

over-modest, and, though a poor man, absolutely without eagerness for money; one who never, on any single occasion, suggested that the day's pay should be raised or the Trinkgeld increased. I am glad to think that, after climbing was long over both for him and me, he came in September 1890 to pass some few days with me at Kandersteg. It was our last meeting.

THOMAS BROOKSBANK.

GLACIER OBSERVATION.

THE Committee of the Alpine Club having before them Captain Marshall Hall's letter published in the February number of this journal (p. 321), have addressed the following letter and enclosure to the Governments of the British dependencies and colonies which comprise glaciated ranges, with the object of obtaining such information as is available from officials of the Government and other travellers with regard to the contemporary movements of glaciers. The Committee hope to receive the co-operation of any members of the Club visiting mountains other than the Alps, where glaciers exist, and the Hon. Secretary will, on application, furnish instructions and forms to be filled up.

Members who take a camera to the Alps are reminded that photographs of the snout of a glacier form an interesting record when its relative position to any easily recognisable rock is shown. Such photographs should have the date on which they were taken and the distance and compass bearing of the camera in relation to the rock referred to written on the back.

The Hon. Secretary will be happy to receive copies, which will be kept together in the Club rooms for reference.

The following is the letter:—

‘Alpine Club, 8 St. Martin's Place, London, W.C.

‘SIR,—At the desire of the Committee of the Alpine Club I beg to send you the following memorandum with regard to the observation of glacier movements, and to request that it may be brought under the consideration of your Government.

‘A fairly complete record of the movements of glaciers in the European Alps is now kept and published through the efforts of the Continental Alpine Clubs and the individual energy of M. Forel of Morges. It is very desirable that a similar record should be kept in other glacial ranges, with a view to ascertain how far the movements of advance or retreat correspond or differ in date and period, and for other purposes. In Europe much assistance has been given in the ascertainment of local facts by the surveyors engaged on government work in their respective countries. In more distant or less populated regions surveyors and Government agents must obviously be in many cases the principal sources of information.

‘The Committee of the Alpine Club believe that the circulation amongst your officers (together with the general publication in any

form that may seem most suitable) of the enclosed paper of Hints for Observers might lead to valuable and interesting results.

'The Alpine Club has appointed a sub-committee to receive any information that may be sent, and to provide for its regular compilation and publication in a form accessible to the public. It would also be glad to receive any information that may already be in your possession bearing on this branch of inquiry, or on kindred topics connected with mountain exploration.

'Any such communications should be addressed to the Hon. Sec., Mr. J. H. Wicks, 8 St. Martin's Place, London, W.C.

'I am, Sir, yours faithfully,

'D. W. FRESHFIELD, President.'

MEMORANDUM.

The recent movements of glaciers may be noted by the following signs:—

When the ice is advancing, the glaciers generally have a more convex outline, the icefalls are more broken into towers and spires, and piles of fresh rubbish are found shot over the grass of the lower moraines. Moraines which have been comparatively recently deposited by advancing ice are disturbed, show cracks, and are obviously being pushed forward or aside by the glacier.

When the ice is in retreat, the marks of its further recent extension are seen fringing the glacier both at the end and sides in their lower portions, the glacier fails to fill its former bed, and bare stony tracts, often interspersed with pools or lakelets, lie between the end of the glacier and the moulds of recent terminal moraines.

Where a glacier has retreated to any considerable extent, careful observations of the form of its bed are of value. What is the nature of the rock surfaces exposed—convex or concave; are they rubbed smooth on their lee sides; how far have the contours of the cliffs or slopes, or the sides of any gorge, been modified where they have been subjected to ice-friction? Is there any evidence that the ice has flowed over large boulders, or loose soils, such as gravel, without disturbing them? How has it affected rocks of different hardness, for instance, veins of quartz in a less hard rock? Generally, do the appearances indicate that the glacier has excavated, or only abraded and polished its bed; that it has ground out new rock-basins, or only cleaned out, scratched, and preserved from filling-up by alluvial deposits or earthlips, existing basins? What is the general character of the valley bottom and slopes above and below the most conspicuous ancient moraines?

The depth of mountain lakes and the position of the point of greatest depth should be ascertained wherever possible. The marginal rock structure of lake basins, particularly near their outlet, is of much importance with a view to ascertaining whether they are true rock basins, or whether they are reservoirs formed by ancient moraines, earthlips, or alluvial deposits.

The traveller or surveyor should, if possible, paint a mark and date on any conspicuous rock *in situ* parallel with the termination of the glacier at the time of his visit, marking the distance in yards of the ice from it. The next visitor will then be able to measure the movement that has taken place since his predecessor's visit. Leaving out of question elaborate trigonometrical methods, such, for instance, as have been carried out on the Rhone Glacier in Switzerland, the following plan gives very favourable results, and demands no other instruments than a small jar of paint, a brush, a measuring tape, and a pocket compass. To ascertain the recent retreat of a glacier, measure the distance from the end of the ice in front of the longitudinal axis of the glacier to the most advanced terminal moraine, where vegetation first shows itself. The bare ground recently left by glaciers is easily recognisable. The diminution of volume is best measured by ascertaining the height of bare soil left on the sides of the lateral moraines in the portion of the glacier within the zone of vegetation. All photographic representations of the glacier end, and of the ground which has been freed from the glacier ice, are of great value. Those will be of most service that show the position of the glacier-snout with relation to some conspicuous rock or other feature in the local scenery. Each photograph should be dated, and the bearings and distance of the camera with reference to any such feature accurately noted.

It is very important to investigate the state of various glaciers as regards advance or retreat. Neighbouring glaciers often furnish very different results in this respect, owing to the fact that steep glaciers anticipate in their oscillations those the beds of which are less inclined. To ascertain the oscillations of glaciers, it is necessary to fix the actual position of the ice-snout at the end of the glacier with the greatest accuracy. Two methods can be employed for this purpose, either of which may be selected according to circumstances.

Paint some signs on large boulders, not too far from the end of the glacier, and measure their distance from it by a tape (Richter's system), or build a low wall of stones of a few yards in length, and, say 15 to 20 inches in height, some distance from the ice-end, and measure this distance (Gosset's system). It is to be recommended that the stones of these walls should also be painted. If the traveller himself returns after some interval—even after only two or three weeks—he will be able to judge of the movement of the glacier, and he will have laid down a basis for future observations by future travellers.

One of the results most to be desired is an exact knowledge of the dates:

- I. Of the maximum extension of the ice.
- II. Of the commencement of retreat.
- III. Of the minimum.
- IV. Of the commencement of fresh increase.

In dealing with a mountain group, therefore, the traveller should note (where he can get the information as to the past) the date of the commencement of the actual movement of *each glacier*, and in all cases whether the ice is in advance, or retreat, or stationary. Of course the rate of forward movement, or velocity of the ice, and the oscillations in the extension of the ice must be kept carefully distinct.

Should time and circumstances permit, a series of observations of the velocity of the ice is of value. These may be made after Tyndall's method, by planting a line of sticks across the glacier, or by painting marks on boulders, the position of which relatively to ascertained points on the mountain-side has been accurately fixed. The size of the glacier, that is, the area of its basin and its length, as well as the slope of its bed above, as well as at the point measured, should be noted. The rate of movement of the ice appears to be connected both with the volume of the glacier and the inclination of its bed.

On the same subject Captain Marshall Hall writes:—

‘The memorandum on glacier observation drawn up with the advantages of varied experience by our President will, it is to be hoped, result in beating up recruits in both hemispheres. The suggestions are kept within the bounds of what is most pressing in the way of information required, in order to attract observers, who, once engaged in the work, will find it so fascinating that the sphere of their operations will greatly extend itself.

‘In order to attract attention to sundry desirable matters I venture to offer the following spoonful from the inexhaustible stock of field observation.

‘We know but little as to the rate of advance or of spreading out of névé and snowfields. Fragments of property, and, alas! of victims, now and then reappear after a journey of some years, and give us sparse data.

‘Professor F. A. Forel has lately caused a leaden plate, engraved with date and a request to finders that it may be forwarded to a qualified man, to be buried in the recently made snow tunnel near the top of Mont Blanc; and M. J. Vallot has added some pieces of board, with an inscription burnt into them.* Except for this scarcely anything systematic has been done. Here is a very unhackneyed field for observation. The rarity of stones and moraines on the upper névés has much to do with this neglect.

‘Stakes in a line might, as has been suggested, be of use. But in hot weather they must be big and deeply planted. On July 8, 1841, Escher von der Linth planted some 3 feet deep on the Aletsch Glacier. But he found, on August 16 in the same year, no traces of the holes, and all the stakes had fallen.

‘There still exist supporters of the Ramsay theory as to lake formation by ice action. We owe it to sundry distinguished men to supply all

* Dr. F. A. Forel, *Deuxième Rapport sur les Variations Périodiques des Glaciers des Alpes*. Berne: Stampfli. 1892.

the evidence bearing upon this question, which has recently come again to the fore. Several seasons I sought out lakes in support of this theory, but entirely failed to collect facts satisfactorily confirming Ramsay's view. But the arguments are far from being exhausted, and another man might see the same things in a different light, or with a keener eye (let not the reader maliciously ask which eye) detect nature in actions which escaped previous seekers. Against one thing I have to protest. It has been said that modern glaciers are so puny and degenerate that we cannot expect to see the same work as exhibited by the vast weight and mass of their ancestors. But surely the same thing must be going on in kind if not in degree.

'The first of three volumes has just come to my hands which will constitute an exhaustive monograph on Lake Lemán by Professor F. A. Forel.* In the portion which treats of local geology he discusses the glacial theory with good judgment, shrewdness, and undeniable fairness. I recommend my colleagues of the Club, when bad weather or other causes induce them to lay by the ice axe for a few days, to improve the time with this volume in hand, and make a deliberate tour of the lake.

'To get back to our Alps. It is most important to arrive at some kind of estimate as to the approximate amount of detritus and rocks which get *under* a glacier compared with the surface moraines; also of the relation of stones and dirt to the grinding of surfaces, and lastly of the amount annually removed by torrents. And will not some enthusiasts try and explore under the glacier as well as above? Pray let them note how far stones and the fine slime which serves as polishing powder are frozen on to the lower surface of the ice.

'Next year, 1894, the International Congress of Geologists meets at Zurich. If I rightly know the character of my old and dear friends amongst Swiss savants I may safely prophesy that they will no more resist the temptation of discussing ice matters than a hungry trout will fail to look at a May fly.

'It would be most desirable to get such a man as Professor F. A. Forel to consent to act as president of an International Committee consisting of one "rapporteur" from each country possessing glaciers, such as France, Bavaria, Austria, Russia, Norway, Denmark, the United States, and of course our own colonies.

'Each of these would work with a sub-committee in his own country, and a mass of comparative glaciology (pardon the barbarous word) would accumulate, the bearing of which on such questions, amongst others, as periodicity would soon show itself.

'We have at present few data as to whether there be any connection *qua* variations in motion and volume between glaciers in different latitudes and hemispheres, a problem involving many meteorological deductions.

MARSHALL HALL.

'P.S.—For those who have to bring foreign measures into English terms I should like to point out that the chain is just 4 inches more than 20 metres, and a link therefore may be taken as 20 centimetres.'

* *Le Léman: Monographie Limnologique.* Lausanne: F. Rouge. 1892.