

## REVIEWS

A. P. CRARY, ed. *Antarctic snow and ice studies II*. Washington, D.C., American Geophysical Union, 1971. ix, 412 p., illus., maps. (Antarctic Research Series, Vol. 16.) \$24.

*Antarctic snow and ice studies [I]* (Antarctic Research Series, Vol. 2) appeared in 1964. It dealt mainly with conventional glaciological studies of accumulation, movement, strain and mass balance (see *Journal of Glaciology*, Vol. 5, No. 41, 1965, p. 756–58 for review). Two-thirds of *Antarctic snow and ice studies II* are devoted to geophysical and geochemical studies, and to review the volume properly requires careful study of some specialized papers. The reviewer apologises for delay, but a cursory review of such papers would add little to the publisher's fly-sheets.

The geophysical papers fall into two broad headings. Comprehensive reports of oversnow traverse results are given for the Marie Byrd Land traverses of 1959 and 1960 (Bentley and Chang) and for the Dronning Maud Land traverses I and II of 1964–65 and 1965–66 (Beitzel). These present an admirably concise account of the methods and main features of the results of seismic shooting, gravity, altimetry, magnetometry and electromagnetic (radio echo) soundings. Detailed tabulations of results are given together with photographic reproductions of one seismic record for each seismic shooting station. Publication of such records, although expensive, is something that should have been done for all major oversnow traverses over the high Antarctic plateau since the reliability of a number of bedrock reflections has been questioned subsequently. Although the originals must be clearer than the reproductions shown at reduced scale in this volume, clear bedrock reflections are seen at practically all Marie Byrd Land stations and for most stations of the Dronning Maud Land traverses. Comparison with the radio echo soundings on the Dronning Maud Land II traverse also helps here, although Figure 2 could have shown the comparisons more clearly. However, the radio echo profiles of bedrock are shown separately in some detail in order to discuss the relationship between surface slopes, longitudinal stresses and bedrock profiles, which as reported in an earlier paper, fit the more recent theories. Various questions also crop up in Marie Byrd Land, of which the negative gravity anomaly around lat.  $79^{\circ}$  S., long.  $135^{\circ}$  W., makes the reviewer wonder whether it is a tectonic feature or due to a recent rapid thinning of ice. A chapter on the gravity field around Anvers Island adds to our knowledge of the Earth's main field, while the increase of gravity at the South Pole of  $1.0 \pm 0.1$  milligal in 10 years can be explained with the ice sheet in a steady state. There is a useful discussion of the velocity of radio-waves in ice, but it must be admitted that we are still in the stage of measuring and confirming the broad features governing these velocities, rather than getting down to the fine detail. This is not the case in relation to seismic waves.

In a lengthy chapter on seismic anisotropy in western Antarctica, Bentley shows convincingly that much evidence for this anisotropy exists. This chapter takes the analysis and discussion of seismic wave velocities in polar ice sheets much further than any previous analysis. While evidence is given of a marked variation of the density at a constant depth along one profile, one would have liked more discussion of whether the various velocity boundaries were parallel to the surface. One important conclusion is that as one moves toward the faster flowing ice away from outflow centres, the mean inclination of the ice crystal  $c$ -axes tilts increasingly away from the vertical in the flow plane. This is an interpretation of seismic shooting results: possible glaciological reasons for this are not discussed. Nevertheless the results are significant in relation to our knowledge of the dynamics of polar ice sheets, and appear to warrant an effort to recover an ice core from a suitable location to test their validity.

Another chapter by Bentley discusses the low-amplitude seismic echo observed in western Antarctica that appears to come from a horizon a few hundred metres above bedrock. The conclusion is that some early arrivals can only be explained by moraine in the ice, a few could



be due to physical horizons of temperature or changes of crystal orientation in pure ice, and many observations could be due to either. One is still left with an uncertain feeling about the answer—even to wondering if our understanding of wave propagation is adequate. In any case, the evidence is produced and discussed from various angles in admirable detail.

After the geophysical chapters come the sections that carry on the theme of *Antarctic snow and ice studies* [I] for later traverses. Taylor presents results from the South Pole traverse of 1962–63, Koerner for the Dronning Maud Land II traverse, Rundle for the Dronning Maud Land III traverse, while Cameron and Benson report on further work at “Byrd” station during 1961–65. Benson’s work includes a useful comparison with firn structure and parameters in Greenland. The benefits of the experience gained by many Antarctic glaciologists over the previous five to ten years are apparent in the quality of the observations and skill of the observers.

Major developments in the stratigraphic field, which provide basic reference data for the other studies on the high plateau, come from the work of Picciotto, Crozaz and De Breuck, whose studies covered the three Dronning Maud Land traverses. They have collected ice core samples to depths of 2 to 2.6 m for laboratory studies in Belgium. Their major work has been the determination of the level of the surge in  $\beta$  activity which took place in 1954–55 and forms a valuable reference horizon. They have also used the fall-off in activity of lead-210 with depth at a few stations. The methods and details of results are presented clearly. All Antarctic glaciologists are clearly indebted to these workers for applying the skills of the geochemists to the difficult problems of establishing the precipitation over central Antarctica. Their results are completely convincing and show the arid nature of this region.

A short chapter by Hamilton and O’Kelley on particulate matter in Antarctic firn presents results of considerable interest to environmentalists. They discuss the variations with time of deposition of both the insoluble and soluble impurities. The cleanest ice found from a limited number of samples was that deposited around A.D. 600 near “Byrd” station. Some results on the effect of altitude and continentality are also included. It is clearly desirable that more studies of this type should be made, as glaciologists have an outstanding opportunity to provide data of wide interest to the scientific and general community on the variations of atmospheric contamination over past centuries and millennia.

The last paper gives a useful account of the glacial geology of the Victoria Valley system by Calkin. This is a border-line topic for snow and ice studies, but it should remind the straight glaciologists of the relevance of their studies to geology and geomorphology.

The volume provides an admirable record of the application of sophisticated techniques to Antarctic glaciology during the 1960’s and contains a wealth of information on many aspects of U.S. glaciological activities in the Antarctic during this period. Cray’s influence is apparent not only through his effective editing of the volume, but also through his over-all guidance to the projects as Chief Scientist of the United States Antarctic Research Program for much of the decade.

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A. [S.] POST and E. R. LACHAPELLE. *Glacier ice*. Seattle, The Mountaineers; Seattle and London, University of Washington Press, [c1971]. [xiv], 110 p., illus. \$20, £9.50.

ON the international glaciological market Austin Post’s name has become well known during the last ten years and associated with the most magnificent photographs of glacier surges. So it is no surprise that a glacier picture atlas, meeting the highest possible requirements, has now been published. And it is no surprise that Post has joined forces with E. R. LaChapelle, who has contributed a great number of the ground photographs necessary for the proper