Trip I

DEGLACIAL HISTORY OF THE LAKE CHAMPLAIN-LAKE GEORGE LOWLAND

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GENERAL GEOMORPHOLOGY

The Lake Champlain and Lake George Valleys are two separate physiographic units, situated in separate physiographic provinces (see Broughton, et al., 1966). The Champlain Valley lies in the St. Lawrence-Champlain Lowlands while the Lake George trough lies in the Adirondack Highlands. It is the continuous nature of the deglacial history of the two regions that links them together for this field trip. Indeed, the deglacial history of the regions begins at the north end of the Hudson-Mohawk Lowlands near Glens Falls, New York.

Physiography

The Champlain Valley lies between the Adirondack Mountains of New York on the west and the Green Mountains of Vermont on the east. Lake Champlain occupies most of the valley bottom and has a surface elevation of about 95 feet. The Great Chazy, Saranac, Ausable, and Bouquet Rivers enter the valley from the Adirondacks while the Mississquoi, Lamoille, and Winooski Rivers and Otter Creek enter from the Green Mountains. Figure 1 shows the general physiography and the field trip stops.

According to Newland and Vaughan (1942) Lake George occupies a graben in the eastern Adirondacks. The surface of Lake George is about 320 feet above sea level and it drains into Lake Champlain via Ticonderoga Creek at its northern end. In general, Lake George marks the divide between southerly flowing Hudson River drainage and northerly flowing St. Lawrence River drainage.

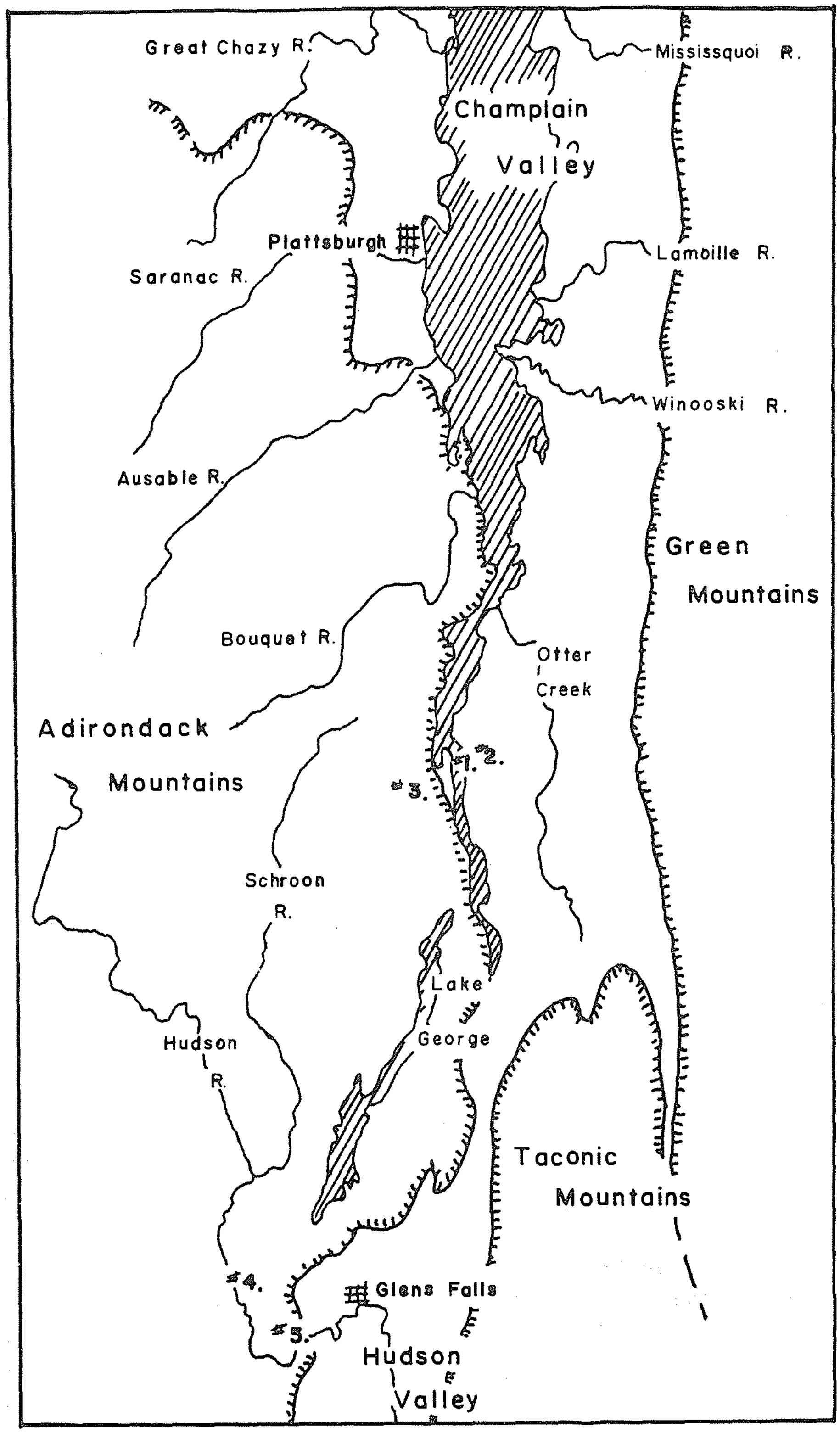

Figure 1. General physiography of the Lake Champlain-Lake George Lowland and field trip stops.

South of Lake George, the northern Hudson Valley lies between the Adirondack Mountains on the west and the Taconic Mountains on the east. This part of the valley is a lacustrine plain that varies in elevation from 180 to about 520 feet. The upper Hudson River and its chief tributary, the Schroon River, drain the Adirondack Highlands. The Hudson enters the Hudson Valley lowland via a gorge in the Luzerne Mountain range west of Glens Falls. The river descends approximately 175 feet over a series of waterfalls from Glens Falls to Fort Edward.

Bedrock

The Adirondack Highlands contain the highest mountains in New York State, in the High Peaks region of western Essex County. The High Peaks are underlain by Precambrian anorthosite that is highly resistant to erosion. Other igneous and metasedimentary rocks of lesser resistance are found in other areas of the Adirondacks. Newland and Vaughan describe the Lake George basin as a depressed fault block surrounded by Precambrian, granitic highlands. The Green Mountains, east of the Champlain Valley are also composed of crystalline, igneous and metamorphic rocks.

The Champlain lowland, and to a large extent the northern Hudson Valley is underlain by Cambrian and Ordovician sandstones, dolostones, and limestones. These rocks appear to dip gently away from the Adirondacks although they are structurally more complex on the east (Doll, *et al.*, 1961). Although Ordovician shales predominate throughout much of the Hudson Valley they are subordinate to carbonates in the north.

GLACIAL DRIFT

The bedrock of the Lake Champlain-Lake George lowland is mantled by a variable thickness of glacial drift. These deposits consist of till, ice-contact stratified drift, outwash, and lacustrine and marine sediments.

Till

Two general types of till are found in and adjacent to the lowlands. Connally (1968a) has referred to the two types geographically as mountain till and valley till while Stewart (1961) has used the genetic designations ablation till and lodgement till. Although it is possible that these tills are products of separate glaciations, or separate processes, they are treated here as related magnafacies.

Mountain till is sandy to gravelly and exhibits limited size-sorting. It is variable in both texture and color however, usually it has a sandy-loam to loamy-sand matrix and is dark-yellowish-orange (10 YR 6/6) in color. This till is the dominant deposit in both the Adirondack and Green Mountains but is found in the northern Hudson Valley as well. On mountain tops and flanks the deposit is probably relatively thin but in intermontane valleys, thicknesses up to 100 feet may be encountered.

In general, mountain till is quite friable and is composed of quartz and feldspar grains derived from the crystalline rocks of the highlands. In the Lake George basin however, the till is quite tough and compact. Although no formal stop is planned during the trip a short stop will be made at an exposure found suitable at the time of the field trip.

Valley till is typical of the Champlain and Hudson Valleys (and the Taconic Mountains in addition). This type of till is very firm, usually very pebbley, and contains abundant carbonate in the valleys. The texture of the matrix is a loam to clay-loam in the Champlain Valley and clay-loam to silty-clay near Glens Falls. In the subsurface this till is usually light-olive-gray to medium-gray.

Three distinct valley tills have been described from both the Vermont (Connally, 1967a) and New York (Connally, 1968a) sides of Lake Champlain. One till is stoney, calcareous, and dark-gray (N 3) with a clay-loam matrix, or sometimes gray-black (N 2). A second valley till is stoney to bouldery, calcareous, and light-olive-gray (5 Y 5/2) with a loam to sandy-loam matrix. A complete weathering profile is necessary to distinguish this till from the dark-gray till because the dark-gray color oxidizes to light-olive-gray near the surface. The third valley till is dark- to moderate-yellowish-brown (10 YR 4/4) with a silt-loam matrix and very few till stones. This silt-rich till is found only in the Ticonderoga quadrangle, both in New York and Vermont, and probably represents the incorporation of lacustrine silty-clays during the Bridport readvance.

Multiple-Till Sections

Two sections will be visited during this trip. The first is the West Bridport section (Stop 1) located south of the abandoned ferry crossing on Lake Champlain, just west of West Bridport, Vermont. In 1964 the exposure showed:

0-2'	silty-clay containing ice-rafted(?) pebbles and boulders.
16'	laminated to thin-bedded lacustrine silt and sand.
5½'	dark-gray (N 3), clay-loam till divisable into three units: a lower 12-18", gray-black (N 2) till; a medial 12-18" oxidized gravel; and an upper, 4' dark-gray till.
3'	light-olive-gray (5 Y 5/2), calcareous, sandy-loam till.
	bedrock with striae oriented N 10°E.

The second section is the Luzerne Mt. section (Stop 5) located in the Hudson gorge west of Glens Falls, New York. In 1968 this section exhibited the following sequence:

4-10'	moderate-olive-gray (5 Y 4/2) till and colluvium overlain by spoil and vegetation.
5-12'	moderate-olive-gray till, very compact, very bouldery, with a sandy-loam matrix and many limestone and shale clasts.
4'	thinly-laminated to thin-bedded sand.
1-17'	gray-black (N 2), bouldery, silty-clay till containing clasts of dark-gray, contorted lacustrine sediment.

Another section close by and to the east shows:

6'	gray-black till, as above.
10'	dark-gray, laminated and rhythmically bedded lacustrine clay, silt, and fine sand, greatly contorted.

A third section a few hundred yards east shows:

4-20'	light-brown till(?), very sandy and choked with angular boulders, showing crude stratification.
2-3'	gray-black till as above.
20'	oxidized, pebbley sand.
20'	spoil.

These sections represent the type section for the Luzerne readvance, as demonstrated by the uppermost, moderate-olive-gray till.

Stratified Drift

As the glacier stagnated and melted upland areas soon emerged from beneath the ice cover leaving stagnant masses of ice in the lowlands. Water flowed into and over these stagnant masses and deposited material in contact with the melting ice. These ice-contact deposits are quite common in and adjacent to the Adirondack and Taconic Mountains. The deposits may vary in thickness from a few tens of feet to hundreds.

Outwash is waterlaid sediment deposited beyond the margin of the ice and it can frequently be traced back upstream to related ice-contact deposits. The outwash may be better sorted than the related ice-contact drift and may contain kettle holes where blocks of ice have been buried by, or deposited with, the outwash. Many sequences of outwash and ice-contact deposits have been described by Connally (1965) adjacent to the Green Mountains where they have been used to infer the retreat of an active ice margin.

Stop 3 will visit an outwash delta that was deposited into Lake Quaker Springs. This massive outwash body, containing kettle holes up to 120' deep, is located just west of the village of Streetroad, New York between Miller and Buck Mountains.

Lake and Marine Deposits

As the margin of the last glacier retreated northward, up first the Hudson and then the Champlain Valley, proglacial lakes were impounded. When the ice retreated north of the St. Lawrence Valley marine waters invaded and the Champlain Sea came into existence. Lacustrine and marine deposits can not be distinguished lithologically so all deposits are discussed as "lacustrine".

Beach ridges and hanging deltas represent former shorelines while thick, rhythmically bedded (varved?) clay deposits are the result of quiet water sedimentation. Reconstruction of former lakes has been discussed by Chadwick (1928), Chapman (1942), and LaFleur (1965).

GLACIATION

Very little is known about the glaciation of the Champlain lowland except what can be deciphered from striae. From striae and till fabric studies Stewart (1961) and Stewart and MacClintock (1964, 1967) have inferred three glaciations in Vermont. The latest (Burlington) glacier advanced from the northwest while the earlier (Shelburne) glacier advanced from the northeast. The earliest (Bennington) glacier also advanced from the northwest. However, in the Adirondacks only northeasterly striae appear to have been recorded. Both Denny (1966) and Connally (1967a) have suggested that the original advance was from the northeast, but that the most recent ice in the valley advanced in lobate form forming northeasterly striae west of the valley and northwesterly striae east of the valley. It is not clear whether patterns document separate glaciations or merely advancing and receding phases of the last Wisconsinan advance.

DEGLACIAL HISTORY

To trace the deglacial history of the Lake Champlain-Lake George lowland it is necessary to understand the complex interrelationships between moraines, readvances and proglacial lakes. Chapman (1942) has summarized proglacial lake history for Vermont and LaFleur (1965) for the Hudson Valley. This report attempts to relate these two studies to the readvances described in the Hudson (Connally, 1968a; 1968b) and Champlain (Connally, 1967a) Valleys.

Three lake levels in the Hudson Valley have been referred to collectively as "Lake Albany" and three lake levels in the Champlain Valley have been referred to collectively as "Lake Vermont". The highest level of "Lake Albany" is confined to the Hudson Valley while the lowest level of "Lake Vermont" is confined to the Champlain Valley and it is suggested here that these names be restricted to these levels. Inferior "Lake Albany" levels are equivalent to the superior "Lake Vermont" levels and it is further suggested that existing names Quaker Springs and Coveville be applied to these water bodies, both north and south of the Lake George graben. There does not seem to be any compelling evidence for Chadwick's Lake Bolton as a separate Lake George event.

Lake Albany

The most recent event south of the Lake George area was the readvance of the glacier near Rosendale, New York (Connally, 1968b). As far as can be shown at present the ice front retreated northward from Rosendale, defending a northward expanding proglacial lake - Lake Albany. LaFleur (1965) has shown that Lake Albany was contemporaneous with the receding ice margin as far north as Troy, New York. As defined here, Lake Albany reached its maximum extent when the ice margin reached Glens Falls or slightly northward.

Luzerne Readvance

The Luzerne Mountain section, west of Glens Falls, shows two ice advances. The uppermost event dammed a lake in the upper Hudson Valley that received proglacial outwash. The ice margin can be traced northward to the valleys followed by Route 9N that connect the Lake George basin with the upper Hudson River valley at Lake Luzerne. A morainal ridge blocks this valley east of Lake Luzerne. Lake Luzerne and associated lakes occupy kettle holes in the outwash on the distal side of the moraine. The Pine Log Camp bog (Stop 4) is situated in one of these kettles. As the Luzerne readvance apparently terminated in the Glens Falls region, and as the ice marginal deltas that date from this event are at Lake Albany levels, the readvance must have been contemporaneous with Lake Albany.

Lake Quaker Springs

As the ice retreated north of the Lake George basin the water level dropped to the lake referred to by Stewart (1961) as the Quaker Springs stage of Lake Vermont. LaFleur (1965) and Connally (1968a) have demonstrated that this level in the Champlain Valley is coextensive with the middle water level earlier referred to "Lake Albany". These two coelescing water bodies are here combined as Lake Quaker Springs. No evidence for Lake Quaker Springs levels has been found north of the Ticonderoga quadrangle. The ice-marginal outwash delta seen at Stop 3 marks the level of Lake Quaker Springs and confirms the presence of stagnant ice associated with this lake. A similar relationship is found south of Middlebury, Vermont.

Lake Coveville

As the ice margin retreated northward from Ticonderoga the lake level must have dropped quite rapidly to the level of Lake Coveville (Chapman's Coveville stage of Lake Vermont). Chapman traced this level as far north as Burlington and Connally (1967b) suggested its presence in the Lamoille River valley east of

Burlington. Since Lake Quaker Springs was restricted to the area south of Ticonderoga, the lacustrine sediments north of that quadrangle evidently relate to younger lakes.

Bridport Readvance

The Bridport readvance has been suggested from many lines of evidence most of which can be observed within the boundaries of the Town of Bridport, Vermont. Exposures of crumpled, lacustrine (Coveville) clays containing boulders are commonly exposed in excavations from the vicinity of Middlebury north to Burlington, Vermont. The uppermost unit at the West Bridport section is either a till whose matrix is composed of redeposited lacustrine silt with scattered boulders, or a lacustrine unit containing ice-rafted boulders. In either case, this unit is separated from the lower tills by boulder-free lacustrine sediments. One mile east of West Bridport (Stop 2) a gravel pit displays a firm lodgement till over stratified material with the stratified material incorporated along shear(?) planes in the base of the till.

Since the contorted clays occur from Bridport to Burlington, it is possible that the ice margin retreated all the way north to Burlington before readvancing to Bridport. However, the exact magnitude of the readvance is unknown and may be much less. It is suggested that the mountain front morainic system of Denny (1966) in the Plattsburgh region was formed during this readvance.

Lake Vermont

As the ice margin retreated north of the Lamoille River Valley the lake level lowered to the Fort Ann stage of Chapman or the restricted Lake Vermont of this report. It appears likely that the dam for this level was formed by the glacier as it deposited the Highland Front Moraine of Gadd (1964).

Champlain Sea

Following the recession of the ice margin north of the St. Lawrence River Valley, marine waters entered the Champlain basin and formed the Champlain Sea. Shells in the marine clays have been found as far south as Crown Point, New York. As the land rebounded the marine waters were cut off and modern Lake Champlain began.

POLLEN STRATIGRAPHY AND ENVIRONMENTS

Site Description and Methods

The Pine Log Camp bog has developed on the glacial outwash on the distal side of the moraine associated with the Luzerne readvance, as described above. The bog is located on the Lake Luzerne quadrangle; 43°21'N latitude, 73°50'W longitude. It is one of several bogs in this area which were probed for greatest depth and presumably longest stratigraphic record. The site itself is a kettle hole with over 30 feet of closure. The sedimentary record indicates that the kettle was formerly a lake, then a closed bog covered by a peat and rootlet mat.

The Lake Luzerne-Lake George region lies in the northern hardwood forest, as described by Küchler (1964), and also contains transitional elements of the Appalachian oak forest. Dominants in the local forest, a mixture of deciduous and evergreen trees; are oak, yellow birch, beech and hemlock along with other forest components; sugar maple, ash, white pine, black cherry, northern white-cedar, basswood and elm.

The bog was probed for greatest depth which was established at 8.0 m at the center of the basin. Coring was done with a Davis-type piston corer, with cores retrieved from the surface to the base in successive 25 cm segments. Since coring was done in the late fall (1967) and cores were extruded directly into tubes, local contamination was minimized. Core samples were processed by standard treatment schedules for pollen analysis, in which up to 300 pollen grains per slide were counted. Seven additional core segments were taken from basal sediments, 7.85-8.0 m, for radiocarbon age determination by Isotopes, Inc.

From the base, the bog consists of: 0.25 m, coarse clastics at base, grading to silt with wood fragments; 1.75 m, gray clay at base grading to black-brown gyttja; 2.25 m, compact fibrous peat with clay decreasing upwards; compact fibrous peat with wood fragments; 2.00 m, compact fibrous peat, water saturated; 1.00 m, brown fibrous peat, relatively dry, with plant detritus at the surface.

Pollen Stratigraphy and Results

The pollen stratigraphy for the Pine Log Camp bog and thus for the late- and postglacial environments in the northern Hudson Valley is summarized in Table 1. Correlations are also provided between the northern Hudson Valley and the southern Wallkill

POLLEN ZONES	NORTHERN HUDSON VALLEY	SOUTHERN WALLKILL VALLEY	SOUTHERN NEW ENGLAND	WESTERN LONG ISLAND	STAGES
C3a-C3b	Spruce Rise Pine, Birch, Hemlock	Oak, Hemlock	Spruce Rise Oak, Hemlock	Oak, Chestnut, Holly	POST GLACIAL
OAK C2	Beech, Pine, Hemlock, Oak, Birch	Oak, Hickory	Oak, Hickory	Oak, Hickory	
C1	Hemlock, Birch, Pine, Oak	Oak, Hemlock	Oak, Hemlock	Oak, Hemlock	
B2	Pine, Oak	Pine, Oak	Pine, Oak	Pine, Oak	
PINE B1	Pine, Birch	Pine	Pine	Pine	
A4	Spruce Maximum Alder, Pine (A3-4)	Spruce Returns	Spruce Returns	Spruce Returns	LATE - GLACIAL
SPRUCE					
A3		Pine, Spruce, Oak (12,850 ± 250)	Pine, Spruce, Oak	Pine, Spruce	
A1,2	Spruce, Pine, Grass (Spruce Park)	Pine, Spruce	Birch, Spruce	Pine, Spruce	
T3	Pine, Birch, Spruce, NAP, Park-Tundra (12,400 ± 200)	Pine, Spruce, Birch	Birch Park-Tundra	Pine, Spruce, NAP	
HERB					
T2	- - - - - - - - - -	Spruce, Pine, Fir	Spruce Park-Tundra	Spruce	
T1	Glaciated	Pine, Birch Shrub-Tundra	Tundra	Park-Tundra	
W		Glaciated	Glaciated	Park-Tundra Near Tundra	

TABLE 1: Correlation of pollen stratigraphy - eastern New York and southern Connecticut (after Connally and Sirkin, 1967; Deevey, 1958; Sirkin, 1967)

Valley (Connally and Sirkin, 1967), southern New England (Deevey, 1958) and western Long Island (Sirkin, 1967). As indicated, the pollen record began with the deposition of clastic sediments directly over glacial outwash in the base of the kettle. The lower 15 cm of the bog section contains some woody plant detritus and is radiocarbon date at *12,400 ± 200 years B.P. The pollen spectra of pine, birch, spruce and nonarboreal pollen (NAP), mainly grass, is interpreted as the initial vegetation in the vicinity of the bog. The presence of significant amounts of willow, alder and birch (mainly the small sized pollen grains often associated with dwarf or shrub species of these plants and of pine) along with the pollen of the rose family, sedge and several herbs, including the genus Shepherdia, is interpreted as representing a tundra vegetation, that of the Herb Pollen Zone. The NAP maximum of 36% of the pollen also occurs in this sequence and helps substantiate this interpretation.

The presence of conifer pollen indicates the rapidity of colonization of the deglacial surface by the boreal forest which was migrating northward with the glacial front at that time and invading and isolating the tundra or shrub-tundra vegetation. Pollen of deciduous hardwoods in the basal spectra indicate long distance transport of pollen from the hardwood forests to the south. The radiocarbon date, 12,400 ± 200 years B.P. is set as the minimum age for deglaciation of this site.

In the regional correlations of pollen stratigraphy from the end moraines to the northern Hudson Valley, the rate of deglaciation is suggested in part by the time transgressive nature of the Herb and Spruce Pollen Zones. For example, it has been postulated that deglaciation began on Long Island a minimum of 17,000 years B.P. (Sirkin, 1967), in southern New England about 15,000 years ago (Deevey, 1958) and in the Wallkill Valley about 15,000 years ago (Connally and Sirkin, 1967). Ages for the lower Spruce Pollen Zone average 14,000 years B.P. at Sandy Hook New Jersey (Sirkin, et al., 1968), range from 13,000 to 12,000 years B.P. in southern New England (Deevey, 1958), and are recorded at 12,850 ± 250 years B.P. in the southern Wallkill Valley (Connally and Sirkin, 1967). In the northern Hudson Valley the Herb Pollen Zone age of about 12,400 years might also be considered as the maximum possible age for

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the Spruce Zone. These ages provide a time scale for the time transgressive aspect of plant migration following deglaciation. Overall, a minimum of 4,600 years (17,000 - 12,400) is required for glacial recession from Long Island to the Luzerne position, and a minimum of 1,600 years (14,000 - 12,400) is required for the migration of the spruce forest from just south of the end moraines to the northern Hudson Valley region. It is believed that deglaciation was initially slow, with a fluctuation of the ice front along northern Long Island (Sirkin, 1968) and a span of at least 3,500 years between recession from the Harbor Hill position into southern New England (using pollen subzone T3 of Port Huron age, as in Deevey, 1958, for control). Thus, deglaciation must have accelerated after 13,500 B.P. in order to bring the ice front to the northern Hudson Valley by 12,600 B.P. (see Regional Correlations). The assumption made with respect to the northern Hudson age is that the basal age of the Pine Log Camp bog closely dates the age of the surficial glacial deposits.

The Spruce interval in the northern Hudson region as interpreted from the pollen evidence can be divided into at least two subzones, tentatively A 1,2 and A 3,4. Subzone A1,2 is interpreted as representing a spruce park or taiga, while subzone A3,4 is marked by the spruce increase and the late-glacial spruce and alder maximum. Significant peaks of pine, cedar and birch, and a fir peak, with the spruce and alder, indicate a spruce dominated, but mixed coniferous forest, possible with alder dominant at the bog site. Similar pollen data were obtained by Cox (1959) in his study of the Consaulus bog, to the southwest in the Amsterdam, New York, Quadrangle. In that study, the arboreal pollen record was interpreted as including subzones A1, A2 and A3. The tundra episode or Herb Zone is omitted from the record in the absence of a NAP record and radiocarbon ages. Although the NAP were apparently not counted, the basal arboreal spectra at Consaulus do not include the pollen of willow and birch, and contain only an insignificant amount of alder. It is presumed that the Herb zone was not encountered.

In southwestern Vermont, the Herb zone was also not encountered at Pownal bog (Whitehead and Bentley, 1963) where the pollen record does include the NAP. The Pownal record was terminated at Zone A, although there may have existed a longer section in that bog. The A zone at Pownal is characterized by the "spruce and fir maximum, low pine and deciduous trees", which correlates with the pollen spectra at Pine Log Camp and at Consaulus. Both Pine Log Camp and

Consaulus record two spruce and fir peaks, Pownal only the upper spruce and fir peak. The upper spruce peak incorporates the spruce maximum of 38% at Pine Log Camp, 60% at Pownal, and about 66% at Consaulus and at Pine Log Camp bog, the grass maximum of nearly 20%. The arboreal pollen vary from 76 to 86% of the pollen in the Spruce zone in this study.

The Pine Pollen Zone (the B zone) in the Pine Log Camp bog pollen record is subdivided into the B1 and B2 subzones. Subzone B1 is characterized by pine and birch dominance, mainly a pine peak and the birch maximum. Also in this subzone, spruce declines and the fir maximum is reached. The NAP are represented by grass, sedge and cattail. Subzone B2 is typified by the pine maximum of 58% at Pine Log Camp. This maximum also occurs in subzone B2 at Pownal and possibly at Consaulus, although the latter bog was not zoned in the pollen study. Significantly, oak reaches a peak in the present study and at Pownal.

The Oak Pollen Zone is represented in this study by three subzones, C1, C2, and C3, and the latter subzone may be split into the C3a and C3b subdivisions. The subzones of the Oak Zone differ from those in more southerly locations in the subordination of oak to hemlock, birch, pine, beech and lastly spruce. Subzone C1 contains rising hemlock and beech profiles, at the top of the C1 subzone. In addition, birch and oak increase and the chestnut maximum occurs here, while pine declines to its minimum amount.

In subzone C2, beech reaches its maximum of 22%, while hemlock drops to less than 20% during mid-C2 time, and pine gains. Hemlock increases in late C2 time with a corresponding falling off of pine, beech and ash. The oak maximum of 22% occurs in lower C3, that is C3a time, accompanied by an increase in beech and a gradual dropping off of hemlock. Subzone C3b shows a distinct change in forest composition with significant increases in pine and birch and by the spruce return which began in C3a time and reaches a peak in C3b time. Also significant at this time is the rapid influx of composite (cf. ragweed) pollen to a maximum of 14%. This phenomenon is typical of pollen records in the northeastern United States where it has been assigned either to pre-Colonial forest fires, i.e. those set by Indians as a device for clearing the land, or as a sign of European colonization and agriculture.

With respect to regional climatic and vegetational adjustments, it is postulated that the Spruce Zone represents vegetation responding to colder climates associated with deglaciation. The A4 subzone is generally correlated with the last advance of continental ice and the end of the late-glacial episode. The B zone has been associated with the climatic optimum, Hypsithermal, which probably extends well into the Oak Zone. Also, it appears that the lake at Pine Log Camp probably entered its bog stage during this warm-dry climate. The advent of the cooler, more moist sub-Atlantic climate is indicated in the Spruce rise of C3b time.

REGIONAL CORRELATIONS

Denny (1966) recognized areas of hummocky topography near the northern edge of the Adirondack Mountains and correlated this with discontinuous patches of moraine in the Saranac and Salmon River Valleys west of Lake Champlain. He proposed the informal name "mountain front morainic system" for these deposits, and interpreted this as a recessional position rather than a readvance.

East of the Champlain Valley, Gadd (1964) defined the Highland Front Moraine as a major morainic system that can be traced for 225 miles from Ganby to Rivier-de-Loup along the southeast border of the Eastern Quebec Uplands. Although the similarity of geographic position between the mountain front and Highland Front systems suggests that they are morphostratigraphic equivalents, Denny (1967) has projected the Lake Coveville shoreline on the mountain front system. Thus, the mountain front system is suggested as the morphostratigraphic equivalent of the Bridport readvance while the ice responsible for the Highland Front Moraine probably dammed Lake Vermont.

Recently McDonald (1968) has argued that the Highland Front Moraine must have been deposited about 12,600 years B.P. Lee (1963) established a maximum age of 12,720 ± 170 years B.P. while the initiation of the Champlain Sea at about 12,000 years ago appears to be a minimum age. McDonald uses a date of 12,570 ± 220 years B.P. for a bog on Mount St. Hilaire (Lasalle, 1966; Torasmae and Lasalle, 1968) as the crucial evidence in establishing the date of 12,600 for the Highland Front position. Although the authors accept McDonald's reasoning, the age is in apparent disagreement with their opinion that sedimentation at the base of the Pine Log Camp bog (12,400) closely postdates the Luzerne readvance. The Luzerne and Bridport readvances both predate the Highland Front system.

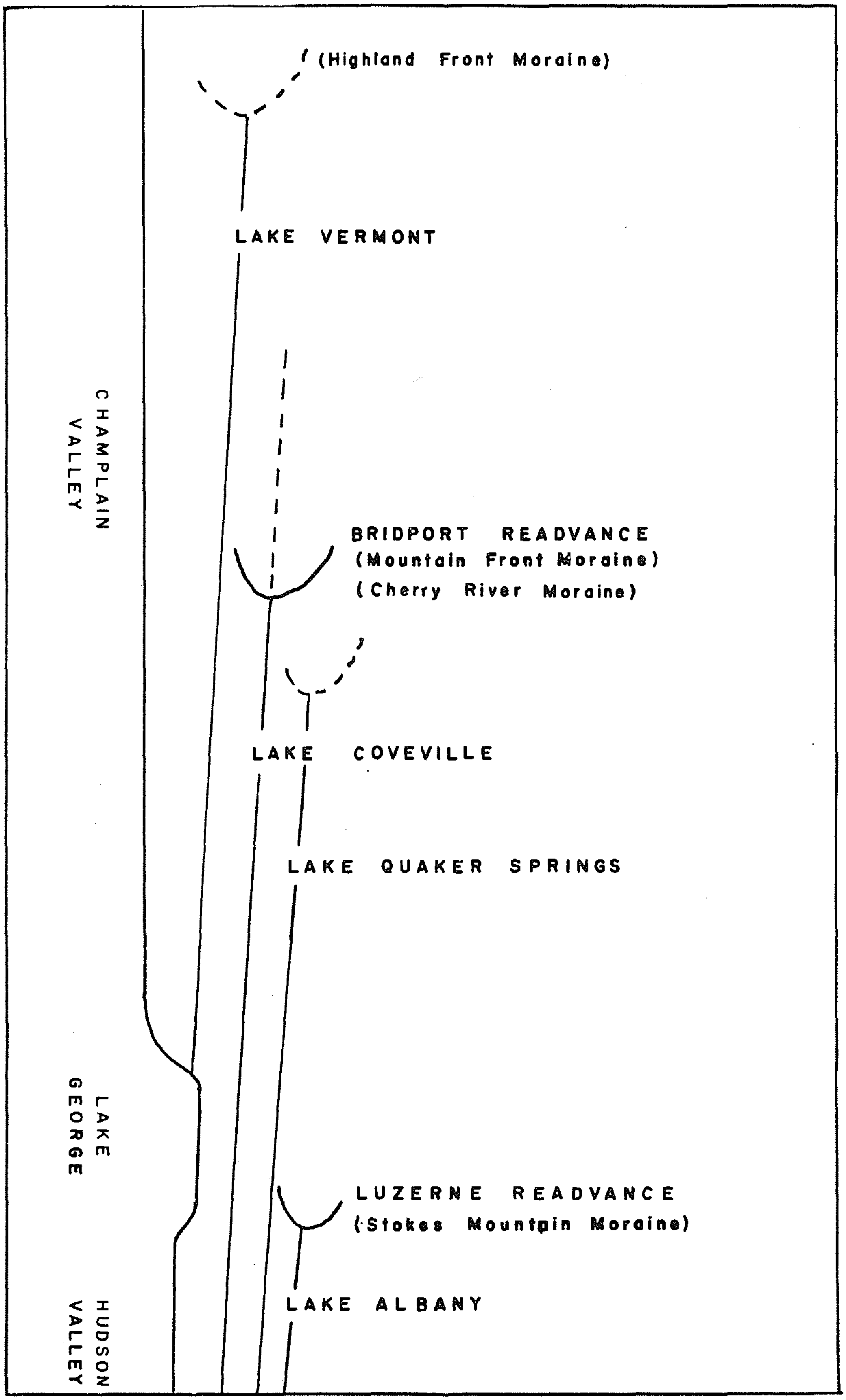

Figure 2. The relationship between lake levels and ice margins in the Lake Champlain-Lake George lowland and their possible upland equivalents.

If one subtracts the counting error from the St. Hilaire date and adds the counting error to the Pine Log camp date, the sequence of events outlined in this report is compatible with that reported by McDonald. If the St. Hilaire bog dates from 12,350 then McDonald could accept a date of 12,400 for the Highland Front Moraine. If the Pine Log Camp bog dates from approximately 12,600 then the Luzerne readvance precedes emplacement of the Highland Front system by 200 years. This leaves ample time for the Bridport readvance and consequent development of the mountain front system between these two events. Thus, the authors suggest that the St. Hilaire bog should be considered to date near its minimum and the Pine Log Camp near its maximum range, placing them in complete agreement with the stratigraphy of McDonald.

McDonald reports two moraines older than the Highland Front Moraine in the Megantic Hills. Both the Cherry River (younger) and Stokes Mountain Interlobate (older) moraines appear to border Glacial Lake Memphramagog. If the relationship between the various levels of this proglacial lake and the lakes of the Champlain Valley can be ascertained it will be possible to correlate the Luzerne and Bridport readvances with events in the Eastern Quebec Uplands. If the readvance to the Cherry River position is contemporaneous with drainage of Glacial Lake Memphramagog through the Lamoille River Valley to Lake Coveville, then it probably correlates with the Bridport readvance and the mountain front morainic system. This correlation is tentatively suggested here. The ice marginal positions corresponding to the Stokes Mountain Interlobate and other moraines of the Eastern Quebec Uplands are suggested as correlates of the Luzerne readvance. Fig. 2 summarizes the relationships.

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