M. MELLOR, *ed. Antarctic snow and ice studies*. Washington, D.C., American Geophysical Union, 1964. xi, 277 p., illus., maps. (Antarctic Research Series, Vol. 2.) $12.

IN *Antarctic snow and ice studies* we find at last a collection of comprehensive and critical papers based on the impressive glaciological programme being carried out by scientists of the United States in the Antarctic. Some of the earlier reports from the United States, which were intended primarily to ensure full and free circulation of results of the International Geophysical Year, contained many tables of figures but little critical discussion. People may have wondered if a critical appraisal of the results of U.S. work on Antarctic glaciology would be made. Glaciologists were aware that such appraisals had been made in scattered papers in geophysical journals and in cheaply produced series such as the World Data Center A *IGY Glaciological Report Series* and the *Research Report Series* of the Geophysical and Polar Research Center of the University of Wisconsin. Now in the Antarctic Research Series, published with the aid of a grant from the National Science Foundation, work of the United States programme on Antarctic glaciology is presented as a volume.

The stated policy of the Antarctic Research Series is to present authoritative work with uniformly high scientific and editorial standards, and the aim has been fulfilled in this volume. The subjects covered in it may be described as general glaciology. Several papers deal with accumulation studies. Aspects of ice temperature studies are mentioned in two papers. Other topics covered include ice movement and strain-rate measurements in particular areas, ice crystal fabrics in relation to structure, firn densification and the particulate content of firn. The emphasis in all papers is on the clarity of presentation, on the errors of measured quantities and on the probable accuracy of interpretation. The way in which these factors are made clear in each paper, so that the reader can judge their reliability for himself, suggests that much credit must go to the editor for his guidance, as well as to the contributors.

The first paper, by R. L. Cameron, deals with studies near Wilkes station. One may not agree with the statement in the abstract that "The main aim of this work was to determine the mass balance of the margin of the ice sheet, because the state of this ice reflects the condition of the entire ice sheet". What Cameron has done is to draw, on the basis of his own and other glaciologists' work in this area, an effective picture of the mass balance in the area in which data on accumulation, strain rates, ice movement, temperature distribution and glacial geology are brought together. The resultant picture is of an ice mass not far off equilibrium with a slight retreat taking place at present.

The second paper, by H. Shimizu, deals with traverse and station studies in West Antarctica. He presents a useful discussion of seasonal factors controlling grain size in the firn, and of the types of snow crystals occurring in the winter precipitation at "Byrd" station. The discussion on factors controlling the 10 m. ice temperature distribution are less convincing—for example the evidence that there is little latitudinal control on the 10 m. temperatures of the Ross Ice Shelf region leads to the conclusion that "the temperature on the ice shelf is affected by sea water beneath". For his general discussion of 10 m. temperatures, he uses the "sea-level temperature" derived from 10 m. temperature by assuming a lapse rate of 0·65°C. per 100 m. elevation. Since he also shows the mean change of 10 m. temperature with altitude is 0·82°C. per 100 m., it is not surprising that he finds that the deviation of his "sea-level temperatures" from those found by extrapolating sea-level data to lat. 90° S. appear to be closely related to altitude.

The next three papers deal with work carried out by University of Michigan expeditions on the Ross Ice Shelf initiated by J. H. Zumberge and later continued under the direction of C. W. M. Swithinbank. The paper by W. Hofmann, E. Dorrer and K. Nottarp on the Ross Ice Shelf Survey, 1962–63, describes a highly accurate method of position fixing across the northern end of the ice shelf by means of distance measurement by tellurometer and angle measurement by theodolite, starting from a fixed point on Ross Island. The major errors are

due to the movement of the ice shelf during the two-month period of the survey. A repeat survey will be necessary for accurate measurements of movement, but in his paper Zumberge estimates movement from comparison of solar fixes in late 1958 by Dawson with Hofmann's results. It would have been informative if position fixes by Swithinbank in the 1959–60 season had been presented as a further indication of accuracy. Movements were estimated as about 800 and 1,500 m. per year on the eastern and western parts of the ice shelf respectively. The more important section of Zumberge's paper deals with strain-rates determined from strain stake rosettes established during the 1959–60 traverse and remeasured during the 1962–63 traverse. A careful evaluation of data, coupled with estimated velocities and rates of thinning based on Crary's ice thickness measurements, suggests that bottom melting becomes negligible about 100 km. inland from the ice front, and bottom freezing occurs further south. In the third paper, J. A. Heap and A. S. Rundle analyse some 2,000 accumulation stake measurements over the same route and period as the strain-rate measurements, plus stratigraphic studies in 31 pits. The pattern of variation about a mean accumulation of $14 \cdot 4$ g. cm.$^{-2}$ over the years 1960 to 1962 is shown.

In discussing "The drainage systems of Antarctica: accumulation" M. B. Giovinetto divides the continent into ten main drainage areas, and relates the measurements of accumulation to the total ice mass in each area to get an idea of the time for 100 per cent mass exchange or, more accurately, the time it would take for the present rate of accumulation to deposit ice equal to the present ice mass in each area. Giovinetto has made a valuable estimate of the total accumulation over Antarctica, and of the errors in this figure. He gives the total as $2 \cdot 1 \pm 0 \cdot 4 \times 10^{18}$ g. cm.$^{-2}$ yr.$^{-1}$. Although one may query his low figure for accumulation in his zone BC, the whole work represents a very useful assessment of Antarctic accumulation. Detailed accumulation studies based on pit stratigraphy along the line from "Byrd" station to Whitmore Mountains are presented in a subsequent paper by R. M. Koerner, who gives an average value for six stations of $13 \cdot 5$ g. cm.$^{-2}$ yr.$^{-1}$ which he believes to be reliable as the individual average accumulations fall within a range of $1 \cdot 6$ g. cm.$^{-2}$ yr.$^{-1}$. An interesting photograph in Koerner's paper is interpreted as indicating a recent rise in the level of the ice alongside Mount Chapman, where holes in the rock eroded by snow drift are seen to continue below the snow surface; their greatest height above the surface (35 m.) is considered to represent the maximum height of the corrasive effect of drifting snow.

K. Kojima deals with the densification of snow in Antarctica, and makes use of all the U.S. traverse measurements of density by direct observation (excluding values derived from seismic measurements). His observations are tied in with the theory of snow densification at low temperatures.

J. R. Reid, Jr., deals with the structural glaciology of an ice layer in a firn fold on the Ross Ice Shelf. He presents data on the relation of crystal orientation to the general structure of the Ice Shelf in the area and to the measured horizontal strain-rates. He finds that stress-induced recrystallization has occurred near the surface within one year in the disturbed area in which he was working, and that a crystal fabric pattern with four maxima centred about the pole to the theoretical shear plane is not explicable by recrystallization from a single maximum fabric as postulated by others. The reason for the four pole pattern is not known.

The final paper by L. D. Taylor and J. Gliozzi presents a study of the distribution of particulate matter in a firn core from "Eights" station. A technique of electronic analysis using a Coulter counter is described; this is rapid compared with previous counting methods and appears to offer scope for future studies on a wider scale. Large fluctuations in particle count with depth suggest a cycle of deposition of approximately two years, judging from other stratigraphic evidence. The paper makes one desire more evidence from the further studies which are now being pursued.

The printing and editing are first class. One can point out that "comprehensive strain" should have been "compressive strain" on p. 29 and that on p. 257 a depth quoted from

Schytt's work should have been 80 rather than 180 m., but such errors are few. The provision of foreign language abstracts would doubtless have been useful, as this is a work that should be studied widely. The general impression left by the volume is to hope that more of the important work done by U.S. scientists such as A. P. Crary and C. R. Bentley can appear in this series, so that it may become the permanent and effective record of U.S. studies of Antarctic glaciology. This can only happen if constant vigilance is maintained by the editors. If they maintain the initial standard, an extremely valuable series will become widely known.

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https://doi.org/10.3189/S0022143000018785 Published online by Cambridge University Press