Lake sediments and glacial history in the High Arctic; evidence from east-central Ellesmere Island, Arctic Canada, and from Inglefield Land, Greenland[1]

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Deciphering glacial history in many High Arctic localities is difficult because: 1) surficial deposits are often thin or non-existent, 2) vast tracts are underlain by soft and friable bedrock, 3) the churning effects of frost action and slope processes tend to eradicate traces of glaciation, 4) cold based ice caps leave little trace of their former presence, except where marginal drainage channels form on uphill slopes, and 5) significant areas still are covered by glacier ice. Where present, striae show that an area has been glaciated, but until a technique is devised to determine when a given set of striae was inscribed, or when a striated surface became exposed to daylight (e.g. Phillips et al. 1986; Elmore & Phillips 1987), the timing of the glacial event responsible remains an enigma.

One way of approaching the problem of dating glacial events, in the High Arctic as elsewhere, is to determine the age of organic deposits associated with till or outwash. Radiocarbon dating of the basal increment from a lake sediment core or a peat deposit provides a minimum age for deglaciation and for the onset of organic accumulation. In this connection the advent of ^{14}C dating by means of accelerator mass spectrometry (AMS) has provided an extremely powerful tool for determining the timing of events more precisely. For instance, the change from marine to lacustrine conditions or, in the case of a lake above the limit of Holocene marine submergence, the onset of lacustrine moss growth can be pin-pointed much more accurately using this technique (Blake 1985).

Available basal dates on reliable organic materials from lakes in east-central Ellesmere Island, an area underlain by granites, migmatites, and associated rocks of the Canadian Shield, do not exceed 9500 radiocarbon years. The oldest age determinations, among seven lakes dated, have been obtained along the outer east coast, facing Smith Sound and Kane Basin: 9370 ± 110 years (TO-111) from Proteus Lake at 390 m on Pim Island (Site 1 on Fig. 1: 78°41.7′N, 74°23′W) and 9130 ± 160 years (GSC-3432) from 'Cliff Edge Pond' at 375 m on Bache Peninsula (Site 2: 79°02′N, 75°04′W; Blake 1987). However, the basal organic sediment in 'Rock Basin Lake', at 295 m south of Ekblaw Glacier in innermost Baird Inlet (Site 3: 78°29.5′N, 76°46.8′W) and 50 km southwest of Proteus Lake, is nearly as old, 8970 ± 160 years (GSC-3051; Blake 1981; Smol 1983; Hyvärinen 1985).

Other lakes at even higher elevations and farther inland have yielded younger dates. The basal organic sediment in an unnamed lake at 650 m on Knud Peninsula (Site 4: 79°03′N, 77°27′W), above the junction of Beitstad and Jokel fiords, is 6210 ± 70 years old (GSC-3602), and algae at a depth of over 4 m in the ice of a lake frozen to the bottom (total ice thickness, 5.45 m) on top of Rundfjeld (close to 830 m a.s.l.; Site 5: 78°29′N, 81°21.5′W) yielded an age of 5730 ± 70 years (TO-530). The latter site is on a mountain top above the western edge of the central Ellesmere Island ice cap.

On the Greenland side of Smith Sound (a mere 40 km wide in places), although several lakes have been cored, ^{14}C dates are available for only 'Kap Inglefield Sø' (Site 6: 250 m a.s.l.; 78°31.8′N, 72°21′W), a lake which, like its counterparts on Ellesmere Island, is well above the limit of Holocene marine submergence. The basal organic sediment is 7210 ± 130 years old (GSC-3732; Blake et al. 1985; Blake 1987). Farther south, however, on Nordvestø in the Carey Øer group, northern Baffin Bay (Site 7: 76°43.5′N, 73°11′W), basal peat on the plateau at 125 m a.s.l., and above the limit of Holocene marine submergence, is 8940 ± 90 years old (GSC-2440; Brassard & Blake 1978; Blake 1987). Still farther southeast, on the peninsula of Tugtuligssuaq in Melville Bugt, the basal organic sediment in Langesø (Site 8: 75°22′N, 58°36′W) is 8540 ± 120 years old (K-3276). This lake, at only 15 m a.s.l., is nevertheless above the local limit of Holocene marine submergence (Fredskild 1985a, 1985b).

Thus, no organic lake sediments have been obtained as yet, in either east-central Ellesmere Island or northwestern Greenland, which span more than Holocene time. A particular effort has been made to penetrate as deeply as possible during the coring process, utilizing specially designed equipment. This has been done in order to see if additional organic materials were present beneath the inorganic horizon (sand, silt, clay, till, or till-like material) in which refusal normally occurs. Using the new equipment (a stainless steel barrel with tungsten carbide teeth fitted outside the normal plastic coring tube), which allowed us to rotate the whole coring device after the hydraulic system failed to drive the tube deeper into the sediments, we recovered 8 cm of frozen sediment at the base of a 90 cm-long core in the lake at 650 m on Knud Peninsula (Site 4: 7.4 m from ice surface to sediment/water interface). In the case of 'Cliff Edge Pond' on Bache Peninsula (Site 2) we recovered cobbles up to 7 cm in diameter. In neither of these lakes, nor in any others we have cored so far, have buried organic layers been encountered.

If any of these sites were free of glacier ice throughout Late Wisconsinan time, then longer records of continuous organic

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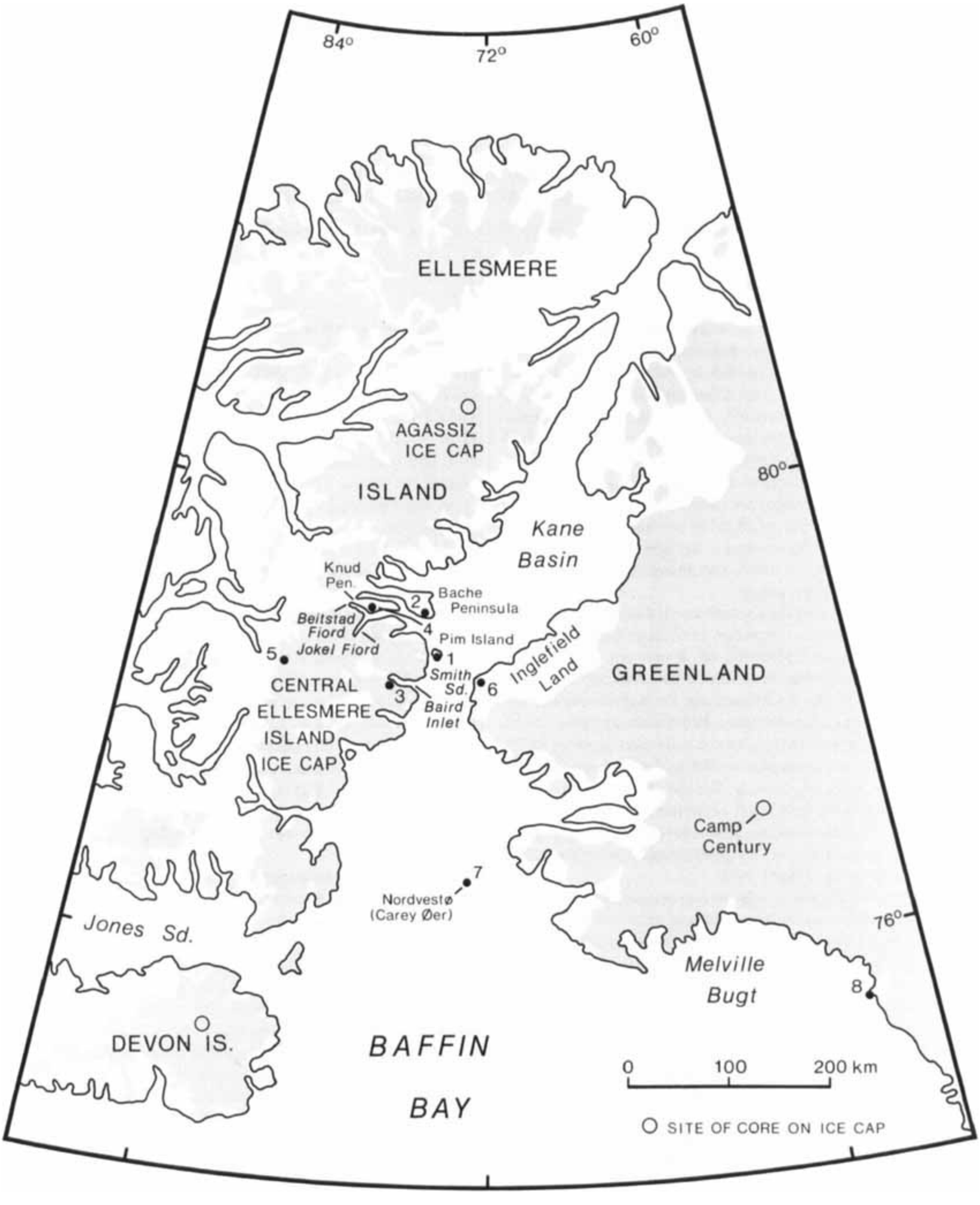

Fig. 1. Location map for sites discussed in the text.

sedimentation should be present, such as those which have been obtained from the Yukon Territory (Rampton 1971; Cwynar & Ritchie 1980) or from Andøya, northern Norway (Vorren 1978). The fact that older organic deposits have not been found suggests that a cover of glacier ice was present until immediate pre-Holocene time. The disappearance of a massive volume of ice at this time is in agreement with the drastic warming documented by the changes in $^{18}O/^{16}O$ ratios from Camp Century, Greenland (Dansgaard et al. 1984) 350 km to the east-southeast, from the Devon Island Ice Cap (Koerner & Fisher 1985) 400 km to the south-southwest, and from the Agassiz Ice Cap (Koerner et al. 1987) some 250 km to the north on Ellesmere Island (Fig. 1).

Presumably a similar pattern of ice cap (ice sheet) growth and demise has occurred during each glacial/interglacial cycle. It is also worth noting that shallow lake basins at high elevations, once excavated, may serve as nuclei for the development of small ice caps during succeeding glaciations. As the climate worsens, the thickness of ice on a lake will increase until the lake freezes to the bottom. The level of the ice surface will continue to build up as most of each winter's accumulation of snow remains intact, a moat no longer develops around the lake during the summers, and permanent snowdrifts develop on the periphery of the lake. The result is that the former lake basin becomes the thickest part of a miniature ice cap and, as the snow and ice masses in adjacent lake basins coalesce, a larger ice cap develops.

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