RIDGE TOP PEATS AND PALAEOLAKE DEPOSITS ON MACQUARIE ISLAND

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(with one table, three text-figures and one plate)

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Palynological analyses of two ridge top peat profiles on subantarctic Macquarie Island are presented and discussed. The profiles record Holocene vegetation changes in a small-scale mosaic pattern. Older records of island vegetation should be sought in valley and lake deposits. A preliminary account is given of several freshwater palaeolake deposits dating from the terminal Pleistocene and early Holocene.

Key Words: peat deposits, palaeolake deposits, Macquarie Island, palynology.

INTRODUCTION

Contrary to earlier views (Mawson 1943, Colhoun & Goede 1974, Löffler & Sullivan 1980, Crohn 1986) that glaciation was an important factor in landscape evolution on subantarctic Macquarie Island, it is now clear that structural control by faulting and tectonic movement is probably a major force responsible for development of the present landscape (Ledingham & Peterson 1984, Christodoulou *et al.* 1984).

Information about tectonic uplift of localised sections of the island has come from several studies. Colhoun & Goede (1973), using data from McEvey & Vestjens' (1973) study of fossil penguin bones and their own studies of peat, calculated an uplift rate of 1.5-4.5 mm/yr for coastal beach terraces at Bauer Bay and Green Gorge. Bergstrom (1985), using evidence from plant microfossils and seal hairs in peat, calculated an uplift rate of 3-6 mm/yr for sites at Green Gorge. Selkirk *et al.* (1983), on the basis of evidence from plant microfossils in peat overlying a raised beach, calculated an uplift rate of 14.5 mm/yr for Wireless Hill, an isolated fault block at the northern end of the island.

The tectonically active nature of the island has implications for any further geomorphological and palaeontological studies. An extensive landslip occurred near the sampled profile at Green Gorge in early 1986 (plate 1). We suggest that peats on ridge tops on Macquarie Island are unlikely to preserve long vegetation records (table 1, p. 89), since they occur in sites very susceptible to landslip during earthquakes and/or periods of heavy rain. Ridge top accumulation sites in active tectonic environments are inherently unstable. Both ridge top sites described in this paper are adjacent to active fault zones (see Finch Creek site in fig. 4, Adamson *et al.*, this volume).

Longer sedimentary and fossil records (table 1) are more likely to be found in lakes and on valley floors than elsewhere on the island, but here too, because of tectonic activity, the records may not be as old as expected. There is also the complication that, in valley sites, landslips may superimpose older peat from ridges on younger valley peats.

Reports on material from two ridge top peat sites and four fossil lake deposits are presented below.

RIDGE TOP PEATS

Numerous peat exposures occur on ridge tops on Macquarie Island. They often form almost vertical faces, exposed by wind erosion, with weathered bedrock at the base and modern vegetation on top. Such exposures allow sampling from freshly cut, vertical faces. Two deposits have been analysed: one from a ridge at about 100 m a.s.l. on the southern rim of the Green Gorge basin (54°38'S, 158°54'E), between the Overland walking track and Sawyer Creek; the other from a ridge on the southern side of Finch Creek valley (54°34'S, 158°55'E) (fig. 1). Results of the analyses are given in figures 2 and 3. Standard palynological techniques (Brown 1960) were used to extract pollen for study.

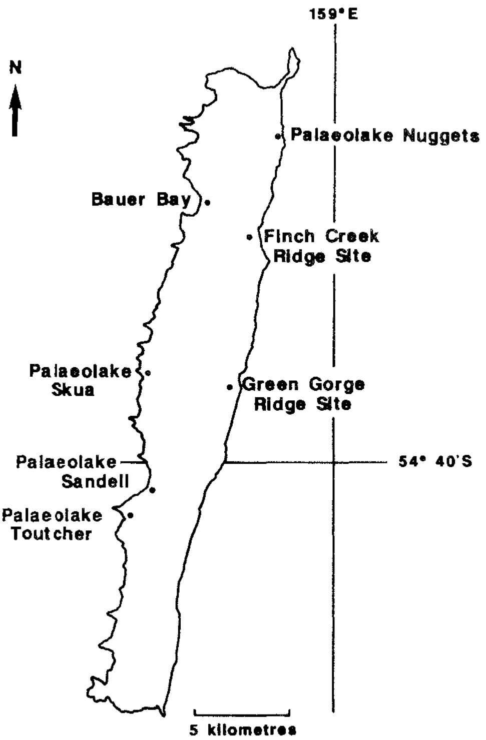

FIG. 1 — Macquarie Island showing study sites.

Modern vegetation topping the peat on the Green Gorge ridge site is short grassland, with *Luzula crinita*, *Festuca contracta*, *Acaena magellanica* and *A. minor*, *Poa foliosa*, *Cerastium fontanum*, *Uncinia sp.*, and the mosses *Campylopus introflexus*, *Orthodontium lineare* and *Thuidium furfurosum*. *Stilbocarpa polaris* and *Pleurophyllum hookeri* occur close by. The Finch Creek exposure is similarly topped by short grassland vegetation.

Vegetational changes recorded in both profiles are interpreted as representing small-scale community dynamics in herbfield or grassland. Both profiles show fluctuations between vegetation dominated by *Stilbocarpa* and/or *Acaena* (Green Gorge exposure) or *Stilbocarpa* alone (Finch Creek) and grassland. The grassland represented in the Green Gorge profile is probably short grassland: seeds of *Luzula* occur in the peat and *Luzula crinita* is at present a dominant in the short grassland. *Stilbocarpa* and/or *Acaena* often dominate herbfields. Short grassland and herbfield often occur in local mosaics.

Several authors have interpreted vegetation changes on Kerguelen in terms of climatic change, often over very short time spans (Bellair & Delibrias 1967, Roche-Bellair 1973, 1976a, b, Young & Schofield 1973). High percentages of *Azorella* pollen coupled with low percentages of *Acaena* have been interpreted as indicating cooler periods on Kerguelen (Roche-Bellair 1976a, b, Young & Schofield 1973) and in the Crozet Archipelago (Roche-Bellair 1973).

There is no need to invoke climatic change to explain the vegetational changes shown in the Green Gorge and Finch Creek profiles. They are best interpreted as representing successional or local changes within communities. Many subantarctic plant species which produce morphologically distinct pollen, easily recognisable in the pollen record (e.g. *Azorella*), have wide ecological tolerances (Barrow & Smith 1983, Pickard *et al.* 1984). Aubert de la Rue (1964) described *Azorella* in Kerguelen as growing at all altitudes from sea level to 840 m. *Azorella selago* is a coloniser of bared surfaces in Kerguelen (Roche-Bellair 1976a, Aubert de la Rue 1964). Huntley (1972) recorded *Azorella* in all communities on Marion Island and regarded it as a pioneer species, providing a substrate for less hardy species. Copson (1984) found *Azorella selago* to be very widespread on Macquarie Island. It occurs on large rocks at low altitudes, where interspecific competition is low, through to high altitudes, where the species is widespread in the feldmark. We believe the basal peak in *Azorella* pollen in each of the profiles studied represents vegetation establishment on bared surfaces.

Dating of Deposits

The Finch Creek ridge site was sampled on three occasions from three trenches (*a*, *b*, *c*), each trench more than 1 m from its neighbour (table 1). Good agreement was obtained in dating corresponding layers from successive samplings, except for the basal date in sampling *a*.

Selkirk & Selkirk (1983) reported the basal date of the Finch Creek ridge deposit described here as 10 275 ± 230 years B.P. (Beta-1386). The site was resampled on two occasions to test the validity of this date, as there seemed to be the possibility of a hiatus in accumulation between the basal layer and the 127 cm level. Basal peats collected on later occasions yielded dates far younger than 10 000 years B.P. Beta-1386 was obtained on a sample of only 0.4 g of carbon. The discrepancy between Beta-1386 and other dates

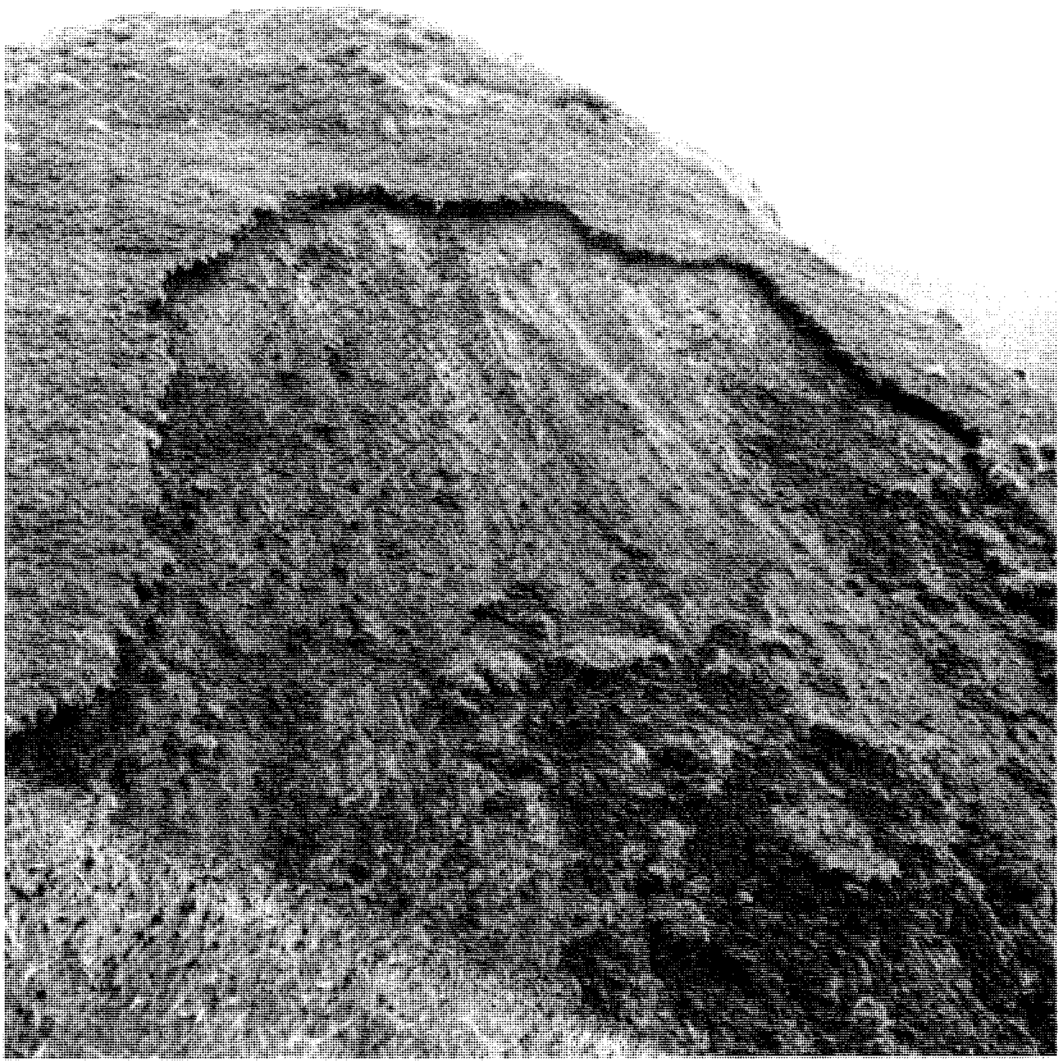

PLATE 1

In early 1986 a landslip removed an extensive area of peat from the eastern side of the ridge the top of which had been earlier sampled as the Green Gorge ridge site. The surface was bared back to bedrock over much of its area.

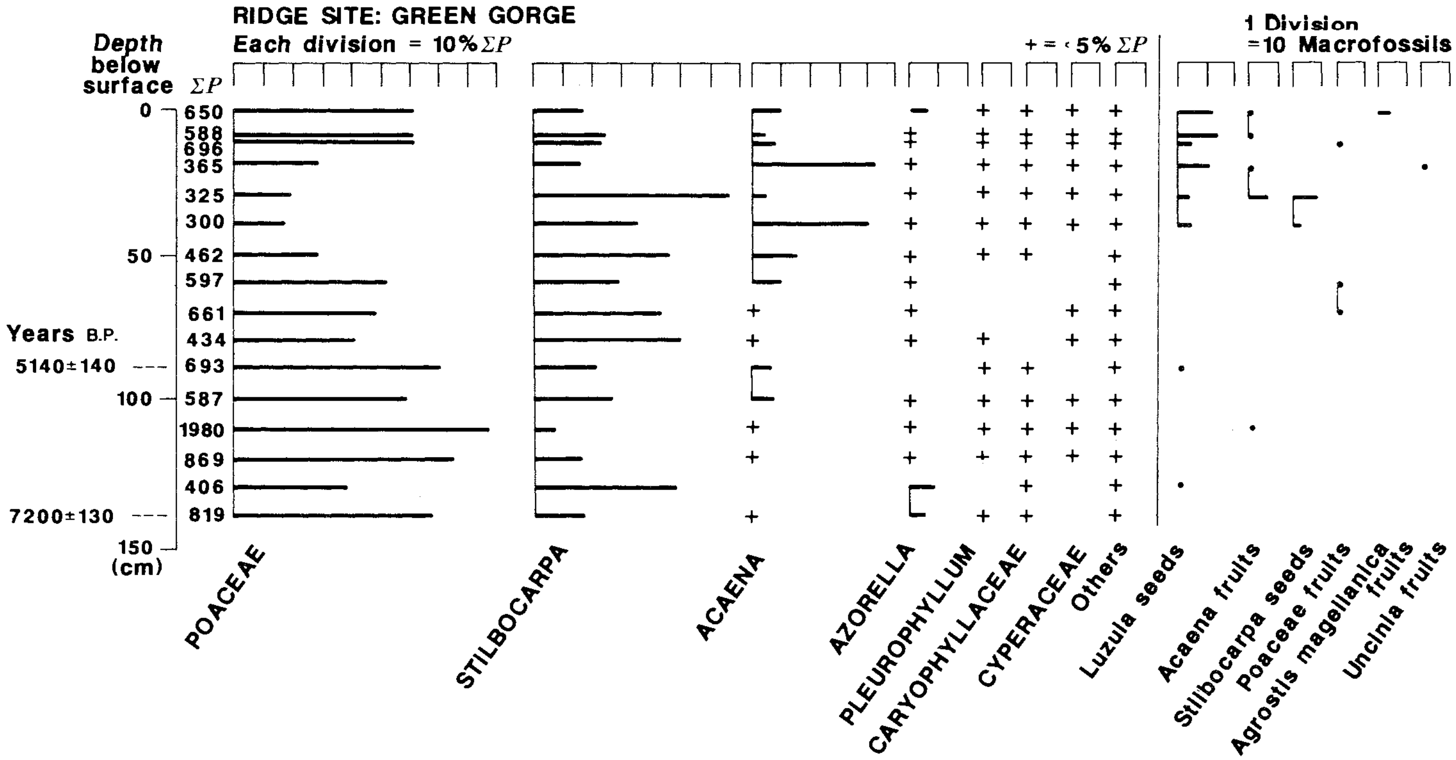

FIG. 2 — Pollen diagram for Finch Creek Ridge site. Ages in radiocarbon years B.P. Calibrated ages and laboratory numbers in table 1.

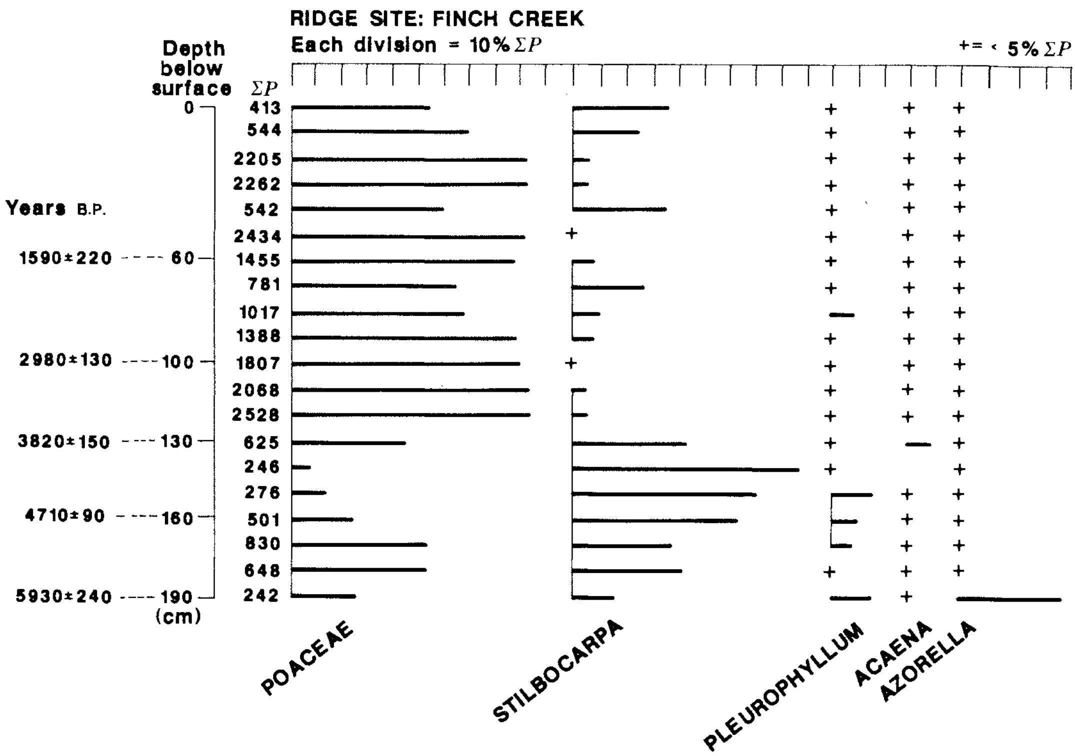

FIG. 3 — Pollen diagram for Green Gorge Ridge site. Ages in radiocarbon years B.P. Calibrated ages and laboratory numbers in table 1.

shown in table 1 probably results from a laboratory error, but could represent fortuitous inclusion of older peat in the original sample.

The Green Gorge ridge site was sampled on two occasions from two trenches 1 m apart (*a*, *b*). Sampling *b* provided a larger sample to refine the error on sampling *a* (table 1).

FOSSIL LAKE DEPOSITS

Palaeolake Skua (fig. 1)

Skua Lake and several other small lakes and ponds lie in a broad shallow basin about 180 m a.s.l. on the western edge of the plateau, west of Mt Ifould and north of Mt Waite. Skua Lake drains via a creek over the cliff into Sellick Bay. Northwest and west of the outlet creek, in the cliff on the northern side of Sellick Bay, exposed lacustrine deposits extend about 9 m above and about 5 m below the present level of Skua Lake. The lake deposits can be followed eastwards in ridges at the southwestern end of Skua Lake.

The 13.6 m of sediments are bedded, the beds dipping northeast at an angle of about 8°. We interpret the sediments as lacustrine, possibly tilted by faulting, indicating the presence of a former, larger Palaeolake Skua, which extended westwards beyond the present cliff. Preliminary examination of the bedded sediments indicates excellent preservation of microfossils (pollen, diatoms) and macrofossils (leaves of *Myriophyllum*, leaves and stems of mosses, and seeds). The fossils present indicate that the entire sequence was laid down in freshwater conditions. We suggest that Palaeolake Skua was partially drained as the western cliffline retreated eastwards, due to marine erosion, to its present position. The present Skua Lake and other small lakes and ponds in its vicinity are remnants of the more extensive Palaeolake Skua whose shoreline was at least 9 m above the present level of Skua Lake.

The lowest bed dated from the sediments of Palaeolake Skua (4.6 m above the base of the bedded deposit) gives an age of 12 470 ± 140 years

B.P. (Beta-20165) (table 1), making it the oldest material dated from Macquarie Island (cf. Colhoun 1985).

Palaeolake Sandell (fig. 1)

Palaeolake Sandell occupies a small shallow valley, about 210 m a.s.l. to the north of Major Lake. A deeply incised creek drains the present mire over the cliff into Sandell Bay. Bedded sediments are exposed in the creek bank to 3.8 m above water level in the creek on the day of sampling. A sample collected by auger from 0.4 m below the creek water level, dated at 7960 ± 110 years B.P. (Beta-20163) (table 1), contains well-preserved microfossils (phytoliths, diatoms, pollen) and macrofossils (leaves of *Myriophyllum*, *Azorella*, leaves and stems of mosses and seeds). Samples from higher levels in the deposit contain well-preserved macrofossils including small woody stems, alternately layered with sandy gravel horizons. Preliminary examination suggests that the deposit represents a mire developed above a former lake.

Palaeolake Nuggets (fig. 1)

A lacustrine deposit topped by Holocene peat forms a 4.5 m exposure in the coastal cliff 30 m a.s.l. at the head of a small gully just north of The Nuggets (Mawson 1943, Selkirk & Selkirk 1983). The sediments contain well-preserved microfossils (diatoms, pollen) and macrofossils (leaves of *Myriophyllum*, leaves and stems of mosses) and have been dated at 9400 ± 220 years B.P. (SUA-1894) (table 1) 4.4 m below the surface (Selkirk & Selkirk 1982, Pickard *et al.* 1984). Palaeolake Nuggets was sampled on two occasions (*a*, *b*). There is good agreement between dates obtained except for the 40 cm and 50 cm levels.

We interpret the deposit as a remnant of a lake which formerly extended eastwards beyond the present cliffline; a lake drained by retreat of the cliffline due to marine erosion.

Palaeolake Toutcher (fig. 1)

Just south of Cape Toutcher, a creek drains Major Lake and a series of smaller lakes and ponds south of and connected to it, then flows over the coastal cliff at about 200 m a.s.l. Diatomites and contained macrofossils exposed in the creek bed near the edge of the plateau date at 11 010 ± 200 years B.P. The bedded sediments contain well-preserved microfossils and macrofossils (leaves of Myriophyllum, stems and leaves of mosses, diatoms and pollen).

DISCUSSION

If the estimated rates of uplift for Bauer Bay and Green Gorge are considered in conjunction with the Quaternary sea-level curve (Chappell 1983) it is apparent that between about 16 000 and 6000 years B.P., sea level was rising more rapidly than the island. If the land was rising at between 1.5 and 6 mm/yr while sea level was rising at about 15 mm/yr (i.e. 150 m/10 000 yrs), erosion of sea cliffs would have been very active. We conclude that it was during this period of post-glacial sea-level rise that cliff retreat drained the palaeolakes described above.

Detailed examination of material preserved in these deposits, dating of additional layers, and sampling of lower layers, as at Palaeolake Toutcher, will allow reconstruction of environmental conditions at each site in the early Holocene and terminal Pleistocene. Preliminary conclusions are that no palaeolake site described above has been subject to marine influence and that the vegetation represented in the deposits was composed of species currently growing on the island.

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TABLE 1

Ages in Radiocarbon Years and Calibrated Ages for Organic Material* Sampled from Six Sites

Site, sampling occasion**		Depth below surface (cm)	Laboratory number	Age in radio-carbon years (B.P. ± s.d.)	Calibrated age (B.P. ± 95% confidence level)***
1. Finch Creek Ridge	b	40	SUA-1850	modern	–
	c	50	SUA-2129	280± 50	380± 95
	b	60	SUA-1849	1590±220	1545P365
	b	100	SUA-1848	2980±130	3150±365
	c	100	SUA-2128	2990± 50	3115±240
	a	127	SUA-1460	3860±140	4320±410
	b	130	SUA-1847	3820±150	4280±430
	c	150	SUA-2127	3880± 90	4340±260
	b	160	SUA-1846	4710± 90	5425±300
	a	182	Beta-1386	10275±230	–
	b	190	SUA-1845X	5930±240	6790±410
	c	190–200	SUA-2126	5630± 80	6380±280
2. Green Gorge Ridge	a	88	SUA-1462	5140±140	5805±495
	b	130	SUA-2164	7200±130	8000±525
	a	138	SUA-1461	6900±900	–
3. Palaeolake Skua		220	Beta-20166	8620±170	9420±340
		900	Beta-20165	12470±140	–
4. Palaeolake Sandell		160	Beta-20164	5220± 80	6025±290
		420	Beta-20163	7960±110	8760±220
5. Palaeolake Nuggets	b	40	SUA-2157	3920±110	4420±300
	a	50	SUA-1468	1700±110	1640±260
	b	55	SUA-2158	6850±100	7685±360
	b	70	SUA-2159	8540±130	9340±260
	b	90	SUA-1893	8300±230	9100±460
	a	150	SUA-1467	8560±200	9360±400
	b	240	SUA-1892	9000±250	9800±500
	a	340	SUA-1466	8230±240	9030±480
	b	440	SUA-1894	9400±220	10200±440
6. Palaeolake Toutcher			Beta-20162	11010±200	–

* Peat from sites 1, 2; lacustrine sediments from sites 3-6.

** a, b or c indicate trenches dug on three separate occasions, each more than 1 m from its neighbour.

*** Ages less than 8000 radiocarbon years have been calibrated following Klein *et al.* (1982); ages between 8000 and 10 000 radiocarbon years have been calibrated by adding 800 years to conventional date and doubling the standard deviation to give 95% confidence interval; ages greater than 10 000 radiocarbon years have not been calibrated.

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