GLACIER FLOW: A REVIEW. ROBERT P. SHARP. *Bulletin of the Geological Society of America*, Vol. 65, No. 9, 1954, p. 821–38.

RESEARCH into glacier flow brings together scientists with varied experience, knowledge and interests. Work in the field, laboratory experiments and theoretical analyses go, or should go, hand in hand. It is therefore important that the scattered literature on the subject should from time to time be sifted and critically reviewed. Professor Sharp's review is written "to bring the geologist up to date on current work, to survey recent progress, and to define some of the problems ahead". It would very well serve to bring all glaciologists up to date for it is an admirably lucid and compact statement of the position.

The review begins, logically, with a section on the physical properties and behaviour of ice and gives a fair summing up of the plastic versus viscous argument, now, one hopes, substantially resolved. It is pointed out that the relation between plasticity and hydrostatic pressure at the pressure melting temperature needs thorough investigation because of its bearing on the velocity distribution within a glacier. Such an investigation could presumably not be entirely experimental for one would have to consider at the same time the heat flow problem of the moving glacier. A survey of studies on crystal sizes and glacier petrofabrics is followed by a section on the various mechanisms by which glaciers may move. The title of this section, "Mechanics of glacier flow", seems unfortunate, and it would be a pity if this usage became general. Would not "mechanisms" be a better word, allowing us to keep the traditional meaning of "mechanics", that is, statics and dynamics? The mechanisms discussed are: (1) slipping on the floor, (2) slipping along large-scale discrete shear planes within the glacier, (3) the transfer of material resulting from changes of state, (4) intergranular shifting, and (5) intragranular yielding. While all these may occur to some extent the evidence points to (1) and (5) as being dominant. As regards (4), which many consider to be a strong candidate, Professor Sharp cogently remarks that if intergranular shifting is predominant in glacier ice there seems little reason why a preferred crystallographic orientation should develop, and every reason why it should be destroyed. One might suggest as an alternative that glacier ice deforms mainly by crystallographic slip on the basal plane, and that this is accompanied by a grain boundary migration which permits the crystals to maintain fairly constant shapes. But the observed crystal orientations do not support such a view. We are surely forced to put the blame either on recrystallisation from new nuclei or, perhaps to a lesser extent, on the operation of a hitherto unseen slip system.

Professor Sharp goes on to review measurements of velocity distributions in both space and time and gives useful discussions of seasonal and diurnal variations of velocity. He emphasizes the need for more study of the movement of waves and bulges through glaciers. Ogive-type bulges at the foot of icefalls, known for so long, remain as mysterious as ever.

In describing the theoretical attempts to explain the velocity distributions Professor Sharp does the best that can be done for the doctrine of extrusion flow, but can find little justification for clinging to it in face of the adverse theoretical analyses and field tests. He is sympathetic to the present writer's ideas on glacier flow although, as he says, they need further examination, analysis and test. It might be added that these calculations can only deal as yet with differential motion within the ice. This is really only one half of the problem. We still lack any convincing analysis of the other major part of glacier motion, namely slipping on the floor.

J. F. NYE

COURS DE GÉOMORPHOLOGIE. DEUXIEME PARTIE: GÉOMORPHOLOGIE CLIMATIQUE. FASCICULE 1: LE MODELÉ DES PAYS FROIDS; 2°, LE MODELÉ GLACIAIRE ET NIVAL. JEAN TRICART *and* ANDRÉ CAILLEUX. Paris, Centre de Documentation Universitaire, [1953]. iv, 408 pages, 144 text-figures.

THIS volume deals with the general aspects of glacier study and glacial geology. A brief history of the study of glaciers and the development of the science of glaciology precedes an account of the

distribution of present day glaciers in terms of the alimentation-ablation balance. The remainder of the first chapter is devoted to the classification of glaciers mainly from the point of view of the geomorphologist. The second chapter outlines the methods available for the determination of the age of Quaternary glacial deposits and summarizes the chronology and extent of Quaternary and earlier glaciations. The final part of this chapter briefly describes the hypotheses developed to explain the climatic changes of the Quaternary period.

The second part of the book (Chapter III) is more directly concerned with the study of snow and ice. The changes that occur in the transformation of snow to ice are described, but little attempt is made to explain the mechanism of the process. By way of introduction to the mechanism of glacier movement, numerous observations on the velocity of glaciers (mostly temperate) are given, and brief mention is made of the properties of ice as determined in the laboratory. The authors note that some 80 theories have been evolved to explain the movement of glaciers, but consider that most are marred by two serious errors:

(1) The extrapolation of laboratory results without sufficient understanding of natural conditions.

(2) Incorrect extrapolation from oversimplified hypotheses.

The hypotheses of Demorest, Nye, Finsterwalder and Haefeli are outlined, but without comment. This part of the book is completed by a review of the theories of glacial erosion and their modification in relation to the development of land forms. The "ultra-glacial" theory, developed towards the end of the nineteenth century, claimed that moving ice was a sufficiently powerful erosive agent for the ultimate land form to be independent of the pre-glacial one. At the opposite extreme was the "anti-glacial" theory developed by Heim, Freshfield and others, that the glaciers acted as protective agents and prevented erosion. A more modern form of this extreme view has supposed that glaciers were capable of acting in the manner of a bulldozer and removing loose surface material. Current morphological opinion would seem to steer a moderate course between these extremes.

The third and largest part (Chaps. IV, V & VI) of this volume deals with the development of those land forms attributable to the action of snow and ice. The problem of cirque formation is dealt with at some length, the older ideas being dismissed in favour of those of W. V. Lewis.

While of considerable interest to the geologist and the geomorphologist the bulk of this part and the whole of the last part (Chaps. VII & VIII), which deals with the indirect consequences of glaciation, would seem to be beyond the scope of glaciology.

The authors have covered a great deal in a comparatively small space and have succeeded in putting forward many points of view, albeit somewhat briefly. The bibliography of some 500 references appears to be well chosen and provides ample material for further study.

It is unfortunate that the quality of production of this book is so poor; line drawings of photographs have suffered especially.

D. W. HUMPHRIES

GEOGRAPHY OF THE NORTHLANDS. *Edited by* GEORGE T. KIMBLE *and* DOROTHY GOOD. (American Geographical Society Special Publication No. 32.) New York, The American Geographical Society *and* John Wiley & Sons, Inc.; London, Chapman and Hall, Ltd., 1955. 534 pages, 43 text-figures, 75 plates, map. Price £4 4*s*. 0*d*.

THE very comprehensiveness of this book forces it to deal in a general manner with its vast subject. There are thirteen chapters on such varying subjects as physiography, weather, biogeography, aboriginal and immigrant populations, economy, transport, and strategic aspects. In addition there