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that sometime the Committee may take the opportunity of considering other aspects and other regions under his guidance. One thing that suggests itself very strongly in listening to his paper is that a great deal more work of a strictly geographical kind is rapidly becoming practicable now that the plant-physiologists have elaborated their data. They know what to look for and what conditions are important, and now that experimental stations are coming into existence in different parts of the world geographical comparisons can be made. One of the objects of this Committee is to encourage properly qualified observers to enter upon such work as is likely in the immediate future to be of value, and to afford them facilities for co-operating with one another. I will ask the Committee to express its thanks to Dr. Unstead for his paper.

OBSERVATIONS ON THE SIR SANDFORD GLACIER, 1911.

By HOWARD PALMER.

IN a previous issue of the *Journal*, the writer gave some account of the topographical features in the vicinity of Mount Sir Sandford, British Columbia, and especially of the glacier having the same name which covers a considerable area immediately to the west of the mountain. During the past summer it was his privilege to make another journey into that region, in company with Professors E. W. D. Holway and Frederic K. Butters, of Minneapolis. The objects in view were mainly those of the mountaineer and explorer, but at the same time it was aimed at to accomplish such scientific work as was not inconsistent with these ends. In particular, it was desired to make additional observations upon the Sir Sandford glacier, which the previous rough measurements had shown to be of some importance in the range, and therefore deserving of a more careful examination. The present paper embodies the results of these observations. In fairness to my associates, it should be stated that for the conclusions here presented the writer is alone responsible. A portion of the field work, however, obviously required the co-operation of all, and it may be said at once that in this my companions' generous advice and assistance were quite beyond acknowledgment.

The instrumental equipment for the work comprised a light transit reading to 5' of arc, a tape for the measurement of the base line, a camera fitted with a good level and a tripod suited to both transit and camera. The difficulties of transport and distance from a base (supplies depended upon portorage in relays) limited the outfit to the simplest appliances, but it was hoped by using especial care, and by repeating the observations a number of times, to obtain results of greater accuracy than such crude equipment would ordinarily afford.

The work on the glacier may be conveniently considered under the following headings: (1) Measurement of the rate of surface flow; (2) Measurement of the average rate of retreat of the forefoot for one year; (3) Mapping the tongue, streams and moraines; and (4) General observations on surface features, etc.

1. *Measurement of the Rate of Surface Flow.*—To establish a line on the ice, the transit was set up over a stone firmly embedded in the crest of the east lateral moraine at base Camp station, and sighted on the sharp vertical edge of a large boulder in the stable moraine across the glacier. For marks, dark coloured, thin, flat stones having one edge straight were selected and carried out on to the ice. At suitable points flat-bottomed niches were cut, and in these the stones were set with the straight edges on the vertical hair of the telescope. In choosing such stones, it was aimed to take advantage of their tendency to melt into the ice, and thus to remain *in situ*. Over the moraine-covered section of the glacier the line was painted on favourably situated stones. Twenty points were marked in this fashion on June 24, vertical angles being read to each.

Four days later (June 28) the instrument was again set up at Camp station, and the line redetermined on the ice which had meanwhile moved into position. Behind each stone an ice axe was adjusted in the proper position according to the transit-man's signals. The distance to the fiducial edge of the stone was then taken with the tape. For computing the horizontal distances of the stations from the instrument, a short base was measured thence along the eastern moraine, and readings were taken to each stone from its extremity. These distances, combined with the vertical angles ascertained as above, furnished the data for the profile of the glacier on the accompanying map. On July 8, fifteen days after the stones were set, measurements to the original line were again read off. The results of all these operations are given in the table on the following page.

In a broad sense, the figures may be taken as harmonizing with the accepted laws of glacial motion, though perhaps they do not form as clear an illustration as might be desired. Very probably a situation further removed from the disturbing effect of the terminal ice-fall would have been preferable. The essentially uniform increase in the rate of motion from the margin to the maximum at Station 14 appears normal; but the fact that this point occurs nearly at the centre of the line raises a difficulty, for we are dealing with a glacier flowing on a broad curve, where the zone of greatest motion is usually to be found near the convex side. However, it is likely that this complication is more superficial than real, and that if the line were moved back so as to transact a greater amount of ice, and the measurements were continued to its extremity, the ordinary relation would be evident.

The absence of a correspondingly uniform decrease in the rate of motion toward the northerly margin may reasonably be accounted for by the influence of the tributary, by the proximity of the ice-fall, or by both of them. From Station 16 to the margin the ice was considerably crevassed, and beyond number 20 it sloped so rapidly that stations could not easily be brought into the field of the instrument for observation.

The lack of agreement between the columns giving the mean daily rates for four days, for eleven days, and for fifteen days suggests the presence of cross currents and variations in the character of the surface upon which the glacier rests.

OBSERVATIONS ON A LINE OF STONES SET ACROSS THE SIR SANDFORD
GLACIER, JUNE 24, 1911.

Stations	Distance from east margin of glacier.	Motion from June 24-28.	Average daily motion from June 24-28.	Average daily motion from June 28-July 8.	Motion from June 28-July 8, 11 days.	Motion from June 24-July 8, 15 days.	Average daily motion for 15 days.	Remarks.
On Moraine or on Moraine-covered Ice.								
Camp	ft.	ins.	ins.	ins.	ins.	ins.	ins.	
	350	0	0	0	0	0	0	
1	215	0	0	0	0	0	0	{ On stable moraine, probably not underlain by ice. Close to margin.
2	108	0	0	0	0	0	0	
3	0	0	0	0	0	0	0	
4	68	3	0·75	0	0	0	0	{ On edges of crevasse. After first measurement they slipped down and could not be replaced accurately.
5	120	2·5	0·63	0	0	0	0	
6	183	7·0	1·75	1·31	14·5	21·5	1·43	{ A backward sliding is likely here.
7	274	4·0	1·00	1·50	16·5	20·5	1·36	
On Clear Ice.								
8	431	13·0	3·25	3·12	34·5	47·5	3·16	{ Maximum. In more or less broken ice; one on a serac. Glacier cascades over a cliff 100 yards below these stations.
9	515	18·0	4·50	5·00	56·0	74·0	4·93	
10	622	21·0	5·25	4·81	53·0	74·0	4·93	
11	714	22·5	5·63	6·36	70·0	92·5	6·16	
12	780	22·0	5·50	7·00	77·5	99·5	6·63	
13	836	22·0	5·50	6·45	71·0	93·0	6·20	
14	884	29·0	7·25	6·54	72·0	101·0	6·73	
15	1000	29·0	7·25	6·00	66·0	95·0	6·33	
16	1053	28·0	7·00	5·61	61·75	89·75	6·00	
17	1131	22·0	5·50	6·36	70·0	92·0	6·13	
18	1196	22·0	5·50	6·13	67·5	89·5	5·96	
19	1230	19·0	4·75	6·68	73·5	92·5	6·16	
20	1445	12·0	3·00	7·18	79·0	91·0	6·06	
Margin	1600							

Approximate width of glacier on line of measurement, 1600 feet.

The close correspondence between the average maximum rates of motion of the three Selkirk glaciers which have been studied is worthy of note. During a period of ten days in the midsummer of 1906 the Asulkan glacier averaged 6·7 inches per day,* while the Illecillewaet,

* *Canadian Alpine Journal*, vol. 1, p. 147, 'Glacier Observations,' by George Vaux, Jr., and William S. Vaux.

I.—LOOKING NORTH-WESTERLY UP SILVERTIP GLACIER. SILVERTIP NÉVÉ LIES IN THE OPENING TO THE LEFT BETWEEN THE TWO PEAKS. SIR SANDFORD GLACIER IN FOREGROUND.

II.—PANORAMIC VIEW OF TONGUE OF SIR SANDFORD GLACIER, LOOKING WEST. SILVERTIP GLACIER ENTERS AT THE RIGHT.

III.—THE MAIN ICEFALL AND UPPER 3 MILES OF SIR SANDFORD GLACIER, LOOKING SOUTH. ALTITUDE OF COL IN RIGHT DISTANCE IS ABOUT 8100 FEET.

IV.—SILVERTIP NÉVÉ, LOOKING SOUTH-WEST. WITH THE GLACIER OF THE SAME NAME WHICH ENTERS AT THE RIGHT, THIS FORMS THE SECONDARY SOURCE OF SIR SANDFORD GLACIER. ALTITUDE OF FLOOR LIES BETWEEN 7500 AND 8000 FEET. LENGTH ABOUT $2\frac{1}{2}$ MILES.

in 1899, at the same season averaged 6·79 inches* for the longer interval of thirty-six days. The Sir Sandford glacier, as noted above, showed a rate of 6·73 inches for fifteen days.

The weather, during the time that the glacier was under observation, was almost continuously cloudy and rainy, with an average minimum temperature of 36·7° F. Accordingly the table doubtless indicates less than the usual summer activity.

The Sir Sandford is in some respects an awkward glacier to study. It lacks a pronounced demarcation between the forefoot and the northern margin and the terminal cascade with the attendant crevassation of the ice for some distance up stream introduces difficulties in field work. It is probable that the true tongue extends westerly as far as the end of the medial moraine from Silvertip glacier, though indications point to a substantial stagnancy of the ice at this point. Future workers will doubtless find that a line between Base station and Signal station will offer the most advantages for carrying out observations on the surface flow.

2. *Measurement of the Average Rate of Retreat of the Forefoot.*—In 1910 the writer made an attempt to secure suitable views for a map of the tongue, but, owing to the extensive braid of streams which traversed the moraine about the tongue (see 1910 view, plate VI.) and the amount of water they carried, it was found to be impracticable to reach a satisfactory station, and was finally abandoned. However, a three-leaved panoramic view of the glacier was taken from Station 1 on July 16. When compared with a similar series exposed from the same point on June 30, 1911, a marked retreat of the ice is noticeable. With a print of the earlier photograph in hand, the rocks numbered 6, 9, 10, 3, 11, 1, and 13 were identified, and their distances from the nearest ice were measured off with a tape. Combining these with the estimated distances of the rocks from the ice in 1910, as shown on the photograph of that year, the intervening retreat was obtained. The results appear in the following table:—

OBSERVATIONS FOR THE RECESSION OF THE FOREFOOT.

Rock No.	Measured distance from nearest ice, 1911.	Estimated distance from tongue, 1910.	Mean retreat for 50 weeks.	Average recession for 50 weeks, 1910-1911.
	ft.	ft.	ft.	ft.
6	50	5	45	46
9	47	0	47	
10	33	0	33	
3	28·5	8·5	20	28·6 — 37·3
11	28	0	28	
1	27	5 back of tongue	32	
13	40	10	30	

(These rocks were not marked. Identification depends on the photographs.)

* *Appalachia*, vol. 9, p. 160, 'The Great Glacier of the Illecillewaet,' by George and William S. Vaux, Jr.

A small moraine a little distance ahead of the most advanced ice may be distinguished in the 1910 view. This indicates the position of the forefoot in 1909. By measurement with the tape this was found to be 25 feet from the position of the ice there shown, which accordingly represents the amount of the retreat for 1909-1910 at this point—a close agreement with the 28·6 feet as shown in the table for 1910-1911.

Other differences apparent from the photographs are an increased elevation or thickening of the ice towards the centre of the glacier, manifest upon a careful comparison of the profiles, and the new courses of the main drainage channel. The stream abandoned its lateral exit to issue in full volume from the foot of the final ice slant. It would seem

V.—TEST PHOTOGRAPH OF TONGUE OF SIR SANDFORD GLACIER TAKEN FROM STATION I., JUNE 30, 1911.

(Photo, Howard Palmer.)

VI.—GLACIER TABLE ON SILVERTIP GLACIER.

that only a subglacial change of considerable moment could be accountable, for the stream had occupied its former bed sufficiently long to erode a decided channel in the ground moraine and pronounced niches in the brink of the gorge into which it plunged. It will be of interest to note whether an ice arch will form above the new outlet. Conditions appear favourable, for this is the thickest portion of the forefoot. The stream is about 40 feet wide where it emerges from the glacier. It is heavily charged with rock flour, and correspondingly turbid in appearance. The final slope of the tongue is about 25° .

Little time was available for work with regard to the position of the ice at an earlier date. At Camp station two prominent well-defined moraines exist, between which a lateral stream flows. On the most westerly, overlooking the ice, a spruce $7\frac{1}{2}$ inches in circumference was cut down. This showed thirty-seven rings of growth, and was the oldest, apparent, on casual observation, anywhere near by on the ice side of the moraine. It occupied a position fully exposed to northerly winds, and was one of a very few specimens. On the easterly slope of the moraine, in a more protected place, another spruce showed thirty-one rings. It is safe to say that this moraine is more than fifty years old. On the easterly moraine, overshadowed by the mature evergreen forest of the valley slope, were noted a spruce with sixty-three rings, and a fir with fifty-three. This would seem to indicate an age of over seventy-five years for the easterly moraine. All these specimens were taken within a hundred paces of Camp station.

3. *Mapping the Forefoot, Streams, and Moraines.*—The accompanying map is based on instrumental triangulation, supplemented by photographic panoramas and single views. (The stations from which the latter were taken are outside the limits of the plan.) The base line is not shown, as the triangles covering the area mapped are part of a larger system. All stations except Station 2 and Signal station were occupied with the transit and their positions, and altitudes depend upon its readings. Stations 1, 2, and 3 served as camera stations, whence panoramas of the tongue and adjacent detail were taken. They consist of prominent boulders, or ledges, and were marked conspicuously in dark green paint, 2 and 3 with signal targets.

The points limiting the margin of the ice, and other prominent features, were determined by intersections from the panoramas according to the methods of photographic surveying. Lateral moraines were paced.

The large boulder indicated on the map at the edge of the surface moraine in the vicinity of Boulder station forms a mark of some prominence. For this reason its position was determined by the transit. On July 8, 1911, it was 1136 feet distant from Boulder station, and 1734 feet distant from Camp station, being 104 feet higher than the former, or at an altitude of 5934 feet. Its diameter was estimated at about 15 feet, which may preserve it from falling into a crevasse. The boulder is well

seen almost exactly in the centre of Plate I. This photograph was taken on July 12, 1910. It so happens that the transit measurements just given were made on July 13, 1911. Upon plotting the azimuth of the boulder as obtained from Plate I., a total motion of 50 feet was read off by the position mapped in the direction of the line representing the border of the moraine. This results in a rate of 1.64 inches per day for the intervening year, which offers an interesting comparison with that of 3.16 inches indicated at Station 8 on the surveyed line, at approximately the same distance from the margin.

4. *General Observations on the Surface Features, etc.*—As a result of the larger triangulation referred to above, it becomes necessary to reduce the length of the main stream of the Sir Sandford glacier from the previous estimate, based on prismatic compass to almost exactly five miles. In like manner a reduction in total length to about twelve miles, and in area to about ten, would probably be warranted. The latter figure refers to the actual area of ice and *névé*. The area of the glacier's drainage basin is far greater. The average slope of the glacier from the pass at its upper extremity to the toe is 570 feet per mile. The altitudes are from triangulation, for which Mount Sir Sandford, at 11,634 feet, served as datum. Names used have been approved by the Geographical Board of Canada.

The line of junction between the Silvertip and Sir Sandford glaciers presents some interesting features to a cursory examination. The two trunk streams meet almost at right angles, and the line of contact for fully half the width of the Silvertip is a straight line (see Plate II.), indicating almost diagrammatically the resultant of their motions. Beyond this point the greater mass of the Sir Sandford begins to tell, and the line is deflected. The unusually regular and delicate curve in the medial moraine of Silvertip glacier also depicts graphically the forces at work in this vicinity. Several good specimens of glacier tables were noted in this moraine. The line just referred to marks the course of the local surface drainage, which flows both ways from a divide in two brooks (see map). One empties into the depression in the corner between the glaciers; the other, a larger stream, into a moulin about as shown on the plan. The streams have sunk their channels as much as 5 feet into the ice at some points, revealing in rather a striking way a number of small crevasses in the walls, which open, perhaps, an inch at the surface of the glacier, but gradually close downward until complete union is effected just far enough above the stream to prevent any escape of the water. Quite a series of these cracks was noted in the south wall of the westerly flowing brook.

Another feature worthy of mention with respect to the junction of these glaciers is the absence of any pronounced medial moraine. A few blocks of ground moraine that apparently had been picked up by the Sir Sandford were seen, but, obviously, these were exceptions. The actual

place of meeting of the ice streams may best be likened to one of the re-entrant angles formed at the corners of a picture frame made out of quarter-round moulding. From the ground moraine the ice rounded up steeply and smoothly on each side without crevasses, forming a depression which the aneroid indicated as being 80 feet below the level of the ice further back on the line of union. The other side of the rough triangle was made up of an unstable pile of lateral moraine. A stream issued from the margin of the Sir Sandford, and flowed into the Silvertip near the junction. A coating of mud on the stones and an ill-defined line on the ice of both glaciers go to show that at times the water rises in the depression to form a lakelet.

A somewhat unusual form of glacier table was exhibited on the side of Silvertip glacier, near the point of meeting. A number of large blocks of pure white snow, apparently the remains of a spring avalanche, had withstood the effects of melting, and, owing to their greater reflecting power as compared with the dirty surface of the glacier, had protected the ice beneath them from the sun to such an extent that they were perched up on distinct pedestals some distance above the normal surface level in grotesque attitudes.

THE ANTARCTIC EXPEDITIONS OF 1911-12.

By HUGH ROBERT MILL, D.Sc.

NEWS of Captain Scott's expedition reached this country on April 2, his ship the *Terra Nova* having arrived at a New Zealand port on the previous day. The information which it is possible to give here is taken from two long telegrams supplied to the press by the Central News Agency, and published on April 2 and 3. There is always some difficulty in interpreting the statements of positions in telegrams, so that it is not possible to be certain on some points of detail, but the general results are clear.

As originally planned, the expedition was to operate simultaneously in four widely different areas: King Edward Land was to be explored by an Eastern party, the great coast range of Victoria Land by a Western party, scientific observations were to be maintained in great detail at the headquarters on McMurdo sound, and a Southern party was to proceed if possible to the pole. The return of the *Terra Nova* a year ago acquainted us with an important change of plan; the Eastern party, being unable to land on King Edward's Land, had proceeded to Cape Adare, whence exploration was to be carried on along the coast on the sea ice.

The news now received carries on the history of the expedition to March 5, 1912, and we may state briefly the result of the year's labours of the four separate parties so far as these can be given.

The number of men at the headquarters at Cape Evans on McMurdo sound varied according to the coming and going of various parties; but
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