growth. A diameter of 6 in. (15·3 cm.) appears to be the maximum limit for spheroidal polsters; many of the larger ones were broken or eroded. A size limit may be imposed by tensile strength of moss stems.

Specimens were sent to Professor W. C. Steere, Stanford University, who identified five species, *Ditrichum flexicaule*, *Andreaea rupestris*, *Pohlia nutans*, *Ceratodon purpureus*, and *Polytrichum juniperinum*. In ordinary habitats the last four of these form a loose mass, whereas *Ditrichum* tends to form compact, close-meshed polsters and is thus a primary factor in the formation of spheroidal bodies.

Internally, both types of polsters have poorly defined cores about one-quarter to one-half inch (0·6–1·3 cm.) in diameter, composed of intermixed dead moss and sandy silt. Concentric layers of moss and enmeshed mineral matrix are discernible either partially or completely enveloping the core. Variations in layer thickness and lack of definite boundaries between layers indicate absence of distinctly cyclic accretion. The included mineral matter is poorly sorted, with grains ranging from clay sizes up to one-quarter inch, although particles of silt and very fine sand are dominant.

Polsters develop from a young plant in the vegetative phase or from a fragment of an older plant. Once a *Ditrichum* plant, or colony, assumes a polster-like form, presumably through normal branching, conditions on the melting surface of a glacier favor development of a spheroidal mass. No material on the surface is sufficiently stable to serve as a substrate; instead, each polster is jostled about and alternately washed by flowing melt water charged with fine rock debris, rolled along melt water streams, tumbled down oversteepened ablation slopes, and slowly rotated as it melts into the ice surface. Fine-grained mineral matter is trapped among the minute surficial leaves. Continued movement molds the spheroidal shape and encourages nearly equal growth on all sides. Mosses temporarily on the underside would conceivably obtain sufficient reflected light for continued photosynthesis.

As mosses are capable of surviving relatively long periods of drought and of reviving to full growth activity within a few hours with light and water available, freezing temperatures or temporary stranding on dry surfaces merely suspends growth.

Moss polsters on Matanuska Glacier furnish an extreme example of plants adapted for, and, in a sense, a product of changing habitat conditions. The growth form, especially of *Ditrichum*, and ability to survive periods of drought, make growth of these mosses possible on the melting glacier surface, where the substrate is too unstable to allow normal plant colonization unless plants can carry with them in their mobile environment a soil-like substrate.

Dr. Eythórsson pointed out that his jökla mýs are contrary to the adage about rolling stones gathering no moss. I would bring to the Editor's attention that the related jökla mýs of Alaska indicate a further paradox—rolling moss does gather stones!

United States Geological Survey,
Washington 25, *D.C.*
24 *May* 1954

WILLIAM S. BENNINGHOFF

REVIEW

DAS EISZEITALTER. PAUL WOLDSTEDT. Grundlinien einer Geologie des Quartärs. Erster Band: Die allgemeinen Erscheinungen des Eiszeitalters. Second edition. Stuttgart, F. Enke Verlag, 1954. VII+374 pages, 136 illustrations, 4 tables.

THIS book provides an excellent summary of recent literature on glaciation and the Quaternary Ice Age. As the author points out in his preface, this volume is limited to general works; it is to be followed by a second giving the regional Quaternary geology of the whole earth—truly a formidable undertaking.

The first chapter is introductory, in both the historical and geological sense, the latter covering the developments of Tertiary fauna, flora and climate which led up to the Ice Age. Following the International Geological Congress of 1948, the beginning of the Pleistocene is placed, rather

vaguely, at the level where first signs of a marked cooling appeared. The next four chapters deal with existing glaciers and ice sheets, height of snow line, structure of firn and glaciers, rate and nature of flow including extrusion flow (which is by no means generally accepted), ablation, erratics and moraines. The maintenance of the Greenland ice sheet is attributed mainly to rime, with heavy snow in the relatively warm air of the occasional cyclones which are not deflected by the ice. An analysis of the Antarctic sheet leads to the conclusion that it is larger than is warranted by the present climate. Periglacial effects and the forms of glacial erosion are fully described and illustrated.

The remaining twelve chapters deal with the Quaternary Ice Age. First the various types of glacial and periglacial deposits are described and illustrated, including loess and dune formation. These are well done, but the treatment of interglacial and interstadial formations is disappointingly brief, as also is the chapter on duration and correlation. The biological history of the Quaternary is treated in some detail—fauna and flora, man and his cultures. In view of recent developments it is interesting to note that the author was obviously doubtful about the Piltdown skull. The chapter on movements of the Earth's crust is of considerable interest. The variations of sea level pose an interesting problem, the oscillations due to locking-up and freeing of water in the ice sheets being superposed on a steady fall of over 150 m. from the Calabrian to the present. As the melting of all existing ice would only raise sea level by 60 m. at most, this retreat can only have been due to deepening of the ocean basins.

The chapter on the climate of the Ice Age includes a useful review of recent German work on the Quaternary climate of Europe, which is beginning to lead to a real understanding of the meteorology of that difficult period. The problem of reconciling weakened solar radiation with the fact that the greatest cooling was in northern latitudes outside the tropics is met by invoking increased cyclonic activity in the early stages of the glaciations, due to oceanic temperatures relatively high compared with the land. The final chapter, however, on the causes of ice ages, merely describes some of the innumerable theories which have been put forward, without any attempt at a synthesis.

The reference value of the book is enhanced by the bibliography, which occupies 18 pages or roughly 500 entries. These are of course only a selection, made as a guide to further reading, but apart from the rather great preponderance of German works, the selection appears to have been made with good judgement.

C. E. P. BROOKS

SNOW CRYSTALS. UKICHIRO NAKAYA.

THIS book, noted in the last issue of this *Journal* as published by the Harvard University Press, is now also published in Great Britain by Geoffrey Cumberlege, Oxford University Press, at £4 net.

GLACIOLOGICAL LITERATURE

THIS bi-annual list of glaciological literature aims to cover the *scientific* aspects of snow and ice in all parts of the world. Attention is drawn to the bibliographies in each number of the *Polar Record* (Cambridge), which aim to cover the significant work dealing with expeditions, research, equipment and conditions of living in the Polar regions. Both journals, however, deal with Polar literature having specific glaciological interest and with general matters of a practical nature such as snowcraft.

Readers will greatly assist the Editor by notifying him of their own, or any other, publication of glaciological interest.

AHLMANN, H. W: SON. Glaciärer och klimat i Norden under de senaste tusentalen år. *Norsk Geografisk Tidsskrift*, Bd. 13, Ht. 3–8, 1951–52 [pub. 1953], p. 56–75. [Climate in northern regions during last thousands of years and its effects, especially on glaciers.]

ANTEVS, E. Climate of New Mexico during the last glacio-pluvial. *Journal of Geology*, Vol. 62, No. 2, 1954, p. 181–91. [Cary glaciation in New Mexico resulted from heavier snowfall with a lower mean June–September temperature.]

ARAKAWA, H. Fujiwhara on five centuries of freezing dates of Lake Suwa in central Japan. *Archiv für Meteorologie, Geophysik und Bioklimatologie*, Serie B, Bd. 6, Ht. 1–2, 1954, p. 152–66. [Description of Lake Suwa and table of freezing dates from 1443 A.D. to present day.]

BALL, F. K. Dirt polygons on snow. *Weather*, Vol. 9, No. 10, 1954, p. 322–23. [Polygons observed with no dirt: possible explanation.]