

GLACIAL GEOLOGY AND THE PLEISTOCENE EPOCH. RICHARD FOSTER FLINT.
New York: Wiley & Sons, London: Chapman & Hall, 1947, p. xviii+589, pls. 6

PROFESSOR FLINT'S book is an outstanding contribution to our knowledge of the Pleistocene when viewed over the world as a whole. Its very comprehensiveness prevents even such a large and informative volume from giving great detail on specific topics, but its balanced judgments encourage the reader to dip further into the literature to which the references cover 40 pages.

The author rather avoids glaciology, which he too narrowly defines as fundamentally the study of the deformation of glacier ice; but his book does not suffer much in consequence, because it is concerned mainly with the Pleistocene deposits and their interpretation. The pregnant but as yet unproved suggestion of Demorest that the deeper ice of a glacier moves faster than the upper layers is accepted without question. One is prompted to ask why the upper layers are not carried forward on the back of the supposedly swifter moving lower layers. Certainly it is going too far in the present transitional stage of our knowledge of glacier mechanics to claim that the rate of flow of glacier ice probably increases as the square of the depth. A later assertion, that the measured rates of glacier flow are so variable that they are of no practical significance, is a frank admission of our present ignorance of this subject.

In the section dealing with the form and distribution of existing glaciers, Hobbs' glacial anti-cyclone theory is perhaps brusquely dealt with, but the author's claim for the hypothesis of Demorest and others that Greenland is kept nourished by depressions from the south-west carries conviction. A map of the Antarctic ice sheet on p. 48 is probably out of date already and should show the ice divide occupying a somewhat more central position.

Under the title "Glacial erosion and transport" the author reviews, most helpfully, the American work on the rate of erosion of boulders and the greater relative speed of erosion on the jagged downstream side of a *roche moutonnée* compared with that on the smooth upstream side. Evidence is brought forward of the surprising height—over 4000 ft. (1220 m.)—to which indicator boulders are raised above their source of origin. But the alternative offered to T. C. Chamberlin's explanation of upthrusting along shear planes is not argued sufficiently closely. The formation of glaciated valleys and cirques is summarily dealt with, but the author's comments are pertinent and a good lead is given into the literature.

The major part of the book is concerned with glacial drift and Professor Flint's mastery of this side of the subject is abundantly evident. The chapter on "Stratified Drift" emphasises its twofold nature with the super-glacial till lying on the basal till, often with a clean-cut unconformity between, and includes a clear statement of the problem of the form, composition and distribution of drumlins. The important group of ice-contact features is well summarized, the reference to eskers being particularly apposite. Drainage, ice-thrust features and aeolian deposits form a strangely grouped trio in Chapter 10, but as usual much information is packed into a few pages, and a clear picture is given of the North American loess deposits. The range of size of loess grains is given as 1/16–1/256 mm., but no mention is made of Bagnold's valuable suggestion that grains of this range of size, unlike coarser sand grains, possess cohesion. Cohesion increases rapidly as grain size falls below 0.1 mm., and this may well be of fundamental importance in explaining the very different types of scenery produced by loess and by sand deposits.

The confident interpretation of glacial stratigraphy of North America contrasts with the hesitant approach to the subject in this country. The author generously attributes this to the complications produced in Britain by the contact of the Scandinavian and the native ice masses. In the United States good use has been made of the degree of leaching and oxidation of the clay-rich till deposits in the Mississippi Basin to differentiate the three main drift sheets—the Nebraskan, the Kansan and the Wisconsin. These methods may not have such wide application in Britain, and we are certainly handicapped by the small extent of this country and by its complicated

geology. One cannot, however, escape the conclusion that workers in the United States—with Professor Flint as an acknowledged leader in their field—have made progress which we in this country must admire and emulate. Professor Flint admittedly avoids the difficult task of correlating the glacial episodes with changes of sea-level, and it is into this subject of river terraces that most work has been put by British geologists interested in the Pleistocene.

In accounting for the former glaciations of Europe Professor Flint considers that here, as with both the western and eastern centres of dispersal in North America, the snow was mainly provided by maritime air masses coming from the west. The resulting accumulation of ice, over the highlands of Scandinavia in the first place, could escape more readily to the west than to the east. The east-flowing ice attracted much snowfall to itself and eventually grew to such height that the divide was east of the highlands. As a generalized picture this probably holds good, but it ignores the view that the Jotunheim probably formed its own centre of dispersion, at least throughout the last glaciation.

In describing the glacial stratigraphy of Europe Professor Flint makes as good use of correlation tables as he does in his earlier chapters on North America. He makes no reference to Solomon's work on East Anglia and confuses the Lake District with the Pennines in his reference to summit heights on p. 317, but these do not signify where all else is so admirable. Not content with the prodigious labour of clarifying our knowledge of the Pleistocene in North America and Europe, the author proceeds to discuss glaciation in other parts of the world—Siberia, the Caucasus, Central and S.E. Asia, Australasia, Africa and Antarctica.

Perhaps the most signal contribution of this century has been the development of methods of dating the Pleistocene, so Professor Flint's review of this aspect of his subject is of particular interest and importance. His co-workers have been quick to learn and apply the technique of varve counts from the Scandinavian authorities, and it would seem that only in the field of pollen analysis do European workers hold a clear lead.

The illuminating preliminary work of Piggot and Urry in obtaining and interpreting cores from the floor of the Atlantic is perhaps too modestly described. The fact that the radium content method of dating layers in these cores does not seem valid beyond 300,000–400,000 years should not limit the findings to that period of years, because once the rate of sedimentation is dated by its radium content, extrapolation over a far longer period may result. The findings of the Swedish Oceanographical Expedition, which is at present using a much improved vacuum coring apparatus, are awaited with the liveliest anticipation.

Chapter 22 on the causes of the climatic fluctuations, like so much of the book, is a joy to read. The various theories are tested in the light of modern knowledge of the Pleistocene and all seem to fail to account for some important facts. It appears necessary to equate glacial and pluvial episodes in North America, and this is wholly against Simpson's Theory. Milankovitch's calculations do not agree with those of Spitaler. They involve nine temperature minima, and cannot account for the present increase of temperature contemporaneously at both poles. Professor Flint offers his own alternative—the Solar-Topographic Hypothesis—in which he combines fluctuations of solar radiation with the uplift of highlands. The late Tertiary uplifts started the ice age as a whole and the fluctuations of solar radiation gave rise to glacial and inter-glacial subdivisions. One would like to see this attractive hypothesis argued more closely and to learn how the inter-glacials, when the climate is generally presumed to have been warmer than at present, are explained. Also why there was such a long interval of time between the main Tertiary uplifts and the onset of glaciation.

This excellent book, which, with the exception of a few of the plates and diagrams, is most attractively produced, should at once take its place as a standard work on world Pleistocene geology.

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