6·5 km. The folding is apparently associated with lateral spreading of the ice and associated decreased velocity. The main features of these folds are not random but can be traced across several medial moraines showing that the ice was deformed as a unit. Below the point where the folds are formed no further large-scale folding takes place, as shown by the unaffected ice derived from the north branch (Fig. 1). However, compressive flow squeezes the existing folds together as the terminus is approached. In the south-eastern part of the glacier, one group of folds is deformed into long parallel ridges almost at right-angles to the direction of ice movement (Fig. 1, center foreground).

Sioux Glacier debris

Photographs of this glacier taken before the 1964 earthquake display a rock-slide avalanche deposit covering more than 1 $km.^2$ which was identified by Tuthill (1966). Except for this, the glacier prior to 1964 was relatively clear of debris, indicating that this rock avalanche was an isolated occurrence.

Conclusions

The bulk of the debris on lower Martin River Glacier is derived from normal mass-wasting of slopes bordering the tributaries in the mountainous upper part of the glacier, which has been transported to the terminus first as lateral and then as medial moraines. The detritus is spread in the terminal area in part by folding of the medial moraines which occurs at a point where the glacier abruptly doubles its width. Small rock falls have contributed considerable material to these moraines but evidence of many large rock-slide avalanches prior to the 1964 earthquake is lacking.

For 100 yr. or more prior to the 1964 earthquake, only minor rock-slide avalanching had occurred on Martin River and Sioux Glaciers despite considerable strong earthquake activity in this general region. The rock-slide avalanches induced by the 1964 earthquake are apparently unprecedented in magnitude and form no basis for computing the contribution of earthquake-induced avalanching to supraglacial debris found near the terminus of many Alaskan glaciers.

U.S. Geological Survey,
Tacoma, Washington, U.S.A.
12 January 1967

AUSTIN POST

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SIR, *Water-spout on Kaskawulsh Glacier, Yukon Territory**

While conducting field research on Kaskawulsh Glacier, Yukon Territory, Canada, an unusual phenomenon was observed which in this instance related to moulin formation. 30 m. from the writers' position, at about 11.00 hr. on 30 June 1966, a vertical spout of water suddenly rose from the glacier surface. This was in the same area where Dewart (1966) observed several moulins.

The spout of water lasted 7–10 sec. and reached a maximum height of 4–5 m. The only sound noted to accompany the phenomenon was the noise of rushing water; there was no sharp sound of fracturing ice. Immediate investigation of the site revealed that the water had issued from a vertical fissure 7–8 cm. wide and orientated perpendicular to glacier flow (Fig. 1).

The site, which at this time of year was in the vicinity of the snow line, was covered with crusted snow to a depth of 15–20 cm. The glacier ice at the fissure itself, however, was blown and washed bare for a distance of more than 1 m. along the length of the fissure and 25 cm. on either side. This rectangular pattern of snow-free ice, along with the splatter pattern left by the falling water in the snow, suggests that in cross-section the fountain of water was tabular rather than columnar.

* Field research on the Kaskawulsh Glacier in the summer of 1966 was sponsored by the Icefield Ranges Research Project of the Arctic Institute of North America and the American Geographical Society.

Water from surrounding slush areas began to flow into the fissure almost immediately. Within 2 days it was apparent that a distinct circular moulin was developing (Fig. 2). By 9 July the original ice fissure had closed, leaving only a circular hole approximately 0·5 m. in diameter (Fig. 3). This opening was not only being maintained, but enlarged, by two tributary streams diametrically entering it. Final observations on 2 August revealed that the moulin had a diameter of approximately 1·25 m. and the two entering streams had entrenched approximately 1 m. into the lip of the moulin (Fig. 4). Throughout the observation period there was no evidence suggesting recurrence of spouting action.

Fig. 1. Site of the water-spout, central arm of Kaskawulsh Glacier, looking south; 30 June 1966

Fig. 2. Developing moulin at the site of the water-spout, looking south-south-east; 2 July 1966

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Fig. 3. Moulin at the site of the water-spout with two tributary melt-water streams, looking west up-glacier (ice-axe at right for scale); 9 July 1966

Fig. 4. The two streams shown in Figure 3 entrenched into the lip of the enlarged moulin, looking west; 2 August 1966

An aspect of this moulin, not observed in others of the immediate area, was an irregular pulsation of air from the mouth carrying aloft a fine spray of water. This discharge of air from the moulin was first observed on 15 July and continued to the end of the observation period.

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3 March 1967

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SIR, *The regime of the western part of the Ross Ice Shelf drainage system*

I am writing to you in connection with the article by Giovinetto and others (1966). In this paper the results of studies on the glaciers flowing through the Trans-Antarctic Mountains are very interesting.

Unfortunately there are two comments which must be made concerning the study of the regime of the drainage basin of these glaciers:

(a) The delineation of the drainage basin is purely hypothetical.

(b) The supposition that all the ice in this hypothetical basin flows exclusively through the glaciers mentioned, and that no ice crosses the western, southern or northern boundaries of this hypothetical drainage basin, cannot be justified at all.

It follows from this that a calculation of errors applied to the terms in the mass balance is nothing but an illusion, as it is not the error calculation which gives precision to a calculation, but the reality of the quantities one uses.

The positive budget they report is therefore of no significance.

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REFERENCE

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SIR, *Accumulation between Mount Chapman and "Byrd" station, Antarctica*

I had the opportunity to re-measure the snow accumulation along the line of the "Byrd" station–Mount Chapman ice-movement markers (Brecher, 1967) this past Antarctic season. It seems to me rather interesting to note that while the mean accumulation between "Byrd" station and array V (300 km. from "Byrd" station) has decreased markedly, from 16·1 g. cm.$^{-2}$ yr.$^{-1}$ for 1962–65 to 11·5 g. cm.$^{-2}$ yr.$^{-1}$ in 1965–66 (the value between arrays V and VI has remained unchanged), the variations of accumulation along the line correspond very closely for the two time intervals with a coefficient of correlation of 0·926. This could well be a topographic effect.

The decrease of accumulation with time has also been observed at "Byrd" station, where measurements of 100 stakes have shown a decrease from 11·0 g. cm.$^{-2}$ yr.$^{-1}$ to 9·4 g. cm.$^{-2}$ yr.$^{-1}$ for this same time period (personal communication from R. L. Cameron).

My paper (Brecher, 1967) contained some minor errors which should be corrected as follows:

i. On p. 575, lines 8 and 9, the standard deviations should be 3·0 and 3·1, respectively.

ii. On p. 575, Table I, the column heading "*Standard deviation*" should read "*Standard error*". The values were obtained from the following expressions:

$$\text{Standard error of mean} = \left\{\frac{\Sigma v^2}{n(n-1)}\right\}^{\frac{1}{2}}$$

$$\text{Standard error of one observation} = (\Sigma v^2/n)^{\frac{1}{2}},$$

where Σv^2 is the sum of the squares of the deviations from the mean and n is the number of observations, and the observations are considered to be several measurements of the same quantity.

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