SNOW SURFACE ELEVATION IN THE FILCHNER ICE SHELF AREA, ANTARCTICA

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ABSTRACT. Altimeter observations made on flights during the austral summer 1963–64 in the vicinity of the Filchner Ice Shelf have allowed the construction of a new topographic map of the snow surface in that area. The ice stream flowing into the ice shelf from the polar plateau is more clearly defined. A previously shown connection from Berkner Island to the grounded ice to the west-south-west appears not to exist. The mass flux from the drainage basin on the polar plateau can be accounted for by a reasonable ice-shelf flow rate. The area of the ice shelf shown on the map is $0{\cdot}43 \times 10^6$ km.^{2}.

RÉSUMÉ. *Altitude de la surface de la neige dans la région du Filchner Ice Shelf, Antarctique.* Des observations altimétriques faites au cours de vols pendant l'été austral 1963–64 dans la région du Filchner Ice Shelf ont permis la construction d'une nouvelle carte topographique de la surface de la neige. Le fleuve de glace qui se jette dans le ice shelf à partir du plateau polaire est défini plus clairement. La connexion déjà signalée de Berkner Island à la glace reposant sur le fond vers le ouest-sud-ouest n'existe pas. Le flux de masse du bassin de drainage du plateau polaire peut être estimé par une vitesse d'écoulement raisonnable de l'ice shelf. La surface de l'ice shelf de la carte est de $0{,}43 \times 10^6$ km^2.

ZUSAMMENFASSUNG. *Die Höhe der Schneeoberfläche im Gebiet des Filchner Ice Shelf, Antarktis.* Radar-Altimeter-Beobachtungen bei Flügen in der Umgebung des Filchner Ice Shelf während des Süd-Sommers 1963/64 ermöglichten die Zeichnung einer neuen topographischen Karte der Schneeoberfläche in diesem Gebiet. Der Eisstrom, der dem Eisschelf aus dem Pol-Plateau zufliesst, wurde schärfer erfasst. Eine früher angenommene Verbindung zwischen dem Berkner Island und dem auf dem Untergrund aufsitzenden Eis im West-Südwesten scheint nicht zu bestehen. Der Massenzufluss aus dem Einzugsgebiet am Pol-Plateau kann durch eine vernünftige Fliessgeschwindigkeit des Schelfeises kompensiert werden. Auf der Karte ist ein Gebiet von 430 000 km^2 des Eisschelfes dargestellt.

INTRODUCTION

During the austral summer of 1963–64, personnel of the University of Wisconsin carried out a program of aeromagnetic observations in Antarctica (Behrendt, 1964[b]). In the course of this work barometric and radio-altimeter observations were made at approximately 15 km. intervals, or closer over steep surface slopes, which enabled calculation of snow surface elevation along the flight lines. The radio-altimeter used operated at 4,300 Mc./sec. so snow penetration was negligible. Oversnow traverse tracks were used as control where crossed. As several of these flights were in the relatively little known Filchner Ice Shelf area they enabled an improved surface elevation map to be drawn.

Data from the following oversnow traverses in the area were also used: Sentinel traverse, 1957–58 (Bentley and Ostenso, 1961), Ellsworth–"Byrd" traverse, 1958–59 (personal communication from E. A. Bradley), Filchner Ice Shelf traverse, 1957–58 (Behrendt, 1962[b]), Commonwealth Trans-Antarctic Expedition, 1957–58 (Pratt, 1960), Ellsworth Highland traverse, 1960–61 (personal communication from C. R. Bentley), Antarctic Peninsula traverse, 1961–62 (Behrendt, 1964[a]), "Byrd"–Pole traverse, 1960–61 (personal communication from F. L. Dowling) and the 1963–64 "Byrd station" traverse (personal communication from M. Hochstein). In addition surface elevation data were used from the 1960–61 aeromagnetic flights (Behrendt and Wold, 1963). The oversnow traverse elevations are accurate for the most part to ± 50 m. The adjusted elevations along the flight lines are believed accurate to about ± 100 m., although they are probably better over the ice shelf itself.

DISCUSSION

Figure 1 is the snow surface elevation map. Several features shown warrant some discussion. The ice stream draining a large part of the polar plateau is indicated by the contours in the area south of lat. 85° S. between long. 60° and 100° W. These contours are not as steep in one location as those shown by Behrendt and others (1962). An error was found in one of the flight lines used in that map; these data were not used here.

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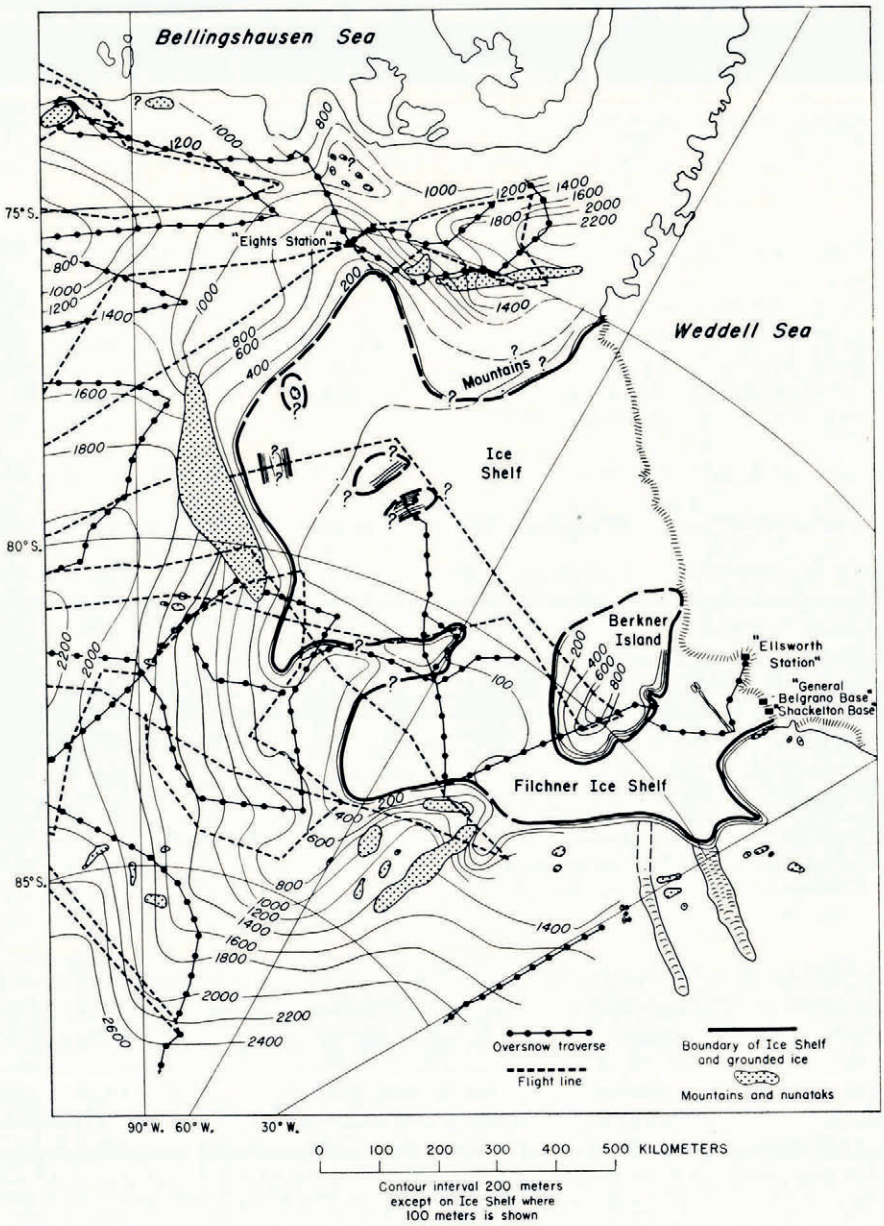

Fig. 1. Snow surface elevation map of the Filchner Ice Shelf area of Antarctica. Elevation data are spaced for the most part at about 6 km. intervals on oversnow traverses and at about 15 km. on flight lines

Behrendt (1962[a]) postulated the existence of this ice stream on the basis of the mass discharge of the Filchner Ice Shelf, and calculated that about 100×10^{15} g. $yr.^{-1}$ of mass flowed out of the section of the ice front between Berkner Island and the coast to the east. Giovinetto (1964), in a discussion of the ice drainage basins of Antarctica, calculated that the mass output in the eastern part of the Filchner Ice Shelf drainage system should amount to

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about 200×10^{15} g. yr.$^{-1}$ from a determination of the mass input in the entire system. The difference of 100×10^{15} g. yr.$^{-1}$ was greater than the observational errors would allow, even neglecting bottom melting beneath the ice shelf. Both authors assumed that the bulk of the drainage from the polar plateau was through the section east of Berkner Island, based on the map of the Filchner Ice Shelf available following the 1957–58 Filchner Ice Shelf traverse (Neuburg and others, 1959). This traverse party, of which the author was a member, projected the grounded ice feature crossed at about lat. 80° 30′ S., long. 62° W. north-eastward to connect with Berkner Island. Two parts of one of the flights shown in Figure 1 crossed the ice shelf in this area and showed no evidence of a grounded ice connection. This being the case, it is clear that a large part of the ice entering from the polar plateau is flowing through this section.

A simple calculation was made to determine whether the discrepancy of 100×10^{15} g. yr.$^{-1}$ noted by Giovinetto (1964) could be explained. The distance between Berkner Island and the grounded ice feature to the west-south-west is about 160 km. as shown in Figure 1. Behrendt (1962[a]) showed an ice thickness of 500 m. for this part of the ice shelf. The product of these quantities gives the cross-sectional area of the ice flowing through this section, 8×10^{11} cm.^{2}. Since the error estimate cited by Giovinetto is $\pm 57 \times 10^{15}$ g. yr.$^{-1}$, the velocity of ice-shelf flow required through this section is obtained by dividing the cross-sectional area into the mass flux difference, viz. $1 \cdot 25 \pm 0 \cdot 71 \times 10^5$ cm. yr.$^{-1}$ or $1 \cdot 25 \pm 0 \cdot 71$ km. yr.$^{-1}$. This is a reasonable figure and thus the discrepancy can be accounted for.

In Figure 1 the line indicating the boundary of the grounded ice connects the feature west-south-west of Berkner Island to the higher ice farther west. This was done because surface observations made by the author and other members of the Filchner Ice Shelf traverse party showed that the grounded ice contact in the vicinity of this feature was at an elevation of about 110 m. This contrast with the 200 m. contour border of the ice shelf in other areas is probably the result of the fairly shallow depth to bedrock in the area where this grounded feature was crossed (Behrendt, 1962[a]) relative to the parts of the area where the 200 m. contour defines the boundary.

The western area of the ice shelf is still relatively unknown and several islands other than those shown could exist. The precise locations and configurations of these are uncertain as they were only seen from the air, with the exception of the one reached by the Filchner Ice Shelf traverse. The position of the flight line shown in the area of these islands is possibly somewhat in error.

It is likely that the boundary of the ice shelf in the vicinity of lat. 77° S., long. 70° W. may actually be farther to the north and that the mountains(?) in this area may be the same as those studied by the Antarctic Peninsula traverse (Behrendt, 1963) in the vicinity of lat. 75° S., long. 70° W. On the flight shown in the latter area, I observed no rock exposures south of those shown and the snow surface appeared to descend continuously to the south. Visual observations on this same flight also showed the apparent ice shelf boundary south of "Eights station" where elevations of less than 200 m. were measured.

The area of ice shelf shown in Figure 1 is $0 \cdot 43 \times 10^6$ km.^{2}, not including the islands, which compares with $0 \cdot 39 \times 10^6$ km.^{2} from Thiel (1962), $0 \cdot 355 \times 10^6$ km.^{2} from Suyetova (1963) and $0 \cdot 50 \times 10^6$ km.^{2} from Giovinetto (unpublished). Giovinetto's value was based on evidence from the Antarctic Peninsula traverse and probably is in agreement with the value obtained from Figure 1 within the experimental error, although it appears somewhat high. Thiel's and Suyetova's values are too low and reflect the maps prior to the discovery of the extension of the ice shelf into the area immediately south of "Eights station" as discussed by Giovinetto and Behrendt (1964). The area could be increased to as much as $0 \cdot 48 \times 10^6$ km.^{2} if the north-western border approaches the mountains mapped by the Antarctic Peninsula traverse as discussed above. These values are comparable to the somewhat larger Ross Ice Shelf of $0 \cdot 54 \times 10^6$ km.^{2} (Giovinetto, 1964).

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