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RECONNAISSANCE STUDY OF PROGLACIAL STEWART LAKES, BAFFIN ISLAND, DISTRICT OF FRANKLIN

Project 810042

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Abstract

Stewart Lakes are dammed by neoglacial moraines in a through-valley between Gibbs and Sam Ford fiords in northeastern Baffin Island. Maximum water depth on the basis of spot soundings is 108 m. Glaciers are retreating at rates between 19 and 34 m/a, and the lake level has lowered from 69 m above sea level to 55 m as a result of ice retreat and downcutting of the moraines. On 13 September 1983, suspended sediment concentrations in Stewart Lakes varied from 66 to 109 mg/L. In Refuge Harbour (Gibbs Fiord) the concentration in overflowing fresh water was 135 mg/L. These values are signficantly higher than those measured in most other ice-proximal lakes and fiords.

Résumé

Des moraines néoglaciaires servent de retenue aux lacs Stewart, dans une vallée glaciaire située entre les fjords Gibbs et Sam, dans la partie nord-est de l'île Baffin. D'après des sondages ponctuels, la profondeur maximum de l'eau est de 108 m. Les glaciers reculent à des vitesses comprises entre 19 et 34 m/a, et le niveau limnimétrique est passé de 69 m à 55 m au-dessus du niveau de la mer, par suite du recul des glaces et de la dissection des moraines. Le 13 septembre 1983, les concentrations de sédiments en suspension ont varié dans les lacs Stewart entre 66 et 109 m/l. À Refuge Harbour (fjord Gibbs), la concentration des sédiments en suspension dans les eaux douces de trop-plein était de 135 m/l. Ces valeurs sont nettement plus élevées que celles mesurées dans la plupart des autres lacs et fjords les plus proches des glaces.

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Introduction

During the shore-based portion of the Sedimentology of Arctic Fiords Experiment in 1983 (Syvitski and Schafer, in press), there was an opportunity on September 13 for a brief reconnaissance by helicopter of proglacial Stewart Lakes. The lakes are located on the floor of a glacial trough between Gibbs and Sam Ford fiords in northeastern Baffin Island (Fig. 61.1). The geomorphology and hydrology of this remote area are uninvestigated, although studies were made by the Geographical Branch of the glacial geomorphology of the upper regions of Sam Ford Fiord (Smith, 1966) and of the peninsula to the northeast of Stewart Lakes (Ives and Buckley, 1969). The results presented here provide a background for proposed detailed study of the sedimentology of these lakes.

Physical setting

The lakes are dammed on the north at 55 m above sea level by the neoglacial moraine of a large glacier, and to the southwest, a large calving glacier terminates in the lake (Fig. 61.2). A moraine from one of the side-entry glaciers separates the lakes (here referred to as North and South Stewart Lakes). Flow of water in the lakes is from south to north, and thence into Refuge Harbour. Summary statistics of the characteristics of the drainage basins and the lakes are presented in Table 61.1.

Although the valley is a major glacial trough with cliffs rising to 1600 m in the vicinity of the lakes, the spot observations of water depth shown in Figure 61.2 indicate that the lakes are relatively shallow, attaining a maximum depth of 108 m.

Glacier fronts around the shores of Stewart Lakes are retreating rapidly from their neoglacial moraines (Fig. 61.3). Between 1961 and 1983 the large glacier at the south (Fig. 61.3a, b) has retreated about 750 m (34 m/a on average). The profile of the lower section of the glacier has also changed significantly in that period. At present a large area appears to have detached from the active glacier, possibly as a result of the ice thinning and then floating to allow lake water beneath. This section now forms a nearly flat-lying, floating ice sheet (Fig. 61.4), the outer edge of which is less than 1 m above lake level.

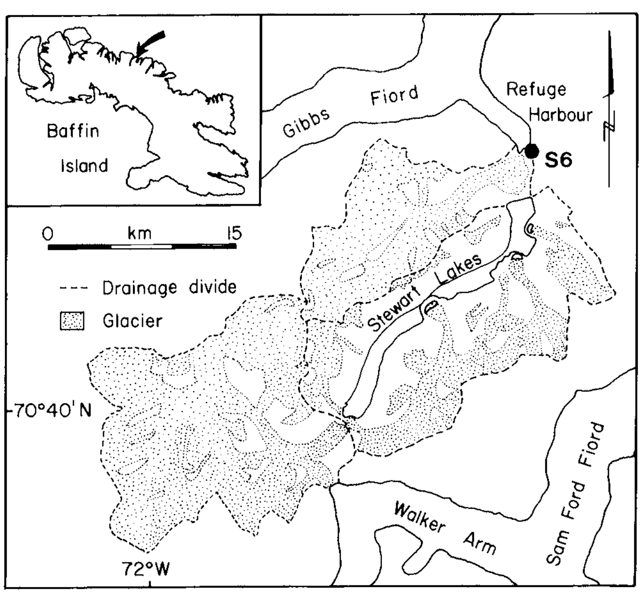


Figure 61.1. *Drainage basins tributary to Stewart Lakes and glaciers to the north and west (from NTS map 27F).*

Ice cored mounds of sediment stand up to 5 m above the present surface (Fig. 61.4, 61.5). The thin veneer of glaciofluvial sand and silt (samples 1 and 2, Fig. 61.6) protects the ice beneath from melt. These are thought to be remanent pockets of deposition in a formally active meltwater drainage system within the ice. Since only a thin floating sheet remains, it is probable that the ice tongue is melting both from above and below. Because the water level in the lakes changes only about 1 m from winter to summer, this sheet has not been calved and broken up, although it is probable that it is unstable, and rapid retreat, at least to the active ice front, will continue.

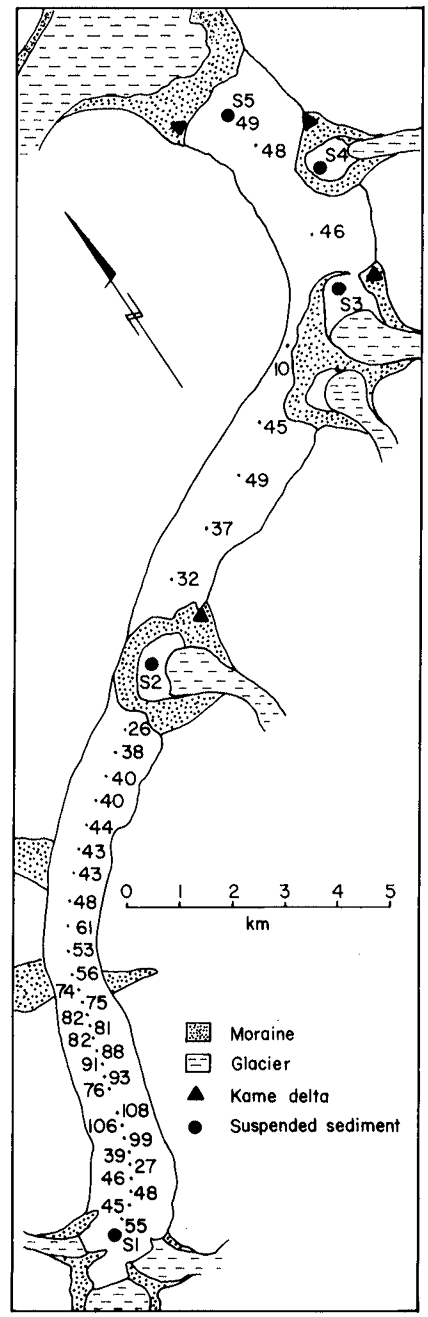


Figure 61.2. *Outline of Stewart Lakes showing bathymetry in metres, location of suspended sediment sampling sites (S1 to S5) and kame deltas. The shoreline indicates ice front locations in 1983.*

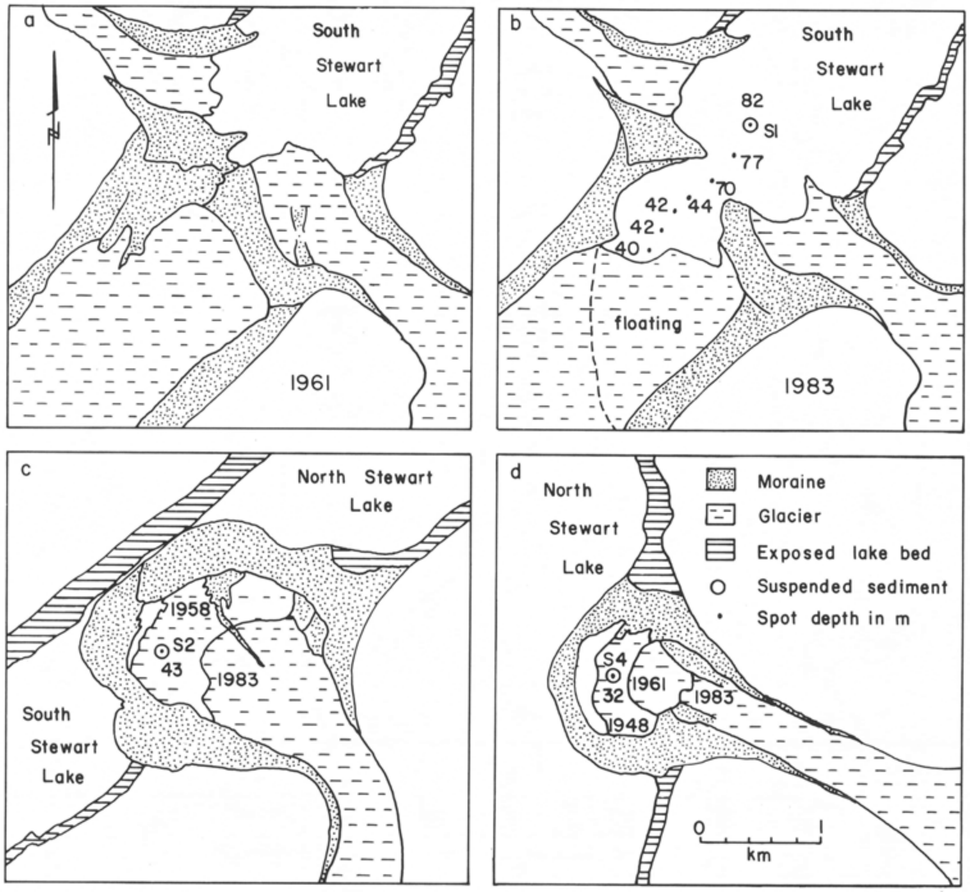
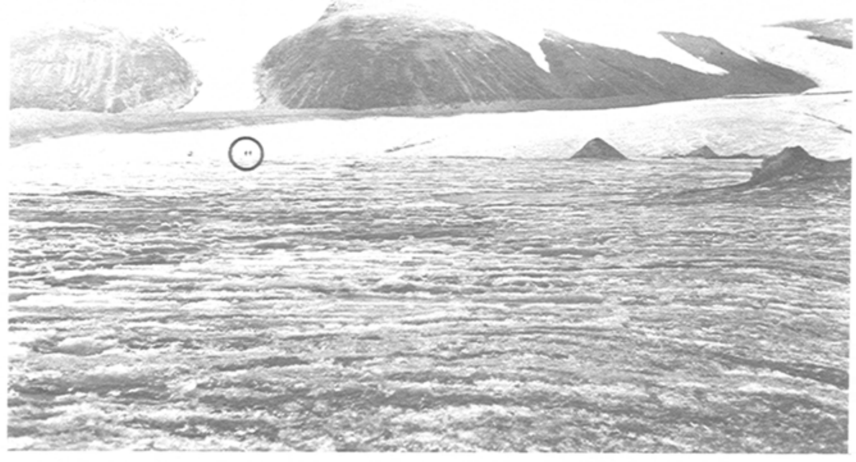


Figure 61.3. *Maps showing the retreat of glaciers around Stewart Lakes; at the south end (a and b), between North and South Stewart Lakes (c) and at the northeast end of North Stewart Lake (d). Ice fronts are mapped from air photos from The National Air Photo Library taken in 1948 (T215R-91), 1958 (A16218-34 and A16300-106), and 1961 (A17045-18,20,33). Ice fronts in 1983 are estimated from photographs taken in the field.*

Figure 61.4

View looking west showing the floating ice tongue and the active glacier at the south end of Stewart Lakes (Fig. 61.3b). Human figures (circled) indicate scale.



During the same period of 1961 to 1983, the side entry glacier shown in Figure 61.3c has retreated 530 m (24 m/a). In air photographs on 22 June and 30 August 1958 a small lake appears at the toe of the glacier (Fig. 61.3c). In photographs on 16 and 27 July 1961 the position of the toe of the glacier is nearly the same, but the lake has disappeared. This may have occurred as the outlet cut down or as water percolated through the moraine. At the present time a lake of 0.88 km^2 and at least 43 m deep exists inside the moraine. The glacier shown in Figure 61.3d has retreated 250 m between 1948 and 1961 (19 m/a) and 480 m between 1961 and 1983 (22 m/a). The present lake inside its moraine has an area of 0.70 km^2 and is at least 32 m deep.

Sometime before the first air photographs were taken in 1948, the level of Stewart Lakes dropped from about 69 m above sea level to the present level of 55 m, and North and South Stewart Lakes became separated by the moraine between them. It is probable that this process occurred slowly over a period of years, as a number of distinct beaches appeared between these two levels. The lowering apparently resulted from downcutting of the moraine dam at the north end of the lakes as the glacier there retreated.

Sedimentary environments

Suspended sediments

Six one litre surface water samples were recovered from Stewart Lakes, the smaller lakes behind the side-entry moraines (Fig. 61.1, 61.2), and the overflowing plume of fresh water in Refuge Harbour. The results of analysis of sediment concentration and grain size are presented in Table 61.2 and Figure 61.7.

The concentrations of suspended sediment are high in comparison to other glacial lakes which range from about 5 to 50 mg/L (Gilbert, 1975; Pickrill and Irwin, 1982; Smith and Syvitski, 1982; Smith et al., 1982). Only in the very high energy environment of Malaspina Lake, Alaska where sediment concentrations reach 700 mg/L (Gustavson, 1975) are reported values higher than those measured in Stewart Lakes. The values from Stewart Lakes are even more remarkable because arctic glacial streams normally carry significantly less suspended sediment than their temperate alpine counterparts (Østrem et al., 1967; Church, 1972; Lemmen, 1984). In addition, the samples were collected from Stewart Lakes in mid-September, well after the period of highest sediment input during mid-summer.

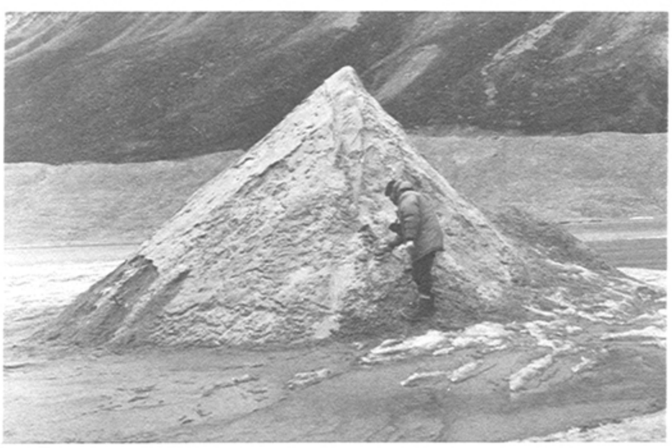


Figure 61.5. Ice-cored debris cone on the floating ice tongue at the south end of Stewart Lakes.

Table 61.1. Characteristics of the drainage basins of Stewart Lakes

Basin	Area km^2 Total	Area km^2 Lakes	Per cent glacier covered	Maximum elevation m
North basin	128	0	80	1870
West basin	260	0	85	1740
Stewart valley	268	27	45	1810

Lake	Area km^2	Length km	Mean width km	Maximum recorded depth m
North Stewart	12.5	10.6	1.18	108
South Stewart	14.4	10.9	1.32	49

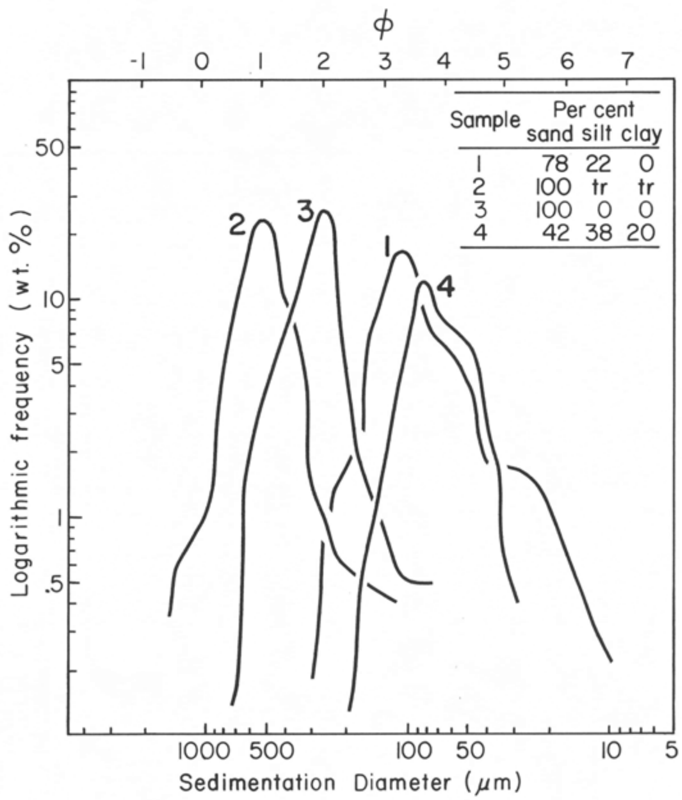


Figure 61.6. Grain size distribution of sediment samples collected from Stewart Lakes. Samples 1 and 2 are from the fine and coarse sediments respectively on the debris cone shown in Figure 61.5. Sample 3 is from the beach on the alluvial fan at the base of the raised kame delta at the south end of North Stewart Lake (Fig. 61.2) and sample 4 is from the topset beds of that delta (Fig. 61.8).

Table 61.2. Summary statistics of suspended sediment samples from Stewart Lakes and Refuge Harbour

		Grain size moment measures			
Sample No*	Concentration mg/L	Mean φ	Standard deviation φ	Skewness	Kurtosis
1	109	9.43	1.03	-1.1	3.6
2	24	9.40	1.01	-0.9	3.4
3	94	9.19	1.11	-0.8	2.8
4	73	9.20	1.07	-0.7	2.9
5	66	9.67	0.92	-1.4	4.5
6	135	9.20	1.22	-0.7	2.3

*for sample locations see Figures 61.1-61.3

The major source of sediment is the large glacier to the southwest. The sediment concentration remains high throughout the length of the lakes, suggesting efficient mixing of the lake waters and significant throughput of suspended sediment. The side entry glacier dividing North and South Stewart Lakes has a much lower input of fine sediment than the other glaciers, and the water colour is a light grey in comparison to the dark brown of Stewart Lakes.

In Refuge Harbour the sediment concentration is the highest of all sites measured, and is significantly higher than that in other fiords on Baffin Island, even at the height of the melt season (Gilbert, 1978; 1982). The high concentration reflects the input from Stewart Lakes, glaciofluvial input from the large glacier nearby, and the restricted mixing in the overflowing fresh water.

The size range (Fig. 61.7) is typical of glacial 'rock flour' (0.25-12 μm; Keller and Reesman, 1963). In all samples, less than about 2% of the material is greater than 10 μm, indicating the settling of coarser particles. This loss of the coarse tail is most apparent in surface sample 5 from the north end of Stewart Lakes.

Deltaic environments

At the sides of some of the moraines in Stewart Lakes are kame deltas which built into the lakes at the older 69 m water level (Fig. 61.2). The most southerly of these was examined briefly. Sections up to 14 m high have been exposed by downcutting streams as the lake level lowered (Fig. 61.8). The delta consists of foreset beds dipping at 20° to 27°. Above are topset beds of rippled sands and silts (sample 4, Fig. 61.6) from a small sandur which built over the delta. The sediments that were eroded as the lake level lowered and streams cut through the delta, were deposited in lower angle (15° to 19°) alluvial fans in front of the delta. These fans are currently being modified by wave action to form beaches (sample 3; Fig. 61.6) as the lake level varies about 1 m between summer and winter.

Discussion

Stewart Lakes are an excellent field site for detailed study of glaciolacustrine processes in an arctic environment. Recent, rapid glacier retreat has created new lakes and exposed portions of the main lakes, so that ice-proximal lacustrine processes can be assessed above a known ice-contact base. High sediment concentration in the lake water indicates large rates of deposition. Processes such as turbidity current flow and redistribution of sediment by slope failure probably predominate. Instability caused by glacier

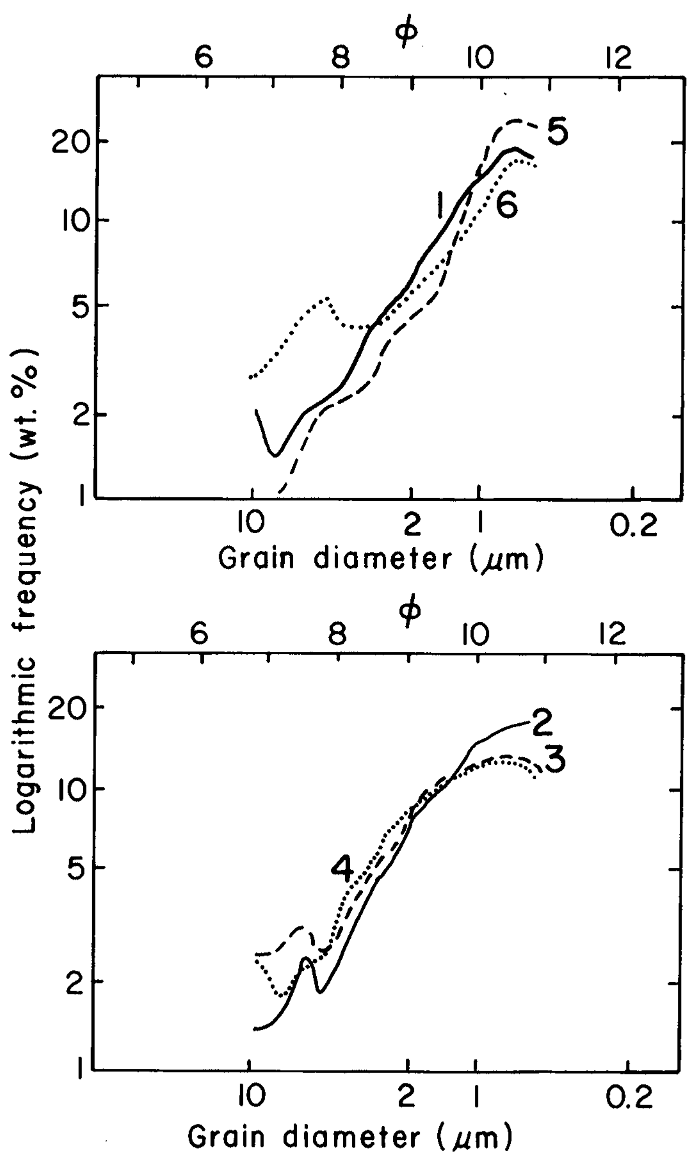


Figure 61.7. Histograms of grain size distribution of suspended sediment samples collected from Stewart Lakes and Refuge Harbour. Sample locations are shown in Figures 61.1-61.3.

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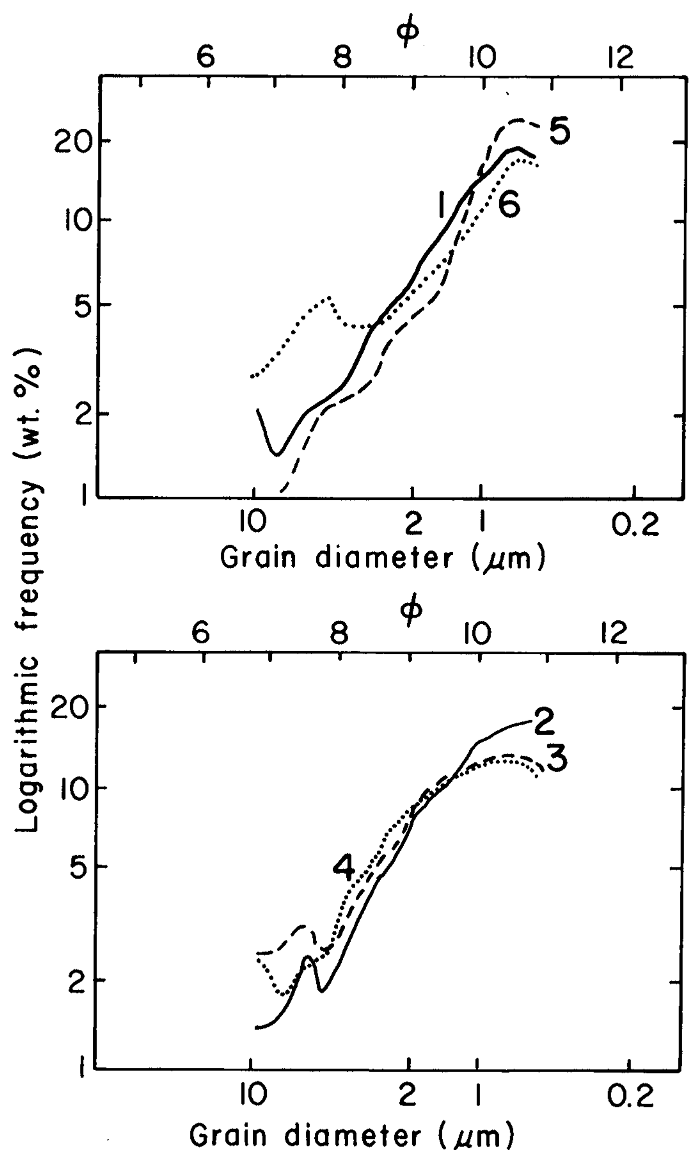

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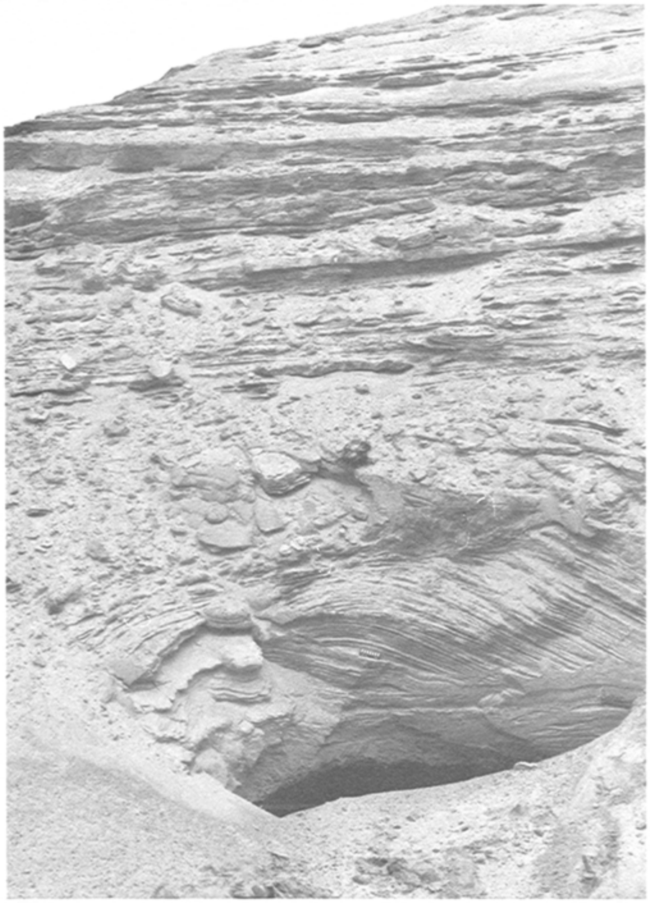

Figure 61.8. Upper section of the raised kame delta at the south end of North Stewart Lake (Fig. 61.2). The topset beds of rippled sands and silts were sampled and analyzed (sample 4, Fig. 61.6).

ice-push and the melting of ice-cored moraines also may be significant sources of disturbance to lake sediments. The different rates of sediment input from the side entry glaciers as compared to those in the main valley provide opportunity to assess different sedimentary processes in a similar climatic setting, and to assess varying sediment yield from a variety of glaciers in the same area.

The sedimentology of the abundantly dissected raised deltas can be investigated in the presence of the glaciers and their sediments that created these features, so that the amount and distribution of water and sediment involved can be estimated reasonably. Such is not the case for most of the Quaternary glacial landforms available for study in section.

The valley of Stewart Lakes may have been occupied by sea water at various times during the Holocene. Long cores and continuous seismic survey through the lake sediments may provide information on the sea level and glacial history of the area.

Finally, the proximity of Stewart Lakes to Gibbs Fiord and Walker Arm will also allow comparison of glaciolacustrine and glaciomarine sedimentology of these areas where conditions of sediment input are similar. It should be possible to compare the quality of a climatic and hydrologic record and the processes of deposition in both the freshwater and marine environment.

Acknowledgments

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