INTERNAL FLOW LINES IN THE ICE SHEET UPSTREAM OF THE YAMATO MOUNTAINS, EAST ANTARCTICA (EXTENDED ABSTRACT)

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The last decade has seen intensive efforts devoted to the so-called flow-line study in wide areas of the Antarctic ice sheet. From these, extensive knowledge has been obtained about the ice sheet, on the surface flow, the surface mass balance and the ice thickness. This allowed numerical determinations of vertical distribution of paths of ice particles to be made along several flow lines (WHILLANS, 1979; BUDD and YOUNG, 1979; RAYNAUD *et al.*, 1979). Aiming at clarifying the dynamics and stability of the ice sheet in East Queen Maud Land as one of the major objectives of the Japanese Glaciological Research Project to be conducted in this area from 1982 to 1987, the present paper gives preliminary results of the numerical computation of internal flow lines, *i.e.* particle paths, and the vertical profile of the ages of ice in an ice sheet upstream of the Yamato Mountains.

A steady-state model was used here with the following assumptions:

(1) The ice sheet flows only by deformation in simple shear and does not slide on the bedrock.

(2) The strain rate parallel to the surface, *i.e.* the two-dimensional dilatation rate, is constant with depth.

(3) Parameters A and n in the flow law of ice, $\dot{\varepsilon}=A\tau^n$, are constant with depth.

Coordinate axes x and z are taken on the surface parallel and perpendicular to the flow direction, respectively, and y in the direction normal to the surface (positive downwards). Velocity components parallel and perpendicular to the surface, u and v (positive downwards), respectively, at depth y, are derived on the basis of the theory of NYE (1952), as follows:

$$u=u_s[1-(y/h)^{n+1}], \qquad (1)$$

$$v=b(1-y/h), \qquad (2)$$

where u_s is the longitudinal velocity at the surface, b the surface mass balance, h the ice thickness, and n the power in the flow law, which is taken to be 3 (GLEN, 1955).

Sources of input data for the numerical calculation are the results obtained by NARUSE (1978) for the surface ice flow, by YAMADA *et al.* (1978) for the surface mass balance and by SHIMIZU *et al.* (1978), as well as by WADA *et al.* (1981) for the ice thickness. None of them were, however, obtained continuously along a flow line. Therefore, based on these intermittent data, the following approximation was made concerning several conditions along a selected flow line in this region:

(a) The surface profile of ice has a parabolic form given by $H_s = 50X^{1/2} + 2200$, where H_s (m) is the surface elevation and X (km) is the distance between the edge of the Motoi Nunatak and a specific point in the upstream area (see Fig. 1).

(b) The bedrock profile has a form given by $H_b = 1.2 \times 10^{-5} (X - 100)^4 + 1000$, where H_b (m) is the bedrock elevation.

(c) The surface mass balance is -0.05 m a^{-1} in the ablation area near the Nunatak ($0 < X < 15$ km), whereas it is $+0.10$ m a^{-1} in the accumulation area inland of the Nunatak ($X > 25$ km). The balance increases linearly in the region $15 \leq X \leq 25$ km.

(d) The surface velocity u_s (m a^{-1}) increases linearly with X (km), *i.e.* $u_s = X/3$, in the region $0 \leq X < 50$ km. In $X \geq 50$ km, u_s has the constant value of 17 m a^{-1}.

The assumption of (d) signifies that the longitudinal strain rate $\dot{\varepsilon}_x$ has the constant value of -3.3×10^{-4} a^{-1} in the region shown in Fig. 1. The transversal strain rate $\dot{\varepsilon}_z$ calculated from the continuity equation

$$0 = b - h(\dot{\varepsilon}_x + \dot{\varepsilon}_z) - u(\partial h / \partial x) , \tag{3}$$

shows values between $+5 \times 10^{-4}$ and $+10^{-3}$ a^{-1}, which agree approximately with the observational results.

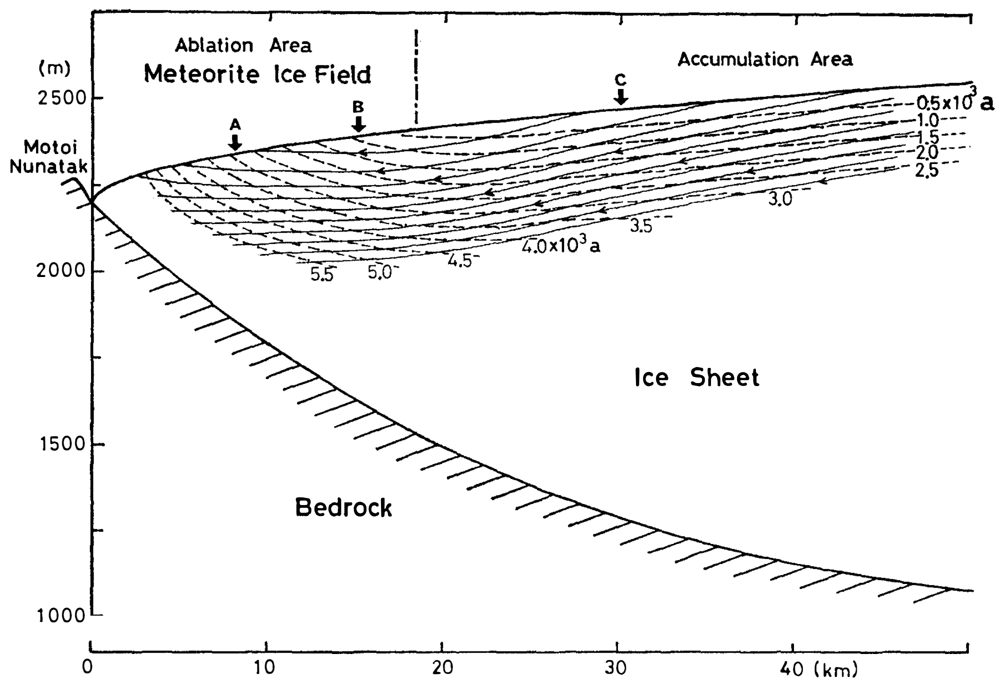

Fig. 1. Results of the flow line modelling showing the particle paths (solid lines with arrows), the age of the ice (dashed lines), and the smoothed surface and the bedrock profiles along a flow line directed northwestwards to the Motoi Nunatak in the southern part of the Yamato Mountains. The deepest particle path starts from a point on the surface, 100 km upstream of the Motoi Nunatak.

Each particle path starting from a point on the ice sheet surface was calculated using eqs.(1) and (2) with a time interval of 25 years. In Fig. 1 solid lines show the particle paths obtained, and dashed lines represent isochrons of the age of ice. It can be seen from this figure that an ice particle at a point A on the surface has travelled within the ice sheet from a point C (about 20 km upstream), taking about 3000 years. In the ablation area (Meteorite Ice Field), the age of the surface ice increases with decrease in distance to the Nunatak. The estimated age ranges from one to several thousand years in this calculated area.

Vertical profiles of the age of ice at points A, B and C in Fig. 1 are shown

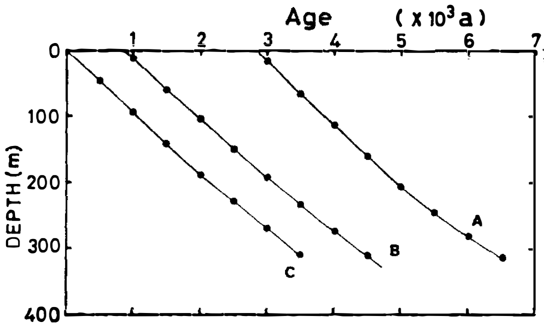

Fig. 2. Vertical profiles of the age of ice. Locations of points A, B and C are indicated in Fig. 1.

in Fig. 2. They show almost a linear increase in age with increasing depth until 200 m and a little rapid rate of increase in the deeper body of ice. Such profiles should be useful for predicting the age of ice core samples.

Although the results are limited only to the location near the surface and at a comparatively short distance from the nunataks, they provide some useful information for the study of the effect of coastal mountains on ice sheet dynamics and for the selection of boring sites in a bare ice area.

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