

After guns, powder, and shot, brandy was what the Indians wished most, plus some blue cloth, kettles, and fine feathers and beads. Unfortunately only one trade goods indent is included in the book but this is enlightening, as well as the fact (p. 164) that a silk handkerchief was worth 1½ beavers.

Several biographies conclude the book, including those of Knight who grew old in the service, and finally perished on a northern voyage in search of minerals; Kelsey his rival, but not Norton who, like many others, was a good linguist, but had little knowledge of building when he was charged with construction of the biggest British Fort in North America (Fort Prince of Wales, Churchill).

And one very definite success story: John Fullartine who started with the Company in 1683 at £6 per annum, was at Albany when the French captured it 3 years later, but repulsed them in 1709 when he was manager. Two years later he was on the Committee and a shareholder, and died in 1738 holding £2000 of stock paying a solid 10 per cent per annum.

The volume is well designed, arranged, and indexed, but one can criticise it seriously on the lack of any map whatsoever. Your reviewer is fairly familiar with the geography of southern Hudson Bay, but the average reader must be totally lost when reading descriptions of the moves of York Factory, or where ships were wrecked or had to winter. Why cannot historians learn a little geography?

P. D. BAIRD

TRAITÉ DE GLACIOLOGIE, TOME II: GLACIERS—VARIATIONS DU CLIMAT — SOLS GELÉS. By LOUIS LLIBOUTRY. Paris: Masson & Cie. 1965. 10 x 7½ inches, 612 pages (429-1040), 224 figures, numerous pictures, 40 plates. 190 f.

The second volume of this monumental text on glaciology has followed the first one (reviewed in *Arctic* 18:202-3) within a very short time. It deals with glaciers, their distribution and behaviour, and with frozen ground, and treats a very wide range of questions connected, occasionally even rather loosely, with the occurrence of ice on earth. The volume shows again the very wide knowledge of the author and is very up-to-date covering the literature to the middle of 1965. The author's claim that this will be the last Handbook of Glaciology written by one author, is probably true. It is unfortunate that in this volume too a great number of publications are mentioned, discussed, or contradicted which are not found

in the extensive references which accompany each chapter. This makes it difficult for the student of the book to weigh the author's opinions independently.

The volume starts in Chapter XII with a description of the principal qualities of glaciers, of their zones of accumulation and ablation, of their mass economy and their motions. Chapter XIII deals with the extent of the present glacierisation, aided by impressive photographs and by some maps.

The geophysical methods used in the study of glaciers, surveying, drilling, and particularly the determination of ice thickness and stratification are described in Chapter XIV which stresses the seismic and the quite recent radar methods. Chapter XV treats in considerable detail the behaviour of glacier ice as a viscous-plastic body starting with Bye's theory and proceeding to more general cases. In this connection the different types of crevasses and deformations of the ice are discussed.

Chapter XVI deals with the ice motion at the surface and at depth. Particular attention is given to the problem of gliding at the bottom; this part contains much original work by the author. In this case actual observations are almost completely missing, and different models of bottom motion, by pressure melting and refreezing, by plastic yield, and by over-riding of depressions are considered. The stationary glacier flow can be disturbed by the formation of waves which move with a speed that exceeds the mean motion of the ice. Their theory is developed. Glaciers might get into an unstable state and might then expand for several kilometres in a few months. Such conditions can also lead to falls of great masses of ice and to the formation and sometimes the catastrophic outbreaks of water bodies stored at the side of or inside a glacier.

The motion of glaciers causes accumulation and erosion of rock material. The author stresses in Chapter XVII the physical processes that come into play. But the conditions of removal and deposition are too complicated for numerical treatment, and he has to restrict himself to a description of the processes and phenomena.

In Chapter XVIII, first the changes of glacier extent in historical times are given. This is followed by a detailed mathematical treatment of the variations that a glacier undergoes under the influence of changes in its mass economy, according to the older theories of De Marchi and Sebastian Finsterwalder and the modern ones of Nye, Weertman, and of the author himself. Chapter XIX deals with

the motion and the development of ice sheets. The theoretical treatment establishes equations for the mean motion of ice sheets with melting point at the bottom, for those with a finite lower layer at melting point, and for those below freezing point throughout. Lliboutry then derives the profiles such ice sheets would have under stationary conditions, and he deals, in a mathematical way, with the time they would take to form and to disappear. He then discusses the changes of the surface level which result from variations of the level of equilibrium between accumulation and ablation. He finds two possible states of an ice sheet, a stable one and an unstable one. Changes of climate act differently upon the two types. Using extensive theoretical treatment the author deals in this chapter also with the rise of the land after the disappearance of ice sheets.

This leads to a discussion, in Chapter XX, of the climatic variations responsible for the origin and disappearance of ice formations on earth. Starting with modern times, present changes of glaciers are related to changes in the general circulation of the atmosphere. Then the methods applicable to earlier times, archeology, pollen analysis, etc. are discussed. Chapter XXI describes the ice sheets of the Quaternary, their chronology and their influence upon variations of the level of the ocean. It then deals with the possible causes of their formation and with the feed-back and self-squashing mechanisms in connection with changes in climate and ocean that might have influenced the history of former ice bodies. Evidently the treatment of the enormous field of the quaternary ice age can only be cursory;

but for this part other detailed books are available.

In the concluding chapters Lliboutry deals with frozen ground, particularly with the permafrost conditions. Chapter XXII treats the penetration of frost into the ground, the distribution of permafrost, the presence of water in the soil, the physics of the freezing of water in different soil types and finally the mechanical properties of frozen soil. This leads in Chapter XXIII to a discussion of the forces displayed in the soil by freezing, and to the description and explanation of the special soil formations that characterise the regions with frozen soil. Finally the influence of frozen soil upon the construction and maintenance of roads and buildings is described.

The second volume confirms the impressions gained from the first. The book represents a most comprehensive and very competent discussion of the phenomena connected with the occurrence of ice on earth. It is clearly written, excellently edited and very nicely illustrated. Written by a physicist and putting the emphasis, wherever possible, upon the geophysical aspects of the subject, it forms a welcome counterpart to the more descriptive books by V. Klebelsberg, Flint, Charlesworth, and Doldstedt. It shows that glaciology, as meteorology and oceanography before, is on the way to being detached from physiography and becoming a special branch of geophysics. The author is to be congratulated on the successful completion of the laborious singlehanded work on this important publication.

F. LOEWE\*

\*Institute of Polar Studies, Ohio State University.