RADIOCARBON DATES FROM NORDENSKJÖLD GLACIER, SOUTH GEORGIA, AND THEIR IMPLICATIONS FOR LATE HOLOCENE GLACIER CHRONOLOGY

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Abstract. Recent recession of Nordenskjöld Glacier has exposed *in situ* a bed of peat formerly covered by the glacier. Radiocarbon dates on the peat allow an estimate of the minimum duration of a period of vegetation development and less extensive ice cover than occurs at present between 2230 ± 70 and 3330 ± 120 years BP (equivalent to calendar age ranges of 2122–2334 and 3395–3689 years BP). Subsequent glacier expansion culminated during the 17th to 19th centuries AD and involved an ice-front advance of at least 0.4 km.

Introduction

The Holocene glacial history of South Georgia, insofar as it is known, is summarized by Clapperton and others (1978). Following the Late Wisconsin ice maximum, a glacier standstill or advance produced a series of prominent end and lateral moraines in many of the fjords and valleys (T3 stage). Radiocarbon dates on organic deposits indicate that the ice had receded from some of these moraines by *c*. 9500–10000 years BP. Reduced glacier cover then appears to have prevailed until Neoglacial moraines formed some distance inside the T3 limits during the 17th to 19th centuries (T2 stage). Clapperton and others (1978) comment that 'it seems logical to anticipate that glaciers on South Georgia would have responded to global climatic oscillations which caused Neoglacial readvances around 5000 and 2500 years BP in other parts of the world. However, since no deposits or landforms clearly associated with a separate glacier advance lie between the moraines of the Little Ice Age expansion of the last few centuries and T3 moraines, it seems likely that any earlier Neoglacial readvances on the island were less extensive than those of the last few centuries, if they occurred at all' (p. 102). Also, in discussion of the paper, D. E. Sugden noted that no evidence had so far been found to indicate significantly warmer climatic conditions than at present (Clapperton and others, 1978, pp. 103–4).

Over the last few decades, corrie and small valley glaciers on South Georgia have been progressively receding since a minor readvance or standstill (T1 stage) during the early 1930s (Smith, 1960; Clapperton and others, 1978; Hayward, 1983). In the mid-1970s some of the larger valley glaciers were at their most advanced positions since the Neoglacial maximum of the 17th to 19th centuries (Clapperton and Sugden, 1980), but they too have receded significantly in the last few years (e.g. Gordon and Hansom, 1986). In the foreland of Nordenskjöld Glacier this recent recession has revealed peat deposits overridden by the glacier during the Late Holocene. Two radiocarbon dates from this peat are reported here and together with two other dates they provide a record of Late Holocene glacier changes.

Nordenskjöld Glacier

Nordenskjöld is a large valley glacier calving into Cumberland East Bay over a 3.5 km wide icefront. Two well-developed moraine systems occur in the eastern glacier

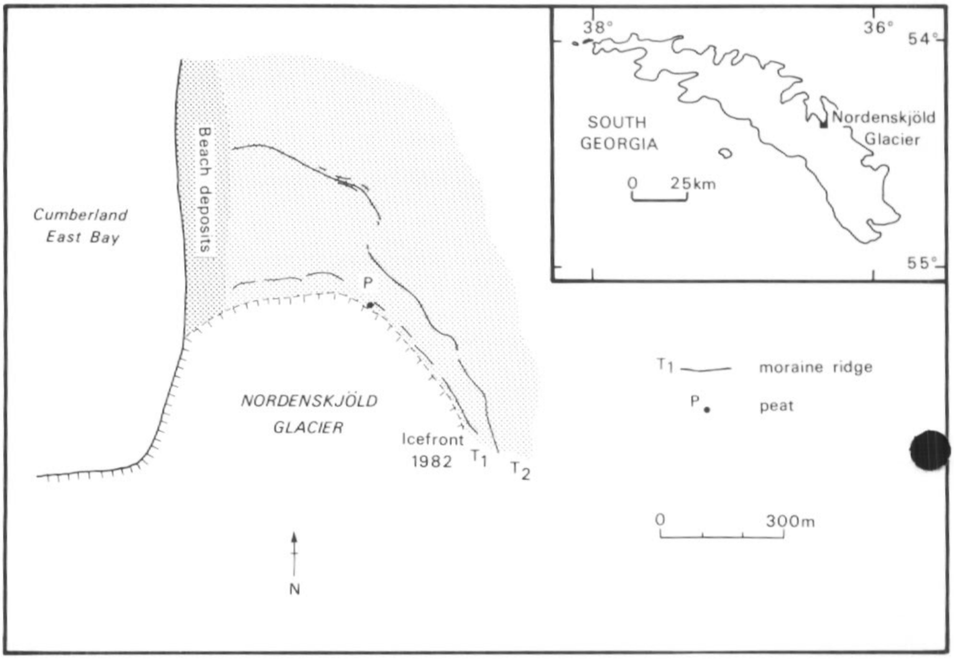

Fig. 1. Map of Nordenskjöld Glacier foreland showing the location of the radiocarbon-dated peat deposit (P) and the moraines associated with the T1 stage (17th to 19th centuries) and the T2 stage (20th century).

foreland where the ice margin terminates on land (Fig. 1). The outer, 300–400 m from the ice edge in 1982, has an extensive vegetation cover and probably represents the maximum of the T2 stage (Clapperton, 1971). A whalebone embedded in the surface of this moraine near its crest gave a radiocarbon date of 1540 ± 70 yr BP (SRR-49) (Harkness and Wilson, 1979). Assuming a reservoir correction of 1000 years for whalebone from South Georgia (Harkness, 1979; Harkness and Gordon, unpubl. data) and bearing in mind the additional uncertainties in calibrating marine radiocarbon dates (Stuiver and others, 1986), then a first approximation of the equivalent calendar date lies within the age range 524–655 yr BP (AD 1295–1426), using the calibration procedure recommended by Stuiver and others (1986). The maximum age for the formation of the moraine lies within this age range. Approximately 1 km down-valley from this moraine, G. Thom (pers. comm.) obtained a radiocarbon date of 1590 ± 30 yr BP (SRR-1497) (unpublished) from the base of a surface peat layer resting on raised beach deposits. Using the calibration procedure of Stuiver and Pearson (1986), this date corresponds with a calendar age range of 1394–1525 yr BP (AD 425–556). The sequence was not overlain by glacial sediments, indicating that Nordenskjöld Glacier has not been significantly more extensive during the last *c.* 1500 years than the position marked by the outer moraine.

The inner moraine is relatively fresher in appearance and in 1982 occurred 45–50 m in front of the ice edge. It represents the maximum of the T1 stage and is probably part of the moraine located variously at, or about 20 m in front of, the ice edge on air photos taken in December 1973 (R.N. *Endurance* 14/73).

At the eastern margin of the glacier in 1982, a meltwater stream had exposed *in situ*

Table I. Radiocarbon dates from Nordenskjöld Glacier foreland

Lab. no.	Material	Radiocarbon date BP	Calibrated date*	
			AD/BC	BP
SRR-2704†	Peat	2230 ± 70	173–385 BC	2122–2334
SRR-2705†	Peat	3330 ± 120	1446–1740 BC	3395–3689
SRR-49	Whalebone	1540 ± 70	AD 1295–1426	524–655
SRR-1497	Peat	1590 ± 30	AD 425–556	1394–1525

† New date.
* Radiocarbon dates are calibrated according to the procedures recommended by Stuiver and Pearson (1986), Pearson and Stuiver (1986) and Stuiver and others (1986).

a 6 cm thick bed of peat extending up to 10 m away from the ice edge. The peat was compacted, rested on till and weathered bedrock and was in turn partly covered by freshly deposited till. Radiocarbon dates of 2230 ± 70 yr BP (SRR-2704) and 3330 ± 120 yr BP (SRR-2705) were obtained from 0.7 cm thick layers sampled from the top and bottom of the peat respectively (Table I). When the calibration procedures of Stuiver and Pearson (1986) and Pearson and Stuiver (1986) are applied, these dates have equivalent calendar age ranges of 2122–2334 and 3395–3689 yr BP respectively. Together they bracket a period of vegetation development and allow an estimate of the minimum duration of a period of ice-free conditions at the site.

Discussion and Conclusions

The evidence reported above indicates the minimum duration of a period of more restricted extent of Nordenskjöld Glacier than in recent years during the Late Holocene between 2230 ± 70 and 3330 ± 120 yr BP (2122–2334 and 3395–3689 calendar years BP). This suggests climatic conditions at least similar to, or possibly warmer than, those of the last decade. Later expansion of the glacier during the T2 stage involved an advance of the eastern land-based terminus of at least 0.4 km which culminated some time after AD 1295–1426 and probably during the 17th to 19th centuries. Subsequently this part of the glacier receded by at least 250–300 m prior to the formation of the T1 moraines which culminated around 1970 (cf. Hayward, 1983). By 1982 the glacier had retreated 45–50 m from these moraines. At present the available evidence indicates that during the last *c.* 3500 years the fluctuations of Nordenskjöld Glacier have not been any more extensive than the position marked by the moraines of the T2 stage.

Published radiocarbon dates from two other glacier forelands have a bearing on the interpretation of Late Holocene glacier fluctuations on South Georgia (Clapperton and others, 1978; Clapperton and Sugden, 1983). At St Andrews Bay a date of 155 ± 45 yr BP (SRR-738) (Harkness and Wilson, 1979) from the top 1 cm of a layer of peat overlain by glacial till provides a maximum date for the T2 advance of Heaney Glacier (Clapperton and others, 1978). However, due to variations in atmospheric levels of ^{14}C in the past, radiocarbon dates may give more than one calendar age when calibrated by dendrochronology (e.g. Stuiver, 1978, 1982). Such variations were most marked during the last 450 years which particularly affects the interpretation of radiocarbon dates relating to Neoglacial glacier fluctuations (Porter, 1981). When calibrated using the scale of Stuiver and Pearson (1986), the date of 155 ± 45 yr BP from Heaney Glacier gives possible calendar age ranges of AD 1667–1703, AD 1720–1823 and AD 1917–1950. Although the last of these age ranges can be excluded from other evidence (Smith, 1960; Clapperton and others, 1978), this still leaves considerable uncertainty as to the exact age of the peat and hence the maximum age of the T2 glacier advance. The latter lies somewhere between AD 1667–1703 or AD 1720–1823.

At Wirik Bay an elephant seal bone buried in a moraine (Stone, 1976) gave a radiocarbon date of 880±40 yr BP (SRR-519) (Harkness and Wilson, 1979). Assuming a reservoir correction of 750 years for seal bone from South Georgia (Harkness, 1979; Harkness and Gordon, unpubl. data), then a first approximation of the equivalent calendar date using the calibration procedure of Stuiver and others (1986) lies within the range 160–285 yr BP (AD 1665–1790). The moraine therefore formed some time after a date within this age range.

The above discussion highlights some of the problems in attempting to interpret the glacial history of South Georgia during the last few centuries. Few radiocarbon dates are available, and natural variations in atmospheric radiocarbon levels produce multiple or wide calibrated age ranges. In addition, for dates on marine samples there is the uncertainty of estimating the magnitude of the appropriate reservoir correction. Consequently it is difficult at present to assess in any precise detail possible wider correlations or variations in timing between glacier fluctuations on South Georgia and those elsewhere in the maritime Antarctic or southern South America.

Acknowledgements

The work was supported by the Joint Services Expedition to South Georgia 1981–82 which included funding from the Royal Geographical Society. I am grateful to NERC and Dr D. D. Harkness for providing the radiocarbon dates SRR-2704 and SRR-2705, to Dr G. Thom for information on an unpublished date from Nordenskjöld Glacier and to Dr C. M. Clapperton for comments on the manuscript.

Received 6 March 1986; accepted in revised form 9 April 1987

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