FLOODING OF THE ICE SHELF IN GEORGE VI SOUND

By A. C. Wager

Abstract. The surface of the ice shelf in George VI Sound between lat. 70°40′ and 71°50′S. floods annually during January and February. The area of flooding is sharply defined and appears to be due to surface contamination by wind-blown rock debris. This decreases the albedo, causing increased radiation absorption and melting. The debris comes from sedimentary rocks found only on the western side of the sound between limits that correspond to the extent of flooding. The frozen surface of the previous year's floods forms an impervious stratum which, together with the low surface slopes of the ice shelf, prevents drainage of melt water.

The surface of most Antarctic ice shelves consists of snow which gradually compacts to form ice as more snow accumulates above it. In contrast, the surface of large areas of the ice shelf in George VI Sound consists of frozen melt water. The sound itself is a channel from 20 to 70 km. wide separating Alexander Island from the west coast of Palmer Land. It is filled for most of its 500 km. length with a floating ice shelf which is between 100 and 475 m. thick (Swithinbank, 1968, p. 412). Parts of the ice shelf flood during the height of each summer, and this paper examines the extent and probable causes of the flooding.

Description

Pools of melt water first appear in December in disturbed ice along the edges of the ice shelf. By January, there are extensive lakes and during late summer a system of pools occupies the whole of the ice shelf between lat. 70°40′ and 71°50′S., an area of about 3,600 km.^{2}. At the height of the flooding one of the most prominent features is the abrupt boundary of the area in which pools occur. Fig. 1 shows the extent of the flooding noted by C. W. M. Swithinbank (personal communication) in 1967 (Fig. 2) and by the author in 1970. Both observations were made during airborne radio-echo sounding flights when particular attention was being paid to navigation, so the differences observed are real and not the result of navigational errors.

Stephenson and Fleming (1940, p. 160), in an account of their visit to the area in 1936, remarked on the surprising amount of ablation caused by rock particles lying on the snow at Ablation Point. Ronne (1945, p. 19) reported that in January 1941, while travelling north up the sound from lat. 71°45′S., there were "lakes with fresh water one foot deep". Fuchs (1947–50, p. 430), in his account of two seasons sledging in George VI Sound, reported that on approaching Ablation Point on 21 December 1948 there were "large areas of water lying on the ice". By contrast, 64 km. farther north he encountered "compacted wind crust which was hard frozen" (Fuchs, 1947–50, p. 435). On 12 December 1949 in lat. 70°59′S., Fuchs (1947–50, p. 763) reported "a long . . . pool of blue water" and on the following day just north of Ablation Point "the morasse of melt water and slush coming out onto the shelf ice from the 'dry valleys'" (Fuchs, 1947–50, p. 765). A pit dug by the author in the centre of the sound in lat. 72°16′S. showed no evidence that flooding had occurred there within 3 yr. before October 1969.

Discussion

Extensive melting has been observed on other ice shelves, notably the ice shelf north of Vassfjellet (lat. 70°45′S., long. 11°40′E.), where an area of about 900 km.^{2} is flooded in summer (Barkov and Konovalov, 1963, p. 329). Aver'yanov (1966, p. 20) believed that areas with a low mean cloud cover have lower ablation rates than areas with high mean cloud cover. Although this may be partly true near Vassfjellet, differences in cloud cover have not been observed in George VI Sound. Kruchinin (1968, p. 70) attributed melting to increased thermal absorption of exposed ice and contamination by debris carried by wind from exposed rock. The area of flooding near Vassfjellet occurs in an ablation area where, unlike the ice shelf in George VI Sound, bare ice reduces the surface albedo. No bare ice appears extensively in George VI Sound until melting is well advanced and it can therefore be discounted as a cause of the flooding.

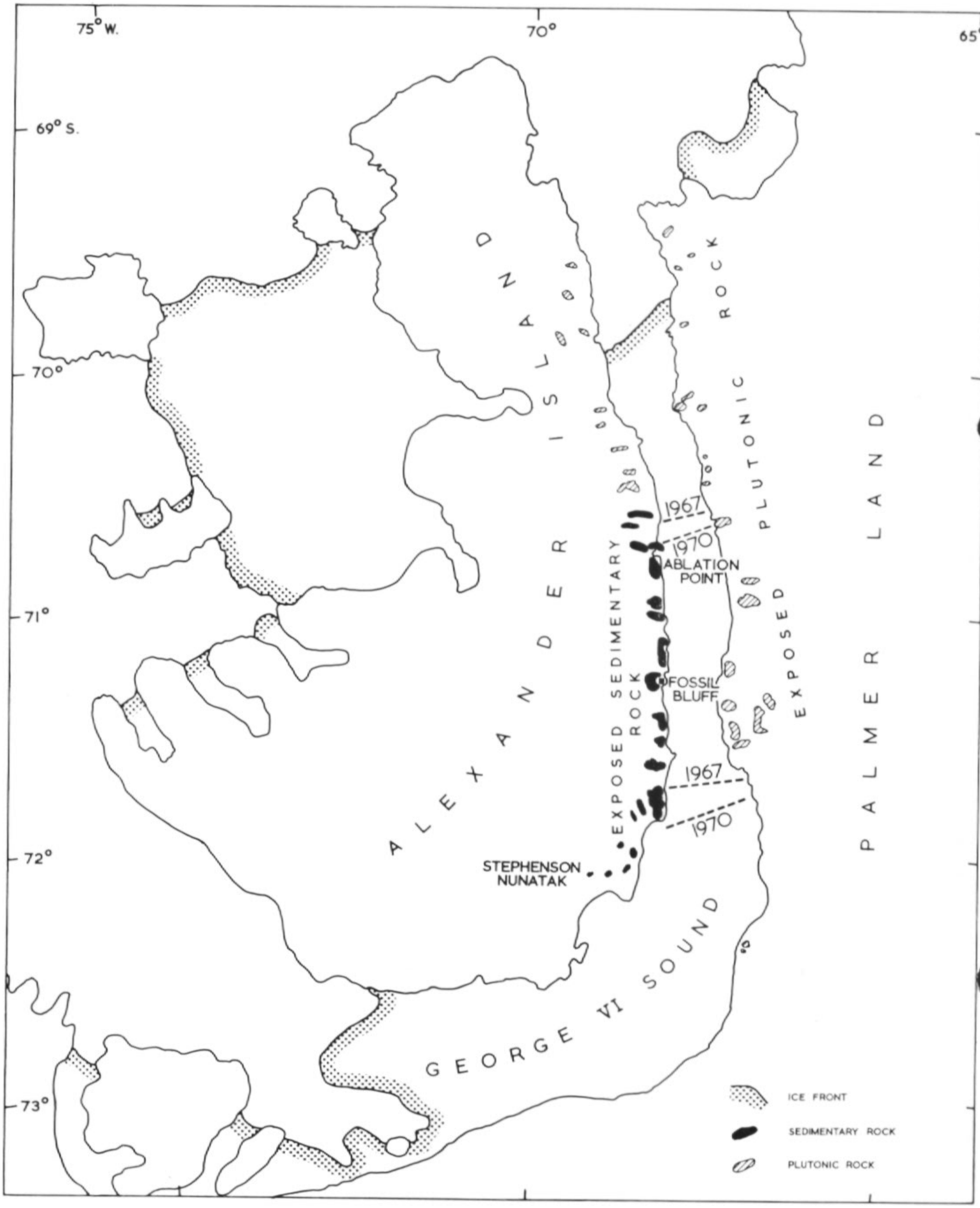

Fig. 1. Alexander Island and part of Palmer Land. The areas of George VI Sound between the sets of dashed lines were flooded in 1967 and 1970.

An alternative explanation is that melt water might drain from the screes and valley glaciers at the edges of the sound. However, radio-echo sounding records indicate that the ice surface is higher in the centre of the sound than it is at the edges.

The remaining possible causes of flooding are a decrease of surface albedo caused by debris wind-blown from the exposed rock at the margins of the ice shelf and transfer of heat by moving air from adjacent sun-warmed rocks (Solopov, 1967, p. 20). The latter involves two separate heat-transfer processes, first from warm rock to cold air, and secondly, from warm air to cold snow. Neither of these exchanges will be efficient, and so the additional heat supplied to the snow must be small. Radiation heating may, on the other hand, provide much additional heat. Megahan and others (1970, p. 76) found that dark powder spread on the snow surface in concentrations as low as 10^{-3} kg./m.^{2} increased absorbed radiation by 50 per cent. With higher

Fig. 2. Part of the flooded area of the ice shelf in George VI Sound. (Photograph by C. W. M. Swithinbank.)

concentrations of impurities, radiation increases of more than 80 per cent were found; even with a 4 cm. layer of new snow, radiation was still increased by 50 per cent.

The surface of the ice shelf in George VI Sound becomes covered with dark dust in the course of winter gales. The effect of this dust can be seen in areas which are too well drained (because of large surface slopes) for pools to form. The dust accumulates unevenly in the lee of surface irregularities such as sastrugi and differential ablation occurs. The contaminated areas ablate more rapidly to leave dust wells, indicating that the dirt in George VI Sound increases the net absorbed radiation and increases melting. It is noticeable that, as the snow melts, lower dust layers are exposed and the surface albedo decreases. Formation of actual melt pools decreases the albedo still further. The pools appear to form on the frozen surface of the previous year's melt which provides an impervious stratum preventing drainage. Thus the flooding of one year probably helps to cause flooding the following summer.

George VI Sound is unique in containing a largely land-locked ice shelf bordered in its northern part by exposed rock and high mountains. The rock provides the debris responsible for melting but it is the level undisturbed surface of the ice shelf which prevents the melt water draining away and so allows the pools to form.

It remains to explain the distribution of the pools in the light of the known geology of the area and the general prevailing wind pattern.

On the west side of the sound between Stephenson Nunatak and Transition Glacier, which is 40 km. north of Ablation Point, there are large outcrops of Cretaceous sediments (Horne, 1967, p. 1) which erode to form the fine debris found on the surface of the ice shelf. On the east side of the sound there are plutonic rocks (Adie, 1955, p. 3) which produce little debris of a size small enough for wind transport. The east coast of Alexander Island north of Transition Glacier also appears to be composed of plutonic rocks (King, 1964, p. 59) which occur in exposures so small that they produce little fine debris. The source area for debris suitable for wind transport over the distances necessary is therefore confined to the west side of the sound between lat. 70°10′ and 71°50′S. The Cretaceous sediments are found as far south as lat. 72°10′S. but they occur in much smaller outcrops separated by large expanses of ice piedmont.

Analysis of the Fossil Bluff weather records for 1961 (Pearce, 1963, p. 20), 1968 (personal communication from D. W. S. Limbert) and 1969 shows that the predominant wind direction is from north to north-west with secondary preferred wind directions which are more variable. Since the prevailing wind carries debris south-eastwards, the lithology shows a correlation with the area in which flooding occurs. It may therefore be concluded that the flooding in George VI Sound is the result of surface contamination.

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