

before and after escape from the ice-sheet, and makes clay-beds, sand-beds, moraines, drumlins, eskers.

It makes glacier dams, producing thereby large lake-basins, by piling up the ice in narrow gorges, or by pressure against the sides of valleys, and thus crossing and so closing open valleys; and small lakes, liable to frequent discharges (page 238), by pressure of the ice against the side of the valley; and, in times of melting and dissolution, it may build *ice-dams* in narrows along river channels out of blocks of floating ice and accompanying glacier debris or drift, converting rivers into lakes. Further, the glacier, wherever it flows, usually leaves its tracks in scratched, grooved, or planed surfaces, upon the rocks passed over; in scratched stones distributed through the drift material; in large scattered bowlders that are traceable to a source in a direction opposite to that of the movement; and also in its moraines and other drift accumulations. In the use of glacial scratches to determine the direction of movement of the ice-mass, it is always to be noted that the direction is quite sure to be diverted from that of the general ice-mass by valleys, or valley-like depressions in the surface beneath the glacier when they are oblique to that course, even if the depression be small; and that a knoll or low ledge of rock may have some divergent effect. Only scratches on high land, without such sources of error, are to be trusted. Moreover, with regard to traveled material or drift, the question is always to be asked whether water or floating ice may not have been the transporting agent.

A glacier period in geological history was first recognized in 1837 by Louis Agassiz, before the Helvetic Society of Natural History, and in 1840 announced at the meeting of the British Association. Agassiz visited Scotland to verify his theory. He says in a letter to Professor Jamieson (1840): "I had scarcely arrived in Glasgow when I found remote traces of glaciers; and the nearer I approached the high mountain chains, the more distinct these became, until, at the foot of Ben Nevis and in the principal valleys, I discovered the most distinct *moraines* and polished rocky surfaces, just as in the valleys of the Swiss Alps." On Nov. 4, 1840, he brought the subject before the Geological Society of London. His theory of the drift was for awhile opposed by advocates of the Iceberg theory, but it now has general acceptance.

The earlier systematic observations on the drift in North America were made between 1832 and 1842 by E. Hitchcock, W. W. Mather, C. Whittlesey, James Hall, and others. Mather devotes many pages to the subject in his New York quarto report (1842), and states that he had gathered facts personally from New England to the meridian of 97° W., "traveling over 100,000 miles." His descriptions of Long Island drift, and that of the Coteau des Prairies and of many regions between, though he was not then a glacialist, are excellent; and they are supplemented with results from other sources, and a long table giving the courses of glacial scratches over different parts of the country.

Among the later investigators, over the Eastern and Central States, there are C. H. Hitchcock, whose work has been mainly in New England, and has been published in the Geological Reports of Vermont and New Hampshire, and elsewhere; T. C. Chamberlin, whose papers have appeared in the Reports of the Wisconsin Geological Survey, those of the U. S. Geological Survey, and in other places; Warren Upham, who, after work in New England, has served as one of the geologists in the survey of Minnesota, and temporarily also in the Canadian Survey, and in each has extended his studies to the Winnipeg region in British America; F. Leverett, R. D. Salisbury, J. S. Newberry, G. K. Gilbert, W. J. McGee, J. C. Branner, Carvill Lewis, G. F. Wright, and others. The author's publications on American Glacial history range from 1856 to 1893, and those giving the results of special investigations, from 1870, onward.

For the Rocky Mountains and the Pacific Slope within the United States, the most important publications are those of J. D. Whitney, Clarence King, I. C. Russell, J. S. Newberry, and J. LeConte; and for British America, those of Dawson, G. M. Dawson, R. Bell, R. G. McConnell, J. B. Tyrrell, and R. Chalmers.