leader.

The catch-penny expression "race to the south pole" is much to be deprecated. The expedition, which includes the south pole in its contemplated work (being the apex of the Victoria Quadrant, which is Scott's allotted sphere of exploration), is a scientific one, the most complete and the best-equipped for scientific work that has ever entered the Polar Regions. People will think of Amundsen's proceeding according to their training and education. Captain Scott is not a man to be put out by it.

Our gallant countrymen are now entering upon the severities of

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