($\rho g d + p_0$) producing the "Orowan spreading" of the material just above the depth d exceeds the horizontal compressive stress (p_0) by $\rho g d$. The rate of vertical compression so produced must equal the rate of longitudinal spreading (constancy of volume and plane strain), and we have seen that such a stress difference $\rho g d$ produces a strain-rate $\dot{\epsilon}$. *Thus, the "Orowan spreading" at the bottoms of the crevasses is exactly sufficient to ensure continuity with the longitudinal extension rate of the underlying layers of the glacier.* Higher up the crevasse walls the Orowan spreading is smaller, by reason of the smaller depth, and so the ice here does not extend longitudinally as fast as the underlying ice of the glacier. This is why the crevasses open up. The argument is strictly correct for very closely spaced crevasses. For a wider spacing, further analysis is necessary.

REFERENCES

1. Discussion on "The Flow of Ice and of other Solids." *Journal of Glaciology*, Vol. 1, 1949, No. 5, p. 235 and 238.
2. Nye, J. F. *Proceedings of the Royal Society*, Series A, Vol. 207, 1951, p. 554–72.
3. Glen, J. W. *Journal of Glaciology*, Vol. 2, No. 12, 1952, p. 111–14. *Nature*, Vol. 172, No. 4381, 1953, p. 721–22.

COMMENTS ON CREVASSE DEPTHS

By G. SELIGMAN

I BELIEVE that I was originally responsible for the statement that crevasses *in temperate glaciers* did not in general exceed 30 m. in depth, although Dr. Orowan, with whom I often discussed the point, no doubt based his views not on my experience but on theoretical grounds. In my paper "The structure of a temperate glacier," *Geographical Journal*, Vol. 97, No. 5, 1941, p. 301, I wrote: "I believe the great depths attributed to crevasses in the Alps are mythical. We explored many, and the greatest depth we reached was 30 m.; a crevasse said to be at least 60 m. deep proved to be no more than 25."

My subsequent observations in the Alps confirmed this assessment, but no doubt there can be exceptions, one of which Dr. Loewe has encountered.

It would be interesting to hear of actual measurements from colder regions than the Alps which could throw further light on Dr. Loewe's statement that many high ice walls in those regions must be at 0° C.

The Editor,

The Journal of Glaciology

SIR,

"Jökla mýs"

Small spheroidal, silt-packed, moss cushions, or polsters, are abundant on the terminus of Matanuska Glacier (lat. 61° N., long. 147° 41′ W.) in the Chugach Mountains of south central Alaska. In outward appearance, these resemble "jökla mýs" (glacier mice), described and named from observations and collections on Hrútárjökull, Iceland, by Dr. Jón Eythórsson (*Journal of Glaciology*, Vol. 1, No. 9, p. 503, 1951). The jökla mýs described were moss-covered stones, whereas specimens from Matanuska Glacier are concentric moss layers in which sandy silt and a few small pebbles have been incorporated during growth.

On 10 September 1950, L. L. Ray, F. C. Whitmore, Jr., A. C. Orvedal and I made a reconnaissance of the broad terminus of Matanuska Glacier. The terminus, at an altitude of approximately 1700 ft., is a gently sloping surface mantled, in places, by mounds and ridges of cobbly ablation moraine with relief as much as 50 ft. The polsters were called to my attention by Dr. Ray, who first noticed them; others of the party aided in determining their widespread occurrence.

Polsters occur on gentle slopes of bare melting ice in about the same abundance as in waters of supraglacial streams; a few were collected on patches of ablation moraine. Where they rested on exposed ice surfaces, they sometimes lay in shallow wells thawed by their insolation. There was no apparent preferred orientation of the polsters in the thaw wells.

The dominant shape is a distinctly oblate spheroid *; the shortest axis does not exceed one-half the longest, which ranges from 1 to 6 in. (2·5 to 15·3 cm.). Irregular shapes are less common and of similar size. Surfaces are firmly bound with living moss, although on spheroidal types one of the two flatter sides, usually that on which it has rested most recently, has a somewhat less luxuriant

* A photograph submitted by Dr. Benninghoff showed forms practically identical with those in the photograph which illustrated Dr. Eythórsson's letter mentioned above.—*Ed.*

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

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