REVIEWS

The Mount Everest region. 1:100,000. [London], Royal Geographical Society, [1962]. 17*s.* 6*d.*

THIS map, compiled and drawn under the supervision of Mr. G. S. Holland, in the Drawing Office of the Royal Geographical Society, and published with the assistance of the Mount Everest Foundation, covers an area of approximately 46 × 40 miles (74 × 64 km.) with Mount Everest very close to the centre.

The heights are given in feet and metres and the contours are at 100 m. intervals. Every part of the map shows the contours mainly in blue and brown, but those taken from less reliable data are given in grey.

The map has been compiled from data received from no less than twelve sources. The names follow the Survey of India spellings, as recommended by the Permanent Committee on Geographical Names, and the control of the map was based on the Survey of India triangulation with the height of Mount Everest given as 29,028 ft. (8,848 m.). No part of the map shows elevations of less than about 15,000 ft. (4,572 m.).

This map will be extremely interesting and valuable to glaciologists, showing as it does in considerable detail the large glaciers running off from the Everest *massif* in every direction.

G. SELIGMAN

A. H. LACHENBRUCH. Mechanics of thermal contraction cracks and ice-wedge polygons in permafrost. *Geological Society of America. Special Papers*, No. 70, 1962, vii, 69 p., illus.

LARGE areas of the Arctic are covered by ice-wedge polygons. Shallow troughs, spaced 10 to 100 feet apart (3–30 m.), form a conspicuous network on the ground surface. Beneath the troughs, buried in the permafrost, are generally found wedge-shaped masses of fairly clear ice, commonly some tens of feet deep and several feet wide at the top; I remember my surprise when Dr. Lachenbruch first showed them to me in an exposure near Point Barrow, Alaska.

In 1915, Leffingwell put forward a theory of the origin of ice-wedges that is now widely, but not universally, accepted. During the winter thermal contraction cracks the ground, and in early spring melt water refreezes in the new cracks. In the next winter thermal tension cracks the ground again at the same place, because the ice vein now situated there is a place of weakness. Again spring melt water refreezes in the crack, and so the process continues; an ice wedge begins to grow. Dr. Lachenbruch has set himself the task of seeing whether this idea of the origin of ice wedges is reasonable from the point of view of mechanics, having regard to what is known about the mechanical behaviour of ice and permafrost and temperature changes in the ground. He concludes that it is. Any such investigation is inevitably limited by the fact that not much is known about the mechanical properties of permafrost and dirty ice, and what is known about brittle fracture shows that its details can be rather complex. Nevertheless, a great deal can be done, as Dr. Lachenbruch's very thorough and carefully argued study shows.

He deduces from qualitative observations a set of rather stringent conditions that must be satisfied if Leffingwell's theory is to work. They relate the maximum thermal tension (which varies with depth) to the strength of the material at *two* definite levels: at the ground surface, that is, at the top of the seasonally thawed layer, and, a foot or so lower down, at the top of the permafrost itself, where the ice wedges are. He is at once able to rule out the simple idea that the frozen soil behaves purely elastically—the tensions would be far too high. More remarkably he is also able to rule out a linear visco-elastic behaviour of the frozen soil. But, with a model that combines elasticity with a non-linear viscous behaviour (strain-rate proportional to the third power of the stress), he succeeds in satisfying all the conditions. It

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appears that it is not the *change* of temperature, or mere low temperature, that cracks the ground; it is high *rates* of temperature change that do it. This is the implication of visco-elastic rather than purely elastic behaviour.

Dr. Lachenbruch goes on to consider the fracture process itself in detail. The area of stress relief due to a crack is an important factor in determining the spacing of the polygonal pattern. Here the latest developments in the elastic theory of brittle fracture are called in. To explain the details of the polygonal pattern, the angles at which the cracks meet and so on, is a general problem in the mechanics of contraction cracks; mud cracks, columnar jointing in cooling basalt, shrinkage cracks in concrete, and cracks in the glaze of ceramics are all aspects of the same problem. The theory of contraction crack patterns seems to be still in a fairly crude state, but, as this study illustrates, some principles are beginning to emerge.

This notable paper is a good example of the power of judiciously chosen simplified models to give insight into natural processes.

J. F. NYE

J. A. HEAP. *Sea ice distribution in the Antarctic between longitudes 7° W. and 92° W.* London, Admiralty. Hydrographic Department, 1963. [iii, 144, iv] p. (H.D. 542.) £12 10*s*.

THIS sea ice atlas follows Swithinbank's atlas (1960) (reviewed in *Journal of Glaciology*, Vol. 4, No. 35, 1963, p. 643–44) in the series produced at the Scott Polar Research Institute, and the method it employs is essentially similar. There are 96 frequency charts, half of them covering the waters immediately adjacent to Graham Land, and half of them the South Atlantic and South Pacific waters to east and west of the peninsula. Each pair of charts covers a period of a quarter month, or roughly a week. The main feature of presentation is that isopleths indicating the limits of ice of particular concentrations at particular times of year are not used; that method is rightly judged to be misleading, both because of the large amount of interpolation required in the present state of knowledge, and because of the dangerous tendency, encouraged by the method, to think in terms of an "average" state of the ice. Instead, sector diagrams are used, which show the ice or open water actually observed in a particular area at a particular time of year, and reflect also the number of such observations. This last point is important, as it affects the reliability of any sector diagram. If it is required to know in which years these observations were made, the ice summaries, which occupy the remaining part of the atlas, supply this information. The user must then draw his own deductions. What the atlas seeks to provide, therefore, is the same as its predecessors of this type, namely the fullest and least distorted summary of all known observations of seasonal change in the state of the ice.

This information can be used for a large number of purposes, of which the most frequent are likely to be the planning of shipping or sledging routes, and the correlation of ice data with meteorological or oceanographical data in climatological or related studies. The method used has the further advantage that new observations may be incorporated relatively easily as they come to hand. Enough information on the compilation of the atlas is given in the one page of explanatory matter for the user himself to be able to recalculate the contents of a given sector diagram after adding, say, five years' new observations. The whole atlas could, and it is to be hoped will, be brought up to date every decade or so.

The atlas is the first application of the sector diagram method to southern waters. The area selected is probably the only one for which there were enough data when the work was started in 1955, Graham Land waters being the most frequented part of the Southern Ocean. The sources consulted, listed chronologically on four pages at the end of the atlas, fall into three groups: ships' logs, ice reports from shore stations, and (the smallest group) published accounts. Heap covers the period from 1898 to 1961, but probably three-quarters of his data relate to the last seventeen years of this. The volume of data will continue to increase,

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