

up the larger gaps and make it possible to determine the volume of rainfall of any year or month with considerable accuracy, and that of any day with fair accuracy.

There are now at work in the Exe valley or on its margin, sufficiently near the watershed to give useful indications, fifty-four observers of rainfall, most of whom keep daily records. In the Medway valley the representation is equally good, and it was only found necessary to supply rain-gauges from the funds of the committee to six altogether.

The comparison of rainfall with stream-flow will involve considerable difficulty, as the general fall over the whole valley on any one day cannot affect the stream at the point where it is gauged at the same time. It will probably be found necessary to discuss heavy local rains in different parts of the basin in some detail, in order to ascertain how soon the rain finds its way down the stream, and to be guided by the result in carrying on the more general discussion. It is desirable to wait until a considerable number of heavy falls have occurred within the period of the river gaugings before proceeding to make this comparison. At present the accumulation of data is proceeding in a satisfactory way.

OBSERVATIONS OF GLACIER MOVEMENTS IN THE HIMALAYAS.

We quote below, with a few omissions and additions, the Introductory Report furnished by Mr. T. H. Holland, F.R.S., Director of the Geological Survey of India, to the detailed descriptions of the work recently carried out by his officers* in the observation of the movements of Himalayan glaciers.

"In 1905 Mr. D. W. Freshfield, on behalf of the Commission Internationale des Glaciers, drew the attention of Lieut.-Colonel S. G. Burrard, F.R.S., Superintendent of Trigonometrical Surveys, to the importance of recording data for determining the secular movements of the principal Himalayan glaciers. As the work required the co-operation of all officers and private travellers likely to visit the glacier regions of the Himalaya, Colonel Burrard referred the question to the Board of Scientific Advice, and, on the recommendation of a sub-committee composed of Colonel F. B. Longe, R.E., Surveyor-General, Dr. G. T. Walker, F.R.S., and myself, the Board agreed on a system of observations, recommending that the distribution of the necessary information and collection of data should be under the control of the Geological Survey Department. The proposals having received the sanction of the Government of India, the first step in the investigation was taken by the deputation of five Geological Survey officers during August and September, 1906, to make a preliminary survey of the principal glaciers in the Kumaon, Lahaul, and Kashmir regions.

"Altogether twelve glaciers were examined, as follows:—

Kashmir Region.—The Barche and Hinarche glaciers in the Bagrot valley; the Minapin, Hispar, and Yengutsa glaciers in the Nagir State; and the Hassana-bad glacier in Hunza. These six were surveyed by Mr. H. H. Hayden.

Lahaul.—The Bara Shigri and Sonapani glaciers were examined by Messrs. H. Walker and E. H. Pascoe.

Kumaon.—The Pindari, Milam, Shan Kulpa, and Poting glaciers were surveyed by Messrs. G. de P. Cotter and J. C. Brown.

* 'Records of the Geological Survey of India,' vol. 35, parts 3 and 4. 1907. London: Messrs. K. Paul, Trench, & Co.; Calcutta: Geological Survey Office.

"In all cases plane-table sketches were made, showing the exact positions of the ice-caves with reference to points cut and painted on rocks in the valley, as well as with prominent and unmistakable peaks in the vicinity. In some cases cairns were built over the marks, and in the Kashmir area these were placed in charge of the nearest village headmen. The cairn built near the Milam glacier was placed in charge of Bai Bahadur Kishen Singh, who is well known to science as 'A.-K.'

"Photographs were taken from various points of view carefully marked on the map and described in the report, showing the state of the glaciers and the principal masses of moraine material at the time of the visit. These photographs will enable subsequent travellers to form an idea of any changes that may have occurred in the interval, and will thus make their observations of value even if the fixed points cut in the rocks are destroyed by weathering or by being overwhelmed with loose material.

"The short time available rendered it necessary that observations should be confined to one aspect of the glaciers, namely, that of their secular advance or retreat. It was impossible, under the circumstances, to make more than passing observations on such questions as the rate of flow, the lamination of the ice, included dirt bands, and erosive action. These interesting questions must be left for future workers, as it was important in as many instances as possible to fix at once, for the purposes of the main problem, the positions of the snouts and general disposition of the ice with regard to fixed features in the ground around.

"The first point that strikes one on examination of the reports is the fact that the glaciers of the Hunza valley and the Karakoram range generally descend to lower altitudes than in the Lahaul and Kumaon regions. In the former region the snouts of the glaciers proceed down to levels of 7000 or 8000 feet, while in the latter region they melt before descending below the level of about 11,000 feet. [In the Kangchenjunga group the lowest point reached by ice is about 13,000 feet in the great Zemu glacier.] In the Hunza region, also, there are two classes of glaciers—

"(a) Those which flow transversely to the trend of the mountain range, and are relatively short, with a steep descent reaching down to elevations as low as 8000 feet and under; and

"(b) Those which lie in troughs parallel to the range, and also approximately parallel to the strike of the rocks of which the range is composed. These, having at their angles of slope a less rapid fall, rarely descend below 10,000 feet, and form long glaciers, in some cases making the most magnificent ice-flows in the Himalayas."

The second point prominently displayed is the evidence of general retreat shown by the occurrence in nearly all cases of old moraines (sometimes grass-covered) below the present ice. This point does not, of course, necessarily mean that the glaciers are now in retreat, and two well-authenticated cases of recent advance have been found in the Yengutsa and Hassanabad glaciers, both steep transverse ice-streams. Since 1892, the date of Sir M. Conway's visit, the Yengutsa glacier has advanced at least 2 miles, nor does this advance appear to have been gradual, as, according to local reports, the ice moved forward suddenly some five years ago, and has since remained stationary. The Hassanabad glacier, according to the statement of the Emir of Hunza, also moved forward suddenly some three years ago, covering in two and a half months a distance variously estimated as from 6 miles to one day's march. Owing to the danger involved to the villages near, it was carefully watched, and the above statements may, we are told, be accepted. It is said that the ice occupied its present position many years ago, and subsequently retreated. It is now apparently stationary.

The valleys below the glaciers, being generally covered by moraine material and talus from the hills around, very seldom reveal the solid rock, and consequently the evidence with regard to the erosive action of the ice is insufficient to show whether the glaciers have eroded material in large quantity, or only succeeded in striating and polishing the rocks over which they flowed.

The Reports are illustrated with a large number of plans and photographs. The best thanks of all interested in glacier science are due to Mr. Holland and his staff for the energy with which this important work has been taken up, and the admirable manner in which it has so far been carried out. It is proposed to attack shortly other parts of the Himalaya, including the Kangchenjunga group. It is much to be desired that the example set by the Indian Government may be followed, and that in other parts of the British dominions overseas where glaciers are found, equally systematic observations may be undertaken and carried on by a scientific branch of the local governments.

REVIEWS.

EUROPE.

THE SCOTTISH HIGHLANDS.

'The Geological Structure of the North-West Highlands of Scotland.' By B. N. Peach, John Horne, W. Gunn, C. T. Clough, and L. Hinxman, with Petrological Chapters and Notes by J. J. H. Teall. Edited by Sir A. Geikie. 1907. Mem. Geol. Surv. Great Britain. Pp. vii. + 668, pl. lii. With coloured geological map on the scale of 4 miles to the inch.

No publication of the British Geological Survey has been so eagerly awaited as the long-promised memoir on the north-western Highlands of Scotland. That country is built of rocks belonging to four groups, which in a traverse from west to east are exposed in the following order: The Lewisian gneiss of the Hebrides and of the western coasts of Sutherland and Ross; the Torridonian, a thick series of sandstones once identified as Old Red Sandstone; a narrow belt, 100 miles in length, of fossiliferous quartzites, shales, and limestones; and, finally on the east, the western edge of the gneisses and schists which form the main bulk of the Scottish Highlands.

The relation of these four rock series to one another has been the most vexed question in British geology. According to Sir Roderick Murchison, the four groups of rocks had been deposited in regular succession, the easternmost being the uppermost and youngest. Nicol, on the other hand, regarded the eastern and western gneisses as belonging to the same series, and the fossiliferous rocks as having been sandwiched between them by earth-movements. According to Nicol the fossiliferous rocks were the youngest, whereas according to Murchison the eastern gneisses were the youngest. Nicol's view was almost unanimously rejected during his lifetime, but shortly after his death a paper by Prof. Bonney proved that some, at least, of the eastern rocks were the old Lewisian rocks upraised by earth-movements. In 1882-3 the truth of the essential part of Nicol's theory was further demonstrated by Prof. Lapworth's detailed survey of some sections beside Loch Eriboll. He explained how the old eastern gneisses came to be above the younger fossiliferous rocks, as he found that the gneiss had been forced westward, riding over the crumpled masses of the younger beds. Murchison's theory was finally abandoned in 1884, when the results of the first season's work of the Geological Survey in this area were announced by Sir Archibald Geikie. The Geological Survey has now