

Interpretation of minimum-limiting radiocarbon dates for deglaciation of Mount Katahdin area, Maine

P. T. Davis

Quaternary Research Center, University of Washington
Seattle, Washington 98195

R. B. Davis

Department of Botany & Plant Pathology and Institute for Quaternary Studies
University of Maine, Orono, Maine 04469

ABSTRACT

Radiocarbon dates from bog- and lake-bottom sediments commonly have been used to estimate the time of deglaciation, although many studies suggest that these dates may be too recent by several thousands of years. Three bog- and pond-bottom radiocarbon dates from Mount Katahdin, Maine, are about 5,000 to 9,000 yr more recent than the time of deglaciation suggested by independent evidence. A radiocarbon date from lake-bottom sediment from the lowland south of Mount Katahdin, however, probably is less than 800 yr more recent than deglaciation. Piping of sediment between large boulders during early stages of alpine bog and pond development may explain the lengthy time lag between deglaciation and accumulation of datable organic material on alpine bog and pond bottoms.

INTRODUCTION

A recurring problem in Quaternary geology involves interpretation of minimum-limiting radiocarbon dates for deglaciation chronologies. Three major studies rely on radiocarbon dates from bottom lacustrine and bog sediments for construction of isochrone maps of late Wisconsin deglaciation of the Laurentide ice sheet (Prest, 1969; Bryson and others, 1969; Mayewski and others, 1980). However, the time lag between accumulation of glacial deposits and accumulation of datable material in depressions on or behind the deposits commonly is unknown. Clayton (1967), Florin and Wright (1969, p. 701), Porter and Carson (1971, p. 411), and Stuiver and Borns (1975, p. 101) inferred time lags as long as 2,500 yr between melting of stagnant ice blocks and the deposition of organic debris in the resulting depressions on ice-sheet deposits in North Dakota, Minnesota, the Puget Lowland, and Maine. From alpine glacier areas, Porter (1976, p. 73) reported a bog-bottom radiocarbon date that is about 4,000 yr more recent than the underlying Hyak drift in Washington, and Madole (1978, p. 220) suggested that hundreds to thousands of years separated deglaciation from the beginning of peat formation in bogs in north-central Colorado.

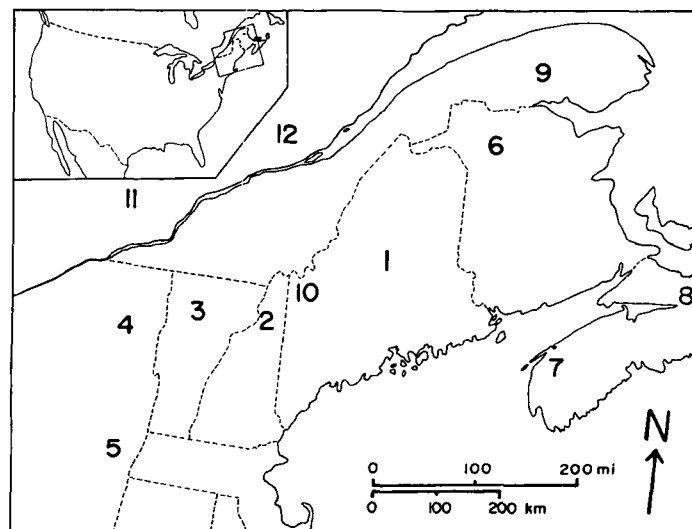


Figure 1. Index map of northeastern United States and adjacent areas of Canada showing proposed locations of highland centers of radial outflow of former glacier ice that postdate recession of continental ice (Flint, 1951, p. 23). 1, Mount Katahdin (Maine); 2, Presidential Range, White Mountains (New Hampshire); 3, Green Mountains (Vermont); 4, Adirondack Mountains (New York); 5, Catskill Mountains (New York); 6, Central Highlands (New Brunswick); 7, Uplands (southwestern Nova Scotia); 8, Cobequid Mountains (Nova Scotia); 9, Shickshock Mountains (Quebec); 10, Appalachians (west-central Maine); 11, Highlands (Quebec); 12, Highlands (Quebec).

A lack of radiocarbon dates has helped fuel a recent controversy that concerns the deglaciation of highland areas in New England, New York, and adjoining Canadian provinces (Fig. 1). In this paper we present five radiocarbon dates taken for the purpose of determining the time of deglaciation of the Mount Katahdin area. We propose that three of the dates from bog- and pond-bottom deposits are as much as about 9,000 yr too recent for dating deglaciation, and we resurrect an old idea to explain the discrepancy. The dates given are in radiocarbon years B.P. (before 1950 A.D.).

DEGLACIATION OF MOUNT KATAHDIN

Mount Katahdin was not a local ice center during the waning stages of Wisconsin glaciation. Unweathered sedimentary,

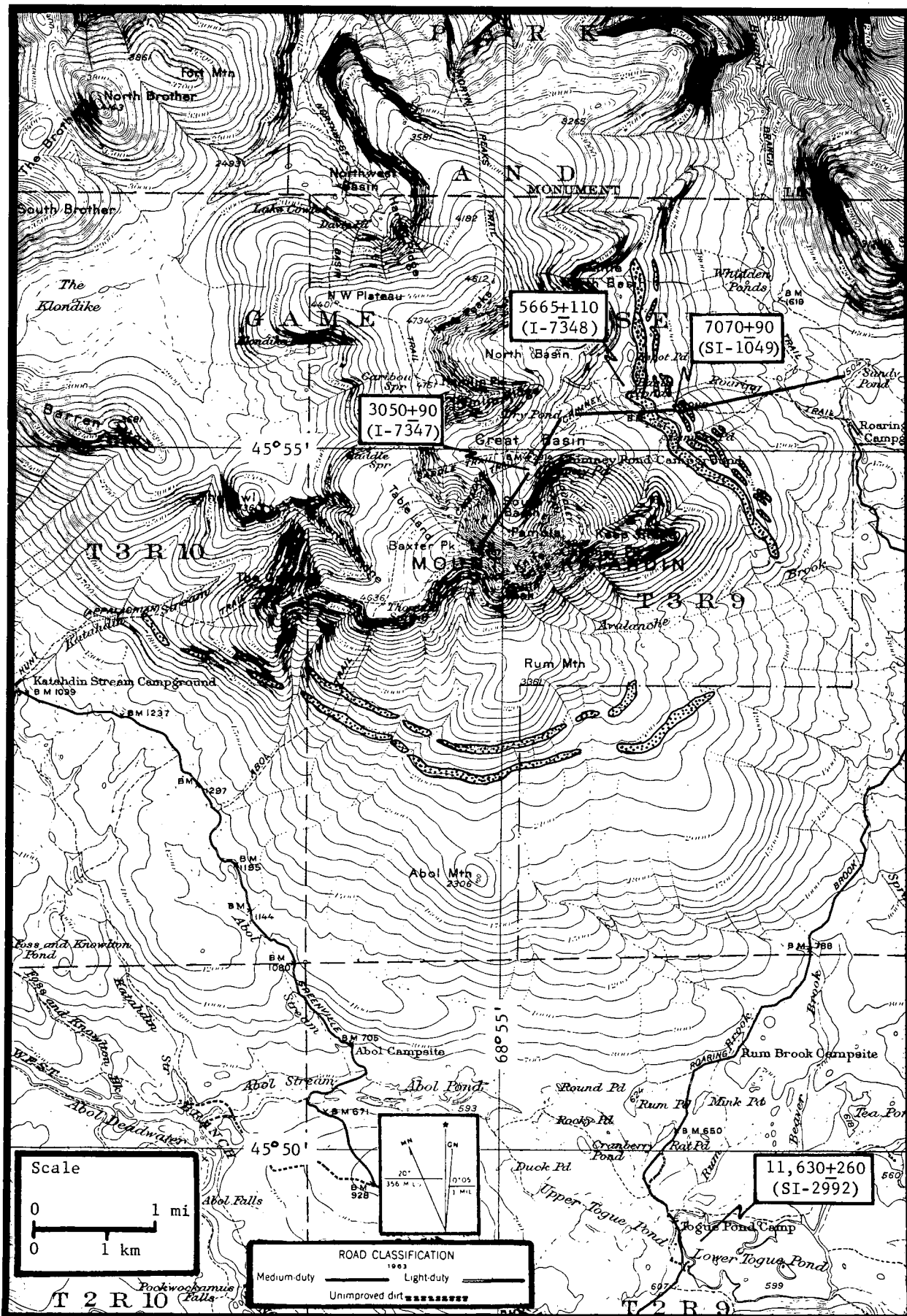


Figure 2. Topography of Mount Katahdin area, Maine. Lateral moraine systems are outlined and stippled (from Davis, 1976). Base map is U.S. Geological Survey, Katahdin 15-minute topographic map sheet, scale 1:62,500, contour interval 20 ft.

metamorphic, and volcanic erratics of northern provenance indicate that the summit of Mount Katahdin was overridden by Laurentide ice. Theoretical ice-sheet profiles constructed along flow lines inland from a dated ice-front position near the present coastline suggest that overriding occurred in late Wisconsin time (Davis, 1976). Moreover, little soil-profile development, only minor weathering of granitic bedrock exposures and erratics, and a polished bedrock surface also suggest that upland areas (1,200 to 1,605 m) on Mount Katahdin were covered by continental ice during late Wisconsin time (Davis, 1978). Davis (1976) found no indisputable evidence that active cirque glaciation post-dated late Wisconsin ice recession from Mount Katahdin; this suggests that the cirques largely predate the late Wisconsin ice sheet. In Northwest Basin (Fig. 2), roches moutonnées with chat-termarks and steep sides facing up-cirque, as well as till of a northern provenance, suggest that continental ice recession was the last Wisconsin glacial event that occurred on Mount Katahdin. Lack of moraines on all cirque floors corroborates the above evidence. Lateral moraines on the east and south flanks of Mount Katahdin (Fig. 2) apparently formed by continental ice during the final stages of deglaciation when the mountain was a nunatak (Davis, 1976).

CORING AND RADIOCARBON DATES FROM MOUNT KATAHDIN

Radiocarbon age determinations were sought on samples from Mount Katahdin to try to calibrate three deglaciation events: (1) deglaciation of uplands from overriding continental

ice, (2) deglaciation of lowlands surrounding Mount Katahdin, and (3) deglaciation of cirques. Topographic depressions with organic material were not found on the upland areas of the mountain, but lakes, ponds, and bogs are numerous in cirques, behind moraines, and in the lowlands. Each basin was probed thoroughly on a grid to select the thickest and oldest sediment section; however, probings were not spaced closely enough to detect an uneven boulder base. Two cores of lacustrine sediment from each of three lakes and ponds were taken with a 5-cm-diameter modified Livingstone corer, and two cores from a bog were taken with a Davis peat corer. Coring ceased when impenetrable coarse gravels or boulders were encountered. The basal sediments from three of the four sites are thought to directly overlie till boulders, because all basal coring tubes were stopped abruptly and the tips severely dented asymmetrically at basal depths during the penetration-by-hammering process. Most basal lacustrine sediments were laminated and did not exhibit slump features or plant macrofossils that would indicate periglacial activity or vegetated stagnant ice. Material immediately overlying till or outwash was radiocarbon dated (Table 1).

The organic detrital material of basal sediments from Chimney Pond, Lower Basin Pond, and the bog fail to date deglaciation. The Chimney Pond basal-sediment date does preclude, however, extensive cirque glacier activity in South Basin after 3050 B.P. Because continental ice retreated by thinning in the valley east of Mount Katahdin, the basal date for the lowest sediment from Lower Basin Pond should be older, rather than 1,400 yr younger, than the 7070 B.P. radiocarbon date from the

TABLE 1. RADIOCARBON DATES AND SEDIMENT ACCUMULATION RATES FROM MT. KATAHDIN AREA PONDS AND BOGS

Lab. No.*	Radiocarbon date (yr B.P.)	Location† Elevation (m) Water depth (m)	Material, sediment depth**, significance	Collectors and year	Mean sediment accumulation rate (cm/yr)††
I-7347	3050 ± 90	Chimney Pond 881 5.3	Bottom silty diatomaceous pond sediment, 383 to 391 cm depth; minimum age for formation of Chimney Pond and deglaciation of South Basin cirque	R. B. Davis and P. T. Davis, 1973	0.13
I-7348	5665 ± 110	Lower Basin Pond 741 3.6	Bottom silty diatomaceous pond sediment, 312 to 322 cm depth; minimum age for formation of Lower Basin Pond by possible readvance of continental ice	R. B. Davis and P. T. Davis, 1973	0.06
SI-1049	7070 ± 90	Bog on Basin Ponds moraine system 705 0	Bottom peaty sediment of bog, 840 to 860 cm depth; minimum age of moraine loop east of Basin Ponds moraine	H. W. Borns, Jr., R. B. Davis, W. Anderson, and R. Hoenstine, 1971	0.12
SI-2992	11,630 ± 260	Lower Togue Pond 183 10.8	Laminated lake sediment, 1,285 to 1,305 cm depth, 50 cm above outwash sand, minimum age for deglaciation of valley southeast of Mt. Katahdin	R. B. Davis and W. Karlén, 1976	0.11
SI-2732	21,300 ± 1900	Do.	Laminated lake sediment, 1,346 to 1,356 cm depth, directly above outwash sand; very small sample, heavily diluted, probably contaminated	Do.	n.a.

*I = Isotopes, Inc.; SI = Smithsonian Institution.

†See Figure 2 for coring locations.

**Top surface of sediment = 0 cm at deepest part of basin.

††Interpolated from radiocarbon dates.

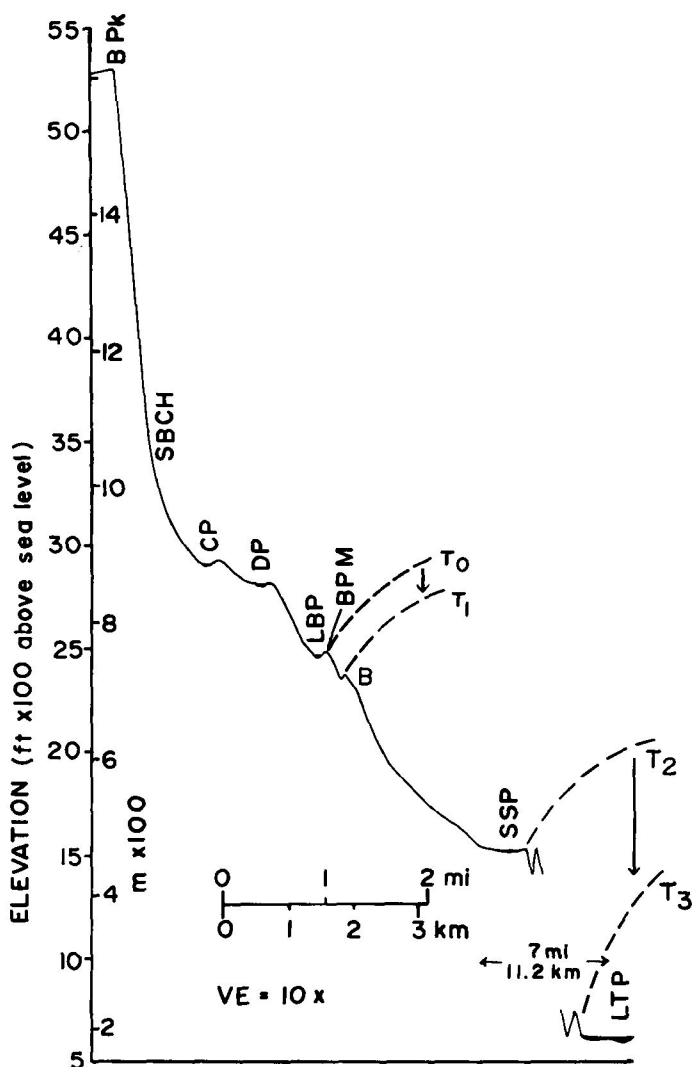


Figure 3. East-west topographic profile, Mount Katahdin, Maine. Vertical exaggeration 10x. See Figure 2 for location of profile. BPK = Baxter Peak [main Katahdin summit, 1,605 m (5,267 ft)]; SBCH = South Basin cirque headwall; CP = Chimney Pond; DP = Dry Pond; LBP = Lower Basin Pond; BPM = Basin Ponds moraine system; B = bog; SSP = Sandy Stream Pond; LTP = Lower Togue Pond. Theoretical retreat of continental ice shown by dashed lines labeled T_0 , T_1 , T_2 , and T_3 .

bottom organic detritus in the bog above a recessional moraine downslope of the Basin Ponds moraine (Table 1, Figs. 2, 3). A near-basal radiocarbon date of 11,630 B.P. from Lower Togue Pond is a minimum-limiting age of deglaciation of the lowland south of Mount Katahdin. A radiocarbon date of 21,300 $\pm$ 1900 B.P. for a sample stratigraphically below sediment that yielded the 11,630 B.P. date (Table 1) was probably contaminated because of the small sample size and heavy dilution in the laboratory. However, the too-old date of 21,300 $\pm$ 1900 B.P. could also be due to ^{14}C -depleted organic matter contained by the wasting continental ice (compare Schroeder and Bada, 1978). An extrapolated sediment-accumulation rate, based on the 11,630 B.P. date and the assumption that the top of the 13-m sediment core is modern, suggests that the age of the very base of the Lower Togue Pond sediments could be about 12,180 yr (Table 1). Such an age accords with 23 radiocarbon dates that suggest that Laurentide ice receded in central Maine between about 13,000 and 12,700 yr ago (Stuiver and Borns, 1975, p. 100). Therefore, about 9,000 yr intervened between deglaciation and the beginning of sediment accumulation in Chimney Pond, about 6,500 yr at Lower Basin Pond, and about 5,000 yr in the bog behind the recessional moraine.

The pond-bottom sediment dates on Mount Katahdin greatly underestimate the time of deglaciation, apparently because of a peculiar evolution of these ponds. Dry Pond (Fig. 2) holds water only for a few days during spring snowmelt and after intense rainstorms (Fig. 4A). Fine material is flushed out through cavities among the large boulders on its floor (Fig. 4B). Probably a similar flushing occurred during early stages of formation of Chimney and Lower Basin Ponds and the bog downslope of the Basin Ponds moraine. Less than 0.6 m of sediment rests in the deepest water (10.1 m) area of Upper Basin Pond. Upper Basin Pond has continued to hold water, according to all historic observations, but the trivial sediment compared to Lower Basin Pond suggests that it has not done so continuously through postglacial time.

DISCUSSION

Mickelson and Borns (1972) interpreted time lags of 800 to 2,500 yr or more between deglaciation and accumulation of peat in kettles along coastal Maine to have resulted from stagnant ice blocks remaining in the kettles following deglaciation. Although

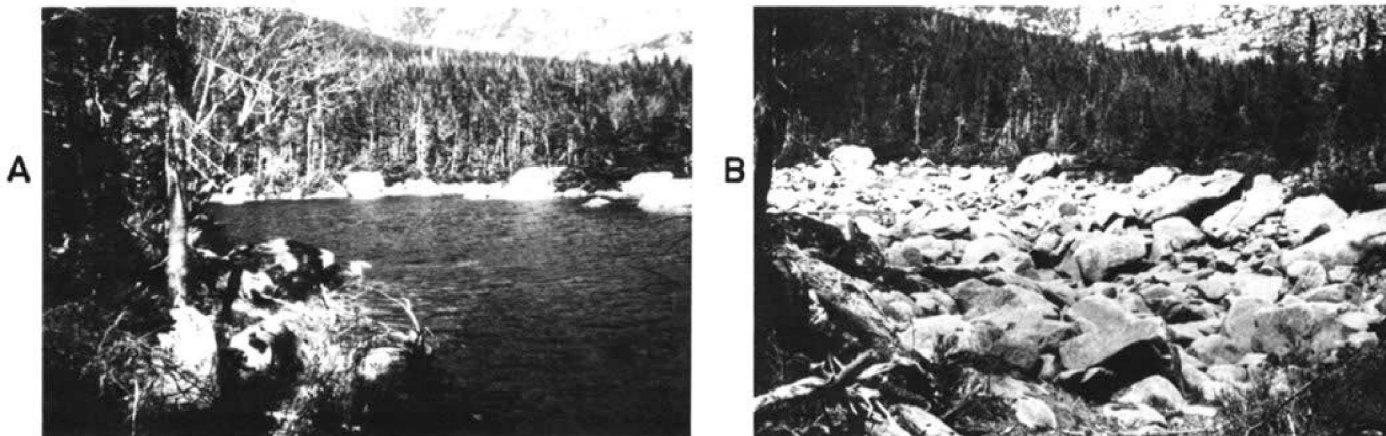


Figure 4. Dry Pond, Mount Katahdin, Maine. (A) Boulder depression filled with water the day after a rainstorm in June 1973. (B) Photograph from same location as for A showing boulder depression drained of water three days later. Piping could have removed sediment—including detrital organic material—from depression through spaces between boulders.

Lower Togue Pond in the lowland south of Mount Katahdin is a multiple kettle, the bogs and ponds on Mount Katahdin are in topographic depressions within hummocky ground moraine or are dammed by lateral moraines and thus are unrelated to deglaciation by stagnant ice. Vegetation on stagnant ice (Madole, 1976, p. 167) also is an implausible explanation for the Mount Katahdin dates because of the attitudes of the laminae and the absence of plant macrofossils in the bottom sediments. Ponds on Mount Katahdin are probably too deep to allow mixing of sediment by lake ice frozen to pond bottoms, an explanation for minimum-limiting radiocarbon dates in Keewatin (Nichols, 1967). A concerted effort was made to core the deepest and oldest organic material on bog and pond bottoms, a concern expressed by Potzger (1956). Because of the variability among the bog- and pond-bottom radiocarbon dates (Table 1), the time lag on Mount Katahdin probably cannot be explained by one climatic or environmental event.

We propose that conditions specific to each mountain basin affect the particular time at which lake bottoms become sealed with sediment. Thus, we believe that piping of sediments through boulder concentrations can occur in other than the periglacial conditions described by Smith (1968). The contrast in bottom radiocarbon dates between lowland Lower Togue Pond and the mountain bogs and ponds implies that caution should be used in obtaining deglaciation times from topographic depressions on mountains.

Flint (1951) proposed that highland areas in northeastern United States and southeastern Canada were centers of regional outflow of ice during late-glacial time, whereas Ives (1978) suggested that many of these areas remained nunataks during the last maximum of the Laurentide ice sheet. Goldthwait (1970) contended that Mount Washington in New Hampshire was overridden by Laurentide ice and was not a center of ice outflow during late Wisconsin time. Borns and Calkin (1977) similarly inferred that the Longfellow and Boundary Mountains in west-central Maine were not centers of ice outflow, but rather were sites of ice-sheet thinning, separation, and stagnation during late Wisconsin deglaciation. Davis (1976, 1978) reached similar conclusions for Mount Katahdin, although all previous workers had inferred active cirque glaciers following Laurentide deglaciation. Only in the Green Mountains, Vermont (Wagner, 1970), and the Adirondacks, New York (Craft, 1979), is there convincing evidence that local ice was active in the mountains following Laurentide deglaciation. A lack of radiocarbon dates from highland glacial deposits remains the major stumbling block to an understanding of deglaciation history of alpine areas in the New England region.

CONCLUSIONS

Bottom sediments from Lower Togue Pond in the lowland south of Mount Katahdin may postdate deglaciation of the area by only 800 yr or less; however, the oldest sediments in two ponds and a bog on Mount Katahdin are as much as about 9,000 yr more recent than the time of deglaciation. Our explanation for the exceptionally long lag times between deglaciation and initial accumulation of sediments in the basins on Mount Katahdin is that the depressions that are floored with boulders failed to hold water and were continuously flushed of sediments until they were finally plugged. Thus, the sequence of radiocarbon dates from bogs and ponds ascending Mount Katahdin cannot be interpreted as a chronologic sequence of deglaciation.

REFERENCES CITED

- Borns, H. W., Jr., and Calkin, P. E., 1977, Quaternary glaciation, west-central Maine: *Geological Society of America Bulletin*, v. 88, p. 1773-1784.
- Bryson, R. A., and others, 1969, Radiocarbon isochrones on the disintegration of the Laurentide ice sheet: *Arctic and Alpine Research*, v. 1, p. 1-14.
- Clayton, Lee, 1967, Stagnant-glacier features of the Missouri Coteau in North Dakota: *North Dakota Geological Survey Miscellaneous Series* 30, p. 25-46.
- Craft, J. L., 1979, Evidence of local glaciation, Adirondack Mountains, New York: *Eastern Friends of the Pleistocene*, 42nd Annual Reunion, Guidebook, 75 p.
- Davis, P. T., 1976, Quaternary glacial history of Mt. Katahdin, Maine [M. S. thesis]: Orono, University of Maine, 155 p.
- , 1978, Quaternary glacial history of Mt. Katahdin, Maine: Implications for vertical extent of late Wisconsin Laurentide Ice: *Geological Society of America Abstracts with Programs*, v. 10, p. 386.
- Flint, R. F., 1951, Highland centers of former glacial outflow in northeastern North America: *Geological Society of America Bulletin*, v. 62, p. 21-37.
- Florin, M. B., and Wright, H. E., Jr., 1969, Diatom evidence for the persistence of stagnant glacial ice in Minnesota: *Geological Society of America Bulletin*, v. 80, p. 695-704.
- Goldthwait, R. P., 1970, Mountain glaciers of the Presidential Range in New Hampshire: *Arctic and Alpine Research*, v. 2, p. 85-102.
- Ives, J. D., 1978, The maximum extent of the Laurentide ice sheet along the east coast of North America during the last glaciation: *Arctic*, v. 31, p. 24-53.
- Madole, R. F., 1976, Bog stratigraphy, radiocarbon dates, and Pinedale to Holocene glacial history in the Front Range, Colorado: *U.S. Geological Survey Journal of Research*, v. 4, p. 163-169.
- , 1978, Chronology of Pinedale deglaciation in the southern Park Range, Colorado: *Geological Society of America Abstracts with Programs*, v. 10, p. 220.
- Mayewski, P. M., Denton, G. H., and Hughes, T. J., 1980, Late Wisconsin ice sheets of North America, in Denton, G. H., and Hughes, T. J., eds., *The last great ice sheets*: New York, Wiley-Interscience (in press).
- Mickelson, D. M., and Borns, H. W., Jr., 1972, Chronology of a kettle-hole peat bog, Cherryfield, Maine: *Geological Society of America Bulletin*, v. 83, p. 827-832.
- Nichols, Harvey, 1967, The disturbance of arctic lake sediments by "bottom ice": A hazard for palynology: *Arctic*, v. 20, p. 213-214.
- Porter, S. C., 1976, Pleistocene glaciation in the southern part of the North Cascade Range, Washington: *Geological Society of America Bulletin*, v. 87, p. 61-75.
- Porter, S. C., and Carson, R. J., III, 1971, Problems of interpreting radiocarbon dates from dead-ice terrain, with an example from the Puget Lowland of Washington: *Quaternary Research*, v. 1, p. 410-414.
- Potzger, J. E., 1956, Pollen profiles as indicators in the history of lake filling and bog formation: *Ecology*, v. 37, p. 476-483.
- Prest, V. K., 1969, Retreat of Wisconsin and Recent ice in North America: *Geological Survey of Canada Map* 1257A, scale 1:5,000,000.
- Schroeder, R. A., and Bada, J. L., 1978, Aspartic acid racemization in late Wisconsin Lake Ontario sediments: *Quaternary Research*, v. 9, p. 193-204.
- Smith, H. T. U., 1968, Piping in relation to periglacial boulder concentrations: *Biuletyn Peryglacjalny*, v. 17, p. 195-204.
- Stuiver, M., and Borns, H. W., Jr., 1975, Late Quaternary marine invasion in Maine: Its chronology and associated crustal movement: *Geological Society of America Bulletin*, v. 86, p. 99-104.
- Wagner, W. P., 1970, Pleistocene mountain glaciation, northern Vermont: *Geological Society of America Bulletin*, v. 81, p. 2465-2469.

ACKNOWLEDGMENTS

Reviewed by H. W. Borns, Jr., G. H. Denton, H. Nichols, and R. B. Waitt, Jr. Many of the ideas presented in this paper are from P. T. Davis's M. S. thesis at the University of Maine at Orono. Field work was partly supported by the Maine Geological Survey. Two radiocarbon age determinations (Isotopes, Inc.) were funded by a National Science Foundation grant to G. H. Denton, and two were kindly provided by R. Stuckenrath, Smithsonian Institution. We acknowledge helpful comments on early drafts of this paper by J. T. Andrews, R. Dubiel, A. R. Nelson, W. W. Locke, and L. Oliver.

MANUSCRIPT RECEIVED NOVEMBER 26, 1979

MANUSCRIPT ACCEPTED MAY 22, 1980