GLACIAL LAKE ALBANY IN THE CHAMPLAIN VALLEY

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The purpose of this article is to document and discuss the expansion of Glacial Lake Albany from the northern Hudson Valley into the southern Champlain Valley. The area under consideration extends ±115 km from Crown Point to the Hoosic River. Crown Point (A on Fig. 1) is on Lake Champlain at 44° 02' N. The Hoosic River (B in Fig.1) is an eastern tributary to the Hudson River at about 42° 55' N.

DEGLACIAL HISTORY

The Woodfordian glacier reached its maximum position across Long Island, Staten Island, and northern New Jersey between 21.75 ka (Sirkin and Stuckenrath, 1980) and 20.18 ka (Stone and Reimer, 1989). Recession was underway by 21.20 at the earliest, or 18.57 ka, at the very latest (Connally, in prep). Glacial Lake Hudson of Reeds (1927) was impounded between the Harbor Hill Moraine, at the Staten Island Narrows, and the receding ice. The outlet probably was eastward, over a bedrock threshold at Hell Gate in the East River (Stanford, 1989). When the ice margin reached the Pellets Island/Shenandoah Moraine, north of the Hudson Highlands, the lake expanded north into the mid-Hudson Valley. From then on the lake is referred to as Glacial Lake Albany. Glacial Lake Albany is defined as the proglacial lake that expanded northward in the Hudson-Champlain trough in direct contact with the retreating Woodfordian glacier margin. As the ice margin retreated north, Glacial Lake Albany continued to expand in contact with the ice front.

Figure 1. The field trip region from Crown Point to the Hoosic River. The map is a portion of Landforms of New York, by James A. Bier copyright 1964. Used by permission.

The glacier continued to retreat north, up the Hudson Valley, interrupted by two, or perhaps as many as four, readvances. The Rosendale Readvance (Connally, 1968a) dammed Glacial Lake Tillson in the lower Wallkill Valley and deposited the Red Hook Moraines (Connally and Sirkin 1986) east of the Hudson River, damming Glacial Lake Jansen. That event occurred sometime between 18.57 and 13.67 ka. Next, events described by Dineen et al (1983) and Dineen (1986) as the Delmar and Middleburg readvances occurred in the Capital District. Then the Luzerne Readvance (Connally and Sirkin, 1971) occurred in the northern Hudson Valley just prior to 13.15 ka. After that, the ice began to recede northward into the Champlain Valley, where the recession was interrupted for the final time by the Bridport Readvance (Connally, 1970) at 11.90 ka (Larsen, 2001; Connally, in prep). Final recession into the St. Lawrence Lowland occurred at about 11.50 ka (Pair and Rodriquez, 1993).

As the ice margin retreated north, Glacial Lake Albany continued to expand in contact with the ice front. In the northern Hudson Valley, Lake Albany was about 24 km wide. The lake divided into a west branch ±4 km wide, in the Lake George trough, and an east branch 7 to 12 km wide, in the valley of Wood Creek and the South Bay of Lake Champlain. In the Champlain Valley it widened to ±35 km, The Luzerne (A in Fig. 2) and Bridport (B in Fig. 2) Readvances are illustrated below, as they relate to Lake Albany.

The Luzerne Readvance

By perhaps 13.20 ka, the ice margin had receded to a position somewhere north of Glens Falls. Presumably Lake Albany deltas had been deposited all the way north to that position. Then the ice margin readvanced at least 50 km. Apparently, this was a major readvance on the order of magnitude of the earlier Rosendale Readvance, farther south. The eastern edge of the readvance reached the north-south valley of the Batten Kill, obliterating pre-readvance Lake Albany features for 42 km, from Fair Haven, Vermont to Greenwich, New York. The western edge intruded into the Adirondacks south of Warrensburg. The southern margin may well have reached the vicinity of Cambridge, New York, just north of the Hoosic River.

Figure 2. The Luzerne and Bridport Readvances. The borders of Lake Albany are Illustrated south of each readvance

The Luzerne Readvance deposited a pitted outwash valley train 8 km long, from Lake Vanare to Lake Luzerne in the eastern Adirondacks, and a kame terrace against the edge of the Luzerne Mountains on the west side of the Hudson Valley. The eastern edge of the readvance forced drainage eastward into the Batten Kill drainage system. However, the Batten kill delta has only sparse evidence of the Rebounded Lake Albany level, though perhaps more than recognized by DeSimone (1983). Between the east-west Batten Kill valley there is a plethora of stagnant ice features probably left by wasting ice from the Luzerne Readvance. Thus, the southern margin probably reached the north edge of the Hoosic River, south of the Batten Kill.

In the Hudson River gorge, east of Corinth, there is a multiple-till section (Figure 3), that is the type section for the readvance. At the base of the section is the main Woodfordian till; a grayish-black (N 2) till with limestone and shale clasts in a silty-clay matrix. At the top is the readvance till; a moderate olive-gray (5 Y 4/2) till, very bouldery, with a sandy-loam matrix.

The small Hidden Valley Moraine marks the terminus of the readvance west of Glens Falls (Connally and Sirkin, 1971, Figs. 2 and 3). Pine Log Camp bog developed in one of the kettles in the pitted outwash on the distal side of the Hidden Valley moraine. Two pollen cores were retrieved two years apart, from this bog. Core #1 was 7.85 m long and Core #2 was 8.10 m long. A ^{14}C date of 12.40±0.20 ka (I-3199) was obtained at -7.85 m for the lowest spruce pollen (A_1, A_2) zone, in Core #1. Two years later, a ^{14}C date of 13.15±0.20 ka (I-4986) was obtained at -8.10 m from the tundra pollen (T) zone, in Core #2.. Sediment accumulation had begun as soon as the kettle ice melted so the actual readvance must slightly pre-date the bog-bottom age of 13.15 ka (Connally and Sirkin, 1971, p. 1002).

The Glens Falls delta on the west, at ±460 ft, and the Fair Haven delta at ±480 ft, on the east, mark the northern extent of Lake Albany in the Hudson Valley. These deltas formed after recession from the Luzerne Readvance maximum, 45 km to the south. However, as the ice margin retreated northward through the Wood Creek valley to the South Bay of Lake Champlain, and through the parallel Lake George trough on the west, Lake Albany continued to expand northward with the ice margin. It would be too much of a coincidence to think that Lake Albany's history ended in the Hudson valley and a new lake replaced it at essentially the same elevation, with the same outlet. There was nowhere for the water to go.

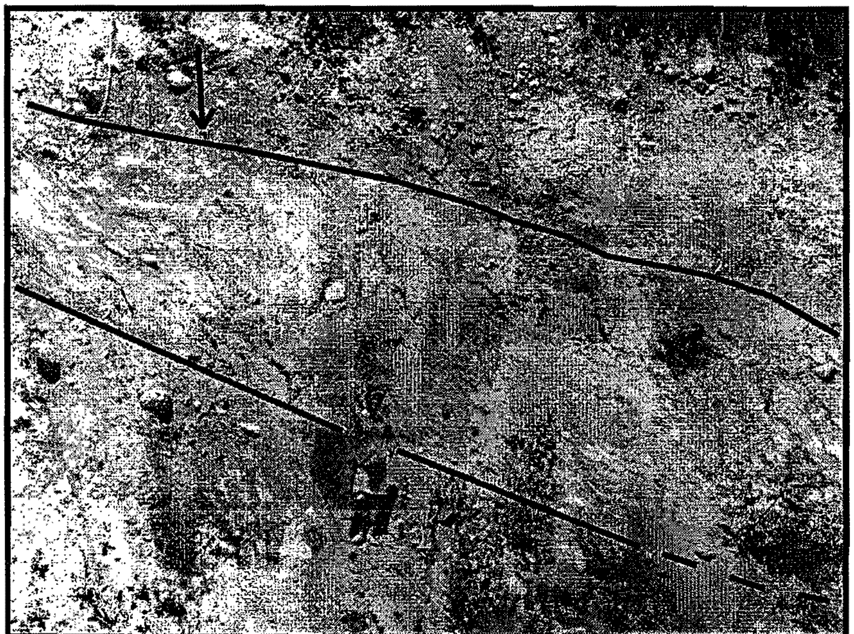
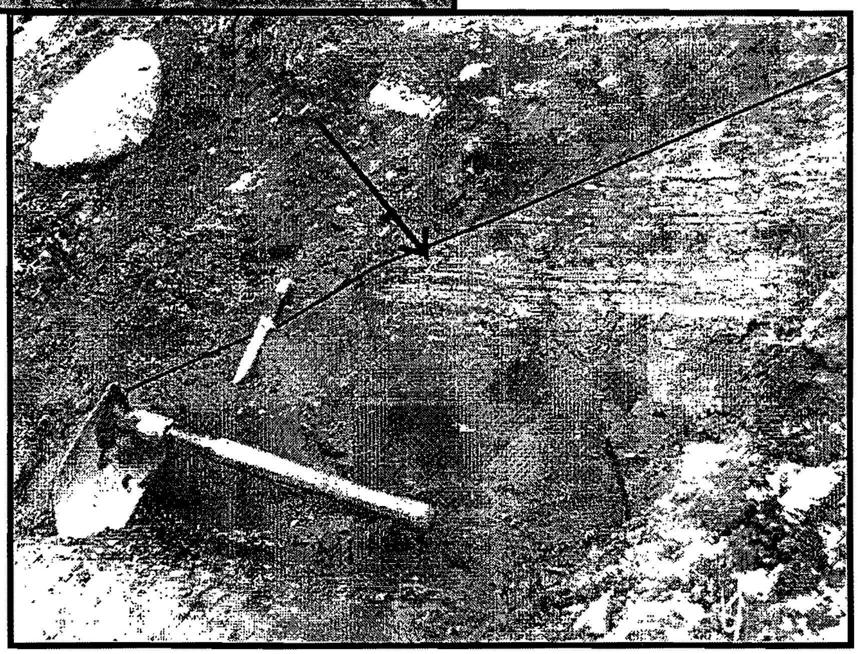


Figure 3. The Luzerne Readvance at the type locality. In 3a, at left, the arrow points to the contact between the olive gray-readvance till above and the grayish-black Hudson Valley till beneath. The late Nancy Austin Wright, former geologist with the NYSGS, appears for scale. In 3b, below at right, the arrow points to the contact between the grayish-black till and a clast of pre-existing lacustrine clay. The Figures are reproduced, with permission, from Connally and Sirkin (1971).



There are several small deltaic (?) deposits bordering Lake George that probably relate to the Lake Albany and lower water planes (see Figure 5). The Lake George trough is connected to the Hudson Valley by two cols. The west col, between French Mountain and the Adirondacks, was filled to ±550 ft with sediment. The east col, between French Mountain and Putnam Mountain, is at ±400 ft. When the ice blocked both cols, drainage from the east left a huge boulder esker (Connally, 1973) that wrapped around the southern end of Putnam and French Mountains. The esker was subsequently buried by Lake Albany sand. The ice remained in the eastern col somewhat longer than the west because there is an outwash delta that prograded southward from the western col. Once the ice had cleared the eastern col, Lake Albany waters invaded the Lake George trough.

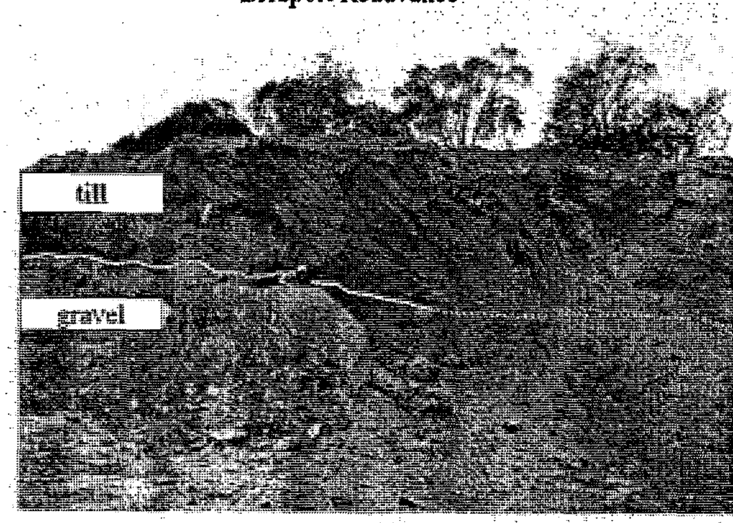
Varved lacustrine clays fill the bottom of Wood Creek valley– now the New York State Barge Canal – to an elevation of ±300 ft. To the east, near Fair Haven, the clay cover rises to more than 400 ft. Because the delta at Fair Haven displays a secondary Lake Albany surface that is slightly low, at ±440 ft, it is possible that ice lingered nearby longer than it did in the Lake George trough. However, to the north, both the Brandon delta and the East Middlebury deltas are graded to the Lake Albany water plane. And farther east, in the Otter Creek valley, as far south as Proctor, Vermont there is a plethora of Lake Albany features. In the Neshobe River drainage net, there are several minor deltaic and ice-contact features at the same elevation as the Neshobe River delta at Brandon. The Neshobe River delta displays the features of most lower lake levels.

The Bridport Readvance

The northward expansion of Lake Albany in the Champlain Valley, was interrupted by the Bridport Readvance at 11.90 ka. This readvance does not appear to be as extensive as the Luzerne Readvance. Thus far, the evidence is limited to the type locality and the two great deltas on either side of the Champlain Valley. However, Connally (1970) suggested that the Bridport Readvance was responsible for the many dropstones present in the lacustrine clays in the Champlain Valley, from Shelburne to East Middlebury, Vermont and almost to Ticonderoga adjacent to Lake Champlain. The total extent may be equivalent to the "bouldery clay" unit of the Surficial Geologic Map of Vermont (Stewart and MacClintock, 1970). For additional evidence see the final section on Core Interpretations.

The type locality for the Bridport Readvance was in a gravel pit 8 km west of Bridport, Vermont. The entire pit was removed and reclaimed circa 1972, but photographs from Connally (1970, Plates 5 and 6) are reproduced here as Figure 4. The photographs show lenses of gravel that were being sheared up into the readvance till.

Bridport Readvance



The Bridport Readvance has long been thought to correlate with the Littleton-Bethlehem Moraine in western New Hampshire and eastern Vermont (Ridge, et al., 1999, Fig. 11). Recently, Larson (2001) has recognized the Middlesex Readvance, south of Montpelier, Vermont, that is dated at 11.90±0.05 ka (GX-26457-AMS). The Middlesex Readvance is correlated with both the Bridport Readvance and the Littleton-Bethlehem Moraine, renamed the Littleton-Bethlehem Readvance by Thompson, et al., (1999).

Bridport Readvance Close-up

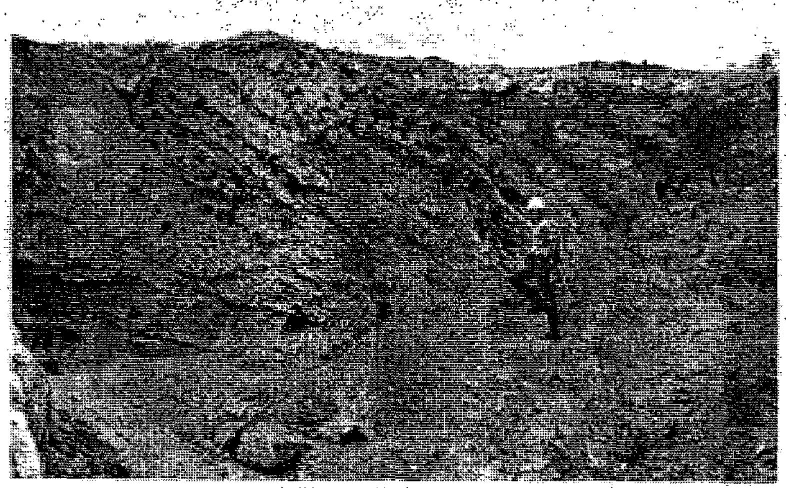


Figure 4. The Bridport Readvance at the type locality. Figure 4a, above, shows the contact between readvance till over gravel. Former Vermont State Geologist Charles Doll is shown behind the large clast. In Figure 4b, at right, the arrow shows a shear plane with gravel dragged into the till. The person in the foreground is Geologist Franklyn Paris. The figure is reproduced from Connally (1970), with permission.

The Bridport Readvance is anchored on the west by the Streetroad delta, a large ice-contact delta adjacent to the Adirondack Mountains and on the east by the East Middlebury delta, a large ice-contact delta adjacent to the Green Mountains. The Streetroad delta was nourished by glacial Putnam Creek. The East Middlebury delta was nourished by the glacial Middlebury River When the ice margin retreated north of Putnam Creek, the Streetroad delta was abandoned and Putnam Creek built the Crown Point delta at the same elevation. This documents the continued existence of Lake Albany even after the recession from the readvance. On the east, the Bristol, South Hinesburg, and Fairfax Falls deltas were deposited successively following retreat from East Middlebury, as discussed by Connally (1982, p.188). Thus, Lake Albany continued to exist as the ice margin retreated into the northern Champlain Valley.

THE DELTAS

There are six great deltas from which the above interpretations have been drawn. These are, from south to north, the Glens Falls, Fair Haven, Brandon, East Middlebury, Streetroad, and Crown Point deltas. This region may have the least complicated set of lacustrine and marine features in the entire Hudson-Champlain trough. Each is discussed below in detail. The spatial relationships are illustrated in Figure 5, extending south to the Hoosic delta and north to the Bristol delta in Vermont.

Throughout this paper, horizontal distances are given in kilometers. However, delta elevations are recorded in feet because they are estimates from the flat upper surfaces observed on topographic maps. Most maps of the Hudson and Champlain Valleys have map scales in English and metric units, while vertical scales remain in English units only. Besides, converting 500 ft to 152.4 m masks the nature of the estimate with an implied precision that does not exist.

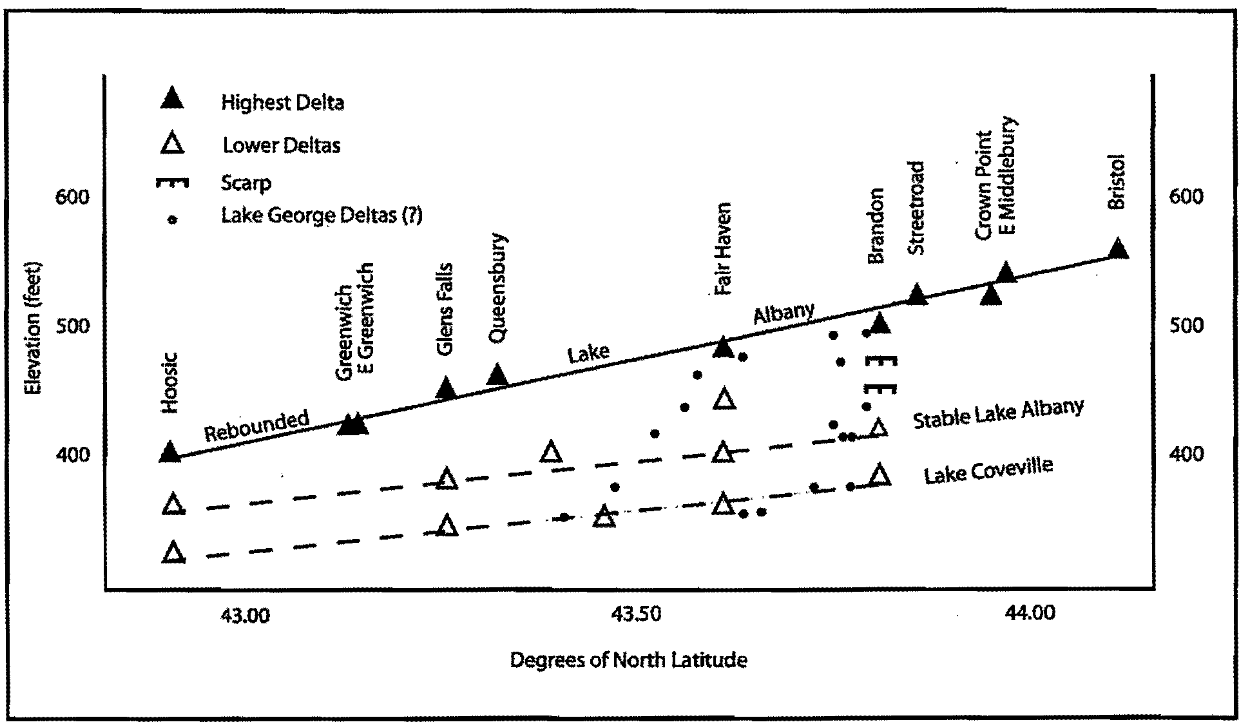


Figure 5. The spatial relations among the Glens Falls, Fairhaven, Brandon, East Middlebury, Streetroad, and Crown Point Deltas. The diagram is extended south to the Hoosic Delta and north to the Bristol Delta. Also shown are seventeen deltaic (?) deposits adjacent to Lake George. Lower "water planes" are included to bracket all the Lake George deposits.

The Glens Falls Delta

When the Luzerne Readvance ice blocked the Hudson River gorge, the water drained southward at the edge of the ice, forming the kame terrace at Wilton. When the ice receded, the Glens Falls delta was deposited by the Hudson River as it debauched from the Luzerne Mountains., southwest of Glens Falls. The upper, sandy surface of the delta is at ±460 ft at Queensbury and ±450 ft adjacent to the gorge. This is the level of Rebounded Lake Albany. There are secondary surfaces at ±380 ft and ±340 ft, with a sandy-clay surface at ±260 ft at Fort Edward. Presumably, these represent Stable Lake Albany, Lake Coveville, and Lake Fort Ann., respectively. There is a 520 to 540 ft ice-contact surface west of Glen Lake that heads at the French Mountain-Adirondack col. That outwash is assigned to a local lake confined to the lower Lake George trough prior to deglaciating the eastern col. All features are displayed on the Surficial Geology of the Glens Falls Region (Connally, 1973)

The Fair Haven Delta

The Fair Haven delta was deposited by the Poultney River, and by its tributary, the Castleton River. It was deposited at the geological contact between the Bomoseen slate belt and the lowland limestones, where the Castleton River debauches from the slate hills. The sandy, pebbly upper surface of the delta appears to be at ±440 ft east of Fair Haven, near Castleton Corners, Vermont. However, outwash adjacent to Lake Bomoseen, and ice-contact deposits in tributary Breton Brook, are graded to ±480 ft. There is a prominent sandy surface at ±400 ft at the village of Fair Haven, while an extensive sand plain to the west is graded to ±360 ft.

The 480 ft surface, clearly associated with active ice withdrawal, is assigned to Rebounded Lake Albany. The 440 ft surface is problematic, between the Rebounded and Stable Lake Albany surfaces. Perhaps the ice lingered there over long, or perhaps the point loading was much less than elsewhere and caused significantly less local rebound. Or, the surface may be erosional. The 400 ft surface is assigned to Stable Lake Albany and the 360 ft surface is assigned to Lake Coveville. Lake Fort Ann features are farther west. However, the Hubbardton River deposited a sandy delta at ±280 ft about 6 km northeast of Fair Haven that is assigned to Lake Fort Ann.

The Brandon Delta

The Brandon delta was deposited by the Neshobe River, where it entered the Otter Creek valley. The upper surface, at Forestdale, is at ±500 ft and represents Rebounded Lake Albany. A flat-topped surface at ±420 ft is assigned to Stable Lake Albany. Hanging deltas at ±380 ft at West Cornwall are ascribed to Lake Coveville, but Lake Fort Ann did not reach as far east as Brandon. These features are displayed on the Surficial Geology of the Brandon-Ticonderoga 15-minute Quadrangles, Vermont (Connally, 1970).

The East Middlebury Delta

The East Middlebury delta was deposited by the Middlebury River where it debauched from the Green Mountains. Ice from the Bridport Readvance blocked westward flow into the valley and diverted the river southward. Initial drainage followed the Halnon Brook channel, thence to a kame terrace at ±600 ft, west of a bedrock ledge. The flat, sandy delta top at ±540 ft is assigned to Rebounded Lake Albany. The foreset slope is south of the river, adjacent to Route 7. In the 1960's and 1970's there were several gravel pits that exposed the smoothly sloping foreset beds. Now, they are occupied by houses and guard dogs. Ice-contact structures were observed in 1965. This delta also is displayed on the Surficial Geology of the Brandon-Ticonderoga 15-minute Quadrangles.

When the Bridport Readvance ice margin retreated northward, the Middlebury River resumed its westward course, depositing a ±420 ft level to the north that is assigned to Lake Coveville. No Stable Lake Albany features have been recognized. Perhaps ice lingered here, blocking westward drainage until Lake Coveville developed. Or, perhaps there had been a 460 ft surface, and it was a casualty of erosion. However, no evidence has been observed to support either hypothesis. The Lake Fort Ann shoreline is farther west.

The Streetroad Delta

The Streetroad delta has a foreset slope adjacent to Route 22 in the hamlet of Streetroad, New York, 4 km north of Ticonderoga. The gravelly delta top is at ±520 ft, sloping down to 340 ft. The 520 ft surface represents Rebounded Lake Albany. There are no secondary levels developed. Until the 1990's, a large gravel pit exposed the entire foreset slope (Connally and Sirkin, 1969, Stop #3). Meltwater and diverted drainage from glacial Putnam Creek deposited the delta. There is an inversion ridge that crests at ±600 ft, representing the outflow channel from the Adirondack headwaters of Putnam Creek. The discharge was diverted southward, between Buck Mountain on the west and Miller Mountain on the east. Several huge kettles, 80 to 100 ft deep, mark the center of the intermontane channel. Since the 1969 field trip, Van Diver (1980, p. 322, Fig. 9.8) has featured the Streetroad delta in his field guide of Upstate New York.

The presence of this delta, and the diverted flow of Putnam Creek, are undoubted evidence of the presence of Bridport Readvance ice north of Miller Mountain. The type locality for the readvance is 5 km east. When the ice receded, Putnam Creek was free to resume its normal eastward path to Lake Champlain and to deposit the Crown Point delta.

The Crown Point Delta

The Crown Point delta is contiguous with the Streetroad delta. It also has an upper surface at ±520 ft, representing the water plane for Rebounded Lake Albany. Deposition of the Crown Point delta marks the termination of the Bridport Readvance. It captured the drainage that had nourished the Streetroad delta.

The Crown Point delta exhibits inset deltaic deposits and/or levels for Stable Lake Albany at ±440 ft, Lake Coveville at ±340 ft, Lake Fort Ann at ±300 ft, Lake Greens Corners (Wagner, 1972, p. 325) at ±200 ft(?), and the Champlain Sea at ±120 ft. When the Bridport Readvance pulled back from the Adirondacks, Putnam Creek re-occupied its preglacial valley. Importantly, the presence of the 520 ft level is evidence that Rebounded Lake Albany still existed as the ice margin receded north. The surficial map of the Crown Point delta is illustrated by Kantrowitz (1968, Fig. 2). The map was created by Connally during a six-week cooperative study between the New York State Geological Survey and the Groundwater Branch of the U. S. Geological Survey in the autumn of 1966, but was published by Kantrowicz without citation or acknowledgment of authorship.

WHY *REBOUNDED* LAKE ALBANY

Why do we assign all of these positions to Rebounded Lake Albany? Earlier Connally, (1970, 1972); and Connally and Sirkin, (1971, 1973) assigned these deltas to three different lake levels. They assigned the Glens Falls delta to Lake Albany, the Streetroad delta to "Lake Quaker Springs", and the Bridport Readvance to Lake Coveville. However, the interpretation changed beginning in 1978.

The 1972 Model

Connally's initial involvement with Lake Albany began in 1965. As a party chief for the Vermont Geological Survey, he mapped the Lamoille Valley deltas in the Mt. Mansfield Quadrangle (Connally (1968b). He also mapped the Middlebury River, Neshobe River, and Otter Creek deltas in the Brandon and Ticonderoga Quadrangles (Connally, 1970, Connally and Calkin, 1972). Prior to Connally's involvement, LaFleur (1965a) had completed mapping in the Capital District of New York. LaFleur, (1965a, Fig. 11) suggested that the lake levels he observed probably intersected levels recorded by Chapman (1937, 1942) for Lake Vermont in the Champlain Valley. He adopted Chapman's terminology, referring to four levels, in descending order, as Lake Albany, the Quaker Springs stage, the Coveville stage, and the Fort Ann stage.

In 1966 and 1967, Connally mapped the surficial geology of Clinton, Essex, Washington, and Warren Counties under a contract with the New York Geological Survey (Connally, 1968c). At that time, he recognized the deltas at Glens Falls, Streetroad, and Crown Point on the west side of Lake Albany and the Fair Haven delta on the east. He agreed with LaFleur's prediction of intersection of Hudson Valley and Champlain Valley water planes.

In an oral presentation in the spring of 1972 Connally naïvely proposed the first modern model for proglacial lakes throughout the entire Hudson-Champlain trough. Because lakes were continuous in both the Hudson and Champlain Valleys, he re-designated the lower levels as Lake Quaker Springs, Lake Coveville, and Lake Fort Ann. Unfortunately, after proposing "Lake Quaker Springs" in the Wisconsinan Stage volume (Connally and Sirkin, 1973) the term became entrenched in the literature. The name Lake Quaker Springs never should have been used, as discussed by Connally (1982, p.188). In this model The Connally (1972) model is sketched below as Figure 7a.

Instead of the expected hosannahs, the model was met with catcalls. Well, almost. Actually, a group of friendly geophysicists pointed out that the model depended on geophysical impossibilities combined with highly improbable coincidence. Each lake experienced instantaneous regional isostatic rebound at its termination – even though the glacier had not yet receded.

After the 1972 presentation, Connally revisited all deltas and inferred shoreline features, from The Terminal Moraine north to the Lamoille Valley. This led to minor adjustments, mainly to Lakes Coveville and Quaker Springs, resulting in almost parallel lake levels, sketched as Figure 7b. Even after the adjustments, the model still demanded instantaneous uplift for "Lake Albany". The adjusted model was almost identical to the one more recently re-proposed by DeSimone and LaFleur (1986), and most recently by DiSimone (1992).

The Problem

One problem just would not go away. When the two parallel levels of Glacial Lake Hudson are projected into the mid-Hudson Valley, they coincide with the *lower two levels* clearly recognizable there. The upper level, that has been recognized as Lake Albany since the time of Woodworth (1905), rises more steeply than the lower two from the Hudson Highlands, northward. But, Lake Albany shares the delta of Moodna Creek, at Cornwall, New York, with Lake Hudson. It diverges from that point to Glens Falls as shown in Figure 6.

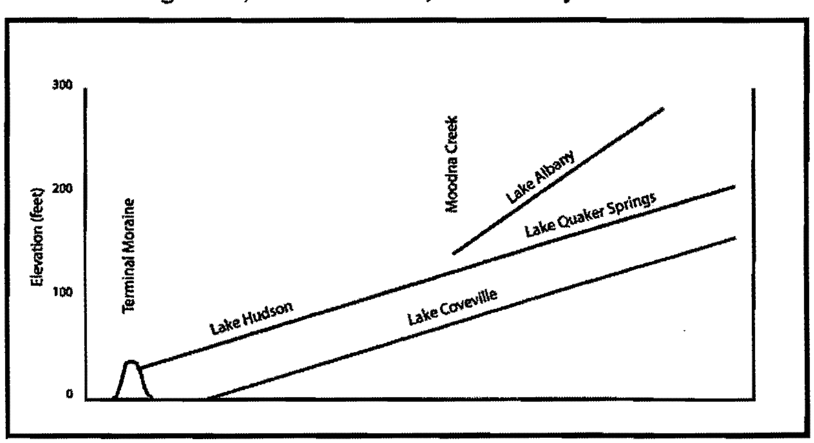


Figure 6. A cartoon illustration of the relationship between lake levels in the lower Hudson Valley during development of the 1972 and 1980 models.

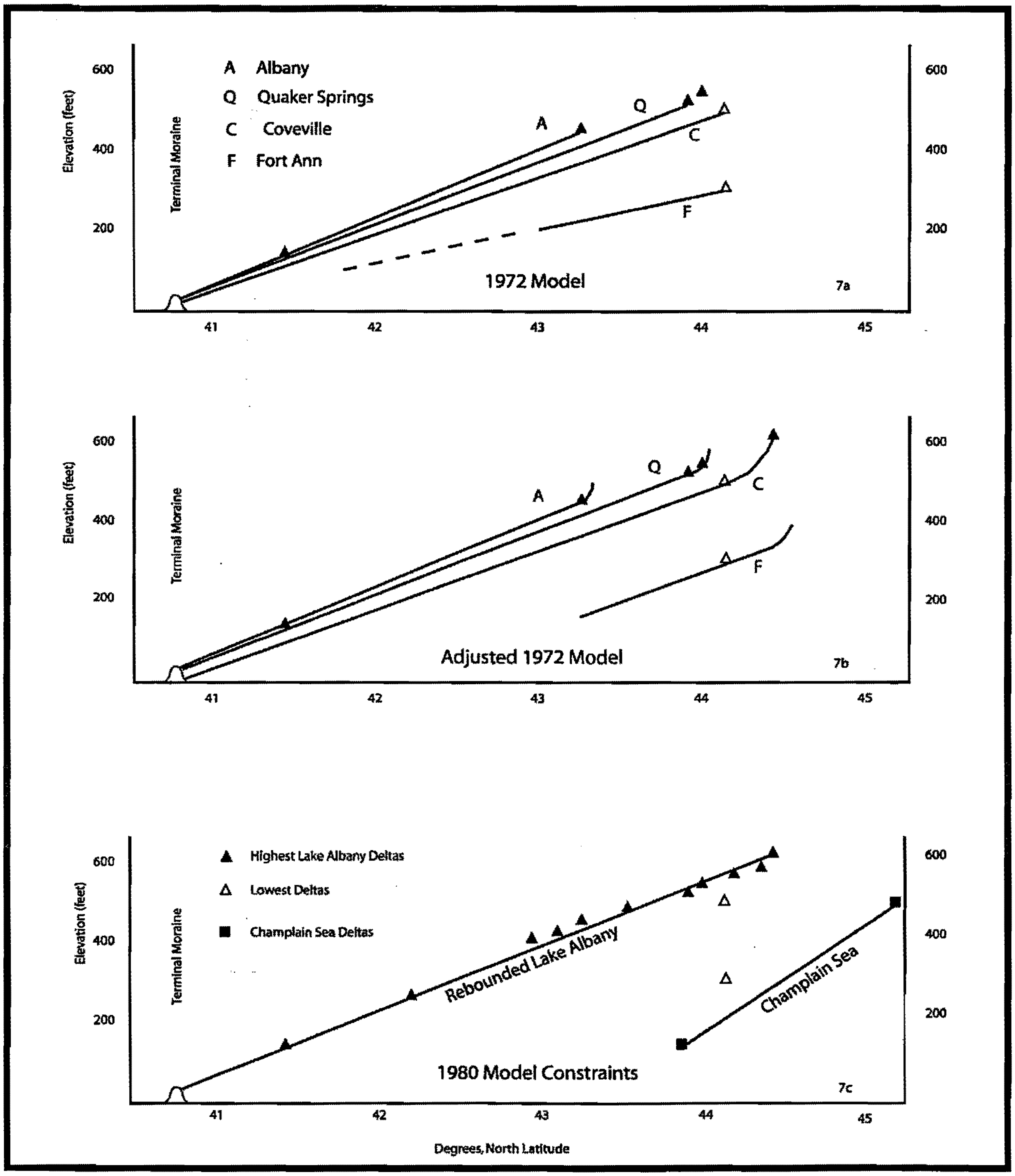


Figure 7. A comparison of the upper constraint on the 1980 model (7c) with the 1972 model (7a) and the adjusted 1972 model (7b) using similar data sets. The lower constraint on the 1980 model is the water plane for the Champlain Sea (7c).

What event could cause a regional isostatic rebound between the two levels? Did Lake Albany exist, and rebound, *before Lake Hudson*? Could ice have remained south of the Hudson Highlands while Lake Albany existed, and rebounded to the north, prior to Lake Hudson? If there was a hinge line at the Hudson Highlands, why didn't it affect lower lake levels? If Lake Hudson projects up the Hudson Valley as the middle level, then isn't that Lake Albany?

The 1980 Model

In the late 1970's, during several consulting projects, Connally re-mapped all the major deltas in the mid-Hudson and lower Hudson Valley. Mapping extended to the Lamoille Valley on the Vermont side and to the Plattsburg vicinity in New York. On the basis of the new mapping, Connally abandoned even the adjusted 1972 model, in its entirety, and re-examined the raw data, disregarding pre-existing models. This led to the development of a new model that was first proposed by Connally (1978) in an oral presentation and illustrated in a consulting report (Connally, 1980) two years later. There were few surprises, and no change in the mid-Hudson Valley. Two differences were obvious, and became constraints for the 1980 model.

The first constraint is that all of the uppermost deltas are related to recession of the ice margin of a single deglaciation. Readvances are considered to be part of that deglaciation. Most of those deltas had been, or could be, demonstrated to relate to an active ice margin. When all of the upper, ice-related deltas were connected by straight-line segments, the lines rose consistently in elevation from the Hudson Highlands to the north end of the Champlain Valley. They all are related to the same "water plane". This eliminated the most serious objection to the 1972 model; it obviates the necessity of proposing isolated rebound events to terminate each lake level. This then is the upper constraint on the model, illustrated in Figure 7c.

The second constraint is that sea level must equal sea level. This is much more than a trite tautology. Sea level, as determined by the Champlain Sea in the Champlain Valley, must equal the sea level at the New York bight, 20 km south of the Harbor Hill Moraine. Chapman (1937, p. 117) reports the Champlain Sea level at 525 ft. at Covey Hill, on the New York side, near the Canadian border. At the Crown Point delta, 120 km to the south, the marine limit is ±120 ft. This is a drop of 405 ft in 120 km or 3.38 ft/km (5.40 ft/mi). If this gradient is projected another 390 km south to the New York bight, it yields a sea level of −1,200 ft. Obviously a sea level 1,200 ft below present sea level is a ridiculous projection. Wagner (1969) reports a Champlain Sea delta top at ±480 ft at Enosburg Falls, on the Vermont side, only 108 km north of Crown Point. Wagner's projection results in a drop of 360 ft in 108 km, or an almost identical 3.33 ft/km (5.33 ft/mi), yielding a sea level of −1,189 ft. This gradient is only slightly more than the 4.7 ft/mi reported by Koteff and Larsen (1985) for the full Connecticut Valley.

How do we find the true marine level in the south? We could go to the various curves for sea level rise. However, as the model developed it became clear that the marine limit bore a consistent relationship to the higher Lake Fort Ann and Lake Coveville levels in the Champlain Valley. In the early 1980's Connally completed mapping all the quadrangles in the mid-Hudson Valley as early preparation for the New York State Surfacial Map (Cadwell and Dineen, 1987 and Cadwell and Pair, 1991), confirming that part of the model presented by Connally and Sirkin, (1986). When Connally and Sirkin recognized that the two projected levels of Lake Hudson projected to "Lake Quaker Springs" and Lake Coveville in the mid-Hudson Valley, it was a simple matter to project a hypothetical sea level there, assuming the same relationship present to the north. In the Champlain Valley, the "Quaker Springs level" is 40 ft above Coveville, 120 ft above Fort Ann, and 260 ft above the marine limit. When the southern level was projected northward, 260 ft below "Quaker Springs" and 220 ft below Coveville, it intersected with the Champlain Valley sea level projection near Ticonderoga, New York. This lower marine limit, that hinges near Ticonderoga, became the lower constraint on the 1980 model, illustrated in Figure 8a.

As implied above, the shorelines immediately above the marine limit in the Champlain Valley are essentially parallel to that limit, as realized by Wagner (1969). In ascending order there is the 1) Champlain Sea, 2) Lake

As implied above, the shorelines immediately above the marine limit in the Champlain Valley are essentially parallel to that limit, as realized by Wagner (1969). In ascending order there is the 1) Champlain Sea, 2) Lake Greens Corners (Lake St. Lawrence[?] of Pair and Rodriguez 1993), 3) Lake Fort Ann (the Fort Ann stage of Chapman, 1937 as modified by Wagner, 1969), 4) Lake Coveville (the Coveville stage of Chapman, 1937, as modified by Connally, 1980), and 5) the highest parallel level, part of which was recognized as Lake Quaker Springs until the term was abandoned, as discussed below. Above the set of parallel water planes, is the Lake Albany water plane that is decidedly not parallel in the 1980 model.

Lakes Coveville and Fort Ann

Before unbending the model to examine Lake Albany, we can make constructive observations about subsequent Lakes Coveville and Fort Ann. Quoting Chapman (1937, p. 95) on Lake Coveville:

> *"... when projected southward, it leads directly to an abandoned channel of the Hudson River... At Coveville, where the southern end of this channel overhang the Hudson River by more than a hundred feet, is a rock ledge which acted as the controlling threshold for the waters during the Coveville stage..."*

In the 1980 model, Lake Coveville projects more than 130 ft above the 200 ft threshold for which it was named. Even Lake Fort Ann projects to 50 ft above the Coveville outlet. It appears that the "Coveville outlet" had no significance, unless it was occupied temporarily as Lake Fort Ann drained. And there is some evidence for such an event. Lake Fort Ann projects 100 ft (Connally, 1978) above it's defined outlet south of Fort Ann, New York. However, lower level, Lake Greens Corners, evidently had its threshold in the Wood Creek valley between Fort Edward and Fort Ann, New York. Yet, three quarters of a century of usage has clearly established nominal priority for the Lake Coveville and Lake Fort Ann features. We suggest that we merely recognize a change in the outlets. But where then was the outlet for Lake Fort Ann?

The *Lakes* Albany

In Figure 8b, we remove the local component of post-Champlain Sea rebound, by straightening the hinge line. Present interpretation moves the hinge line northward from Ticonderoga to the Crown Point vicinity. In this projection, the two levels of Lake Hudson project all the way to the Champlain Valley. The lower level projects as Lake Coveville. In 1978 and 1980, the upper level was unwittingly designated "Lake Quaker Springs". Obviously this water plane represents northward expanding Lake Albany, north of the Hudson Highlands, while the upper divergent level represents traditional Lake Albany. Since 1982 Connally (1982, 1983) and Connally and Sirkin (1986) have recognized *both* upper levels as Lake Albany. The parallel water plane was named Stable Lake Albany.

To complete restoration to Champlain Sea time, the entire model is rotated into the horizontal plane (Figure 8c). This represents the attitude of the water bodies during, and shortly after, the Champlain Sea. From the rotated projection, very similar to that illustrated by Connally (1982, Fig. 4), it becomes obvious why the upper level was named *Rebounded Lake Albany*. This "water plane" diverges from Stable Lake Albany at the Hudson Highlands and does not rejoin it until the Lamoille Valley.

The first question is how did that happen? There are two choices. The first choice - the Big Burp! – is that at the close of Lake Albany time, there was a local rebound event that warped the plane upward. But that also should have involved Stable Lake Albany, and it does not offer any solution to the objections to the 1972 model. Thus, Connally (1982 Fig. 5) and Connally and Sirkin (1986, Fig. 8) invoked the second choice, illustrating a hypothetical "rolling rebound" to explain Rebounded Lake Albany. This was not a regional post-glacial rebound, but rather an adjustment to local unloading of the crust beneath the Hudson-Champlain trough which was comparatively overloaded during glaciation, relative to bounding mountain ranges on either side.

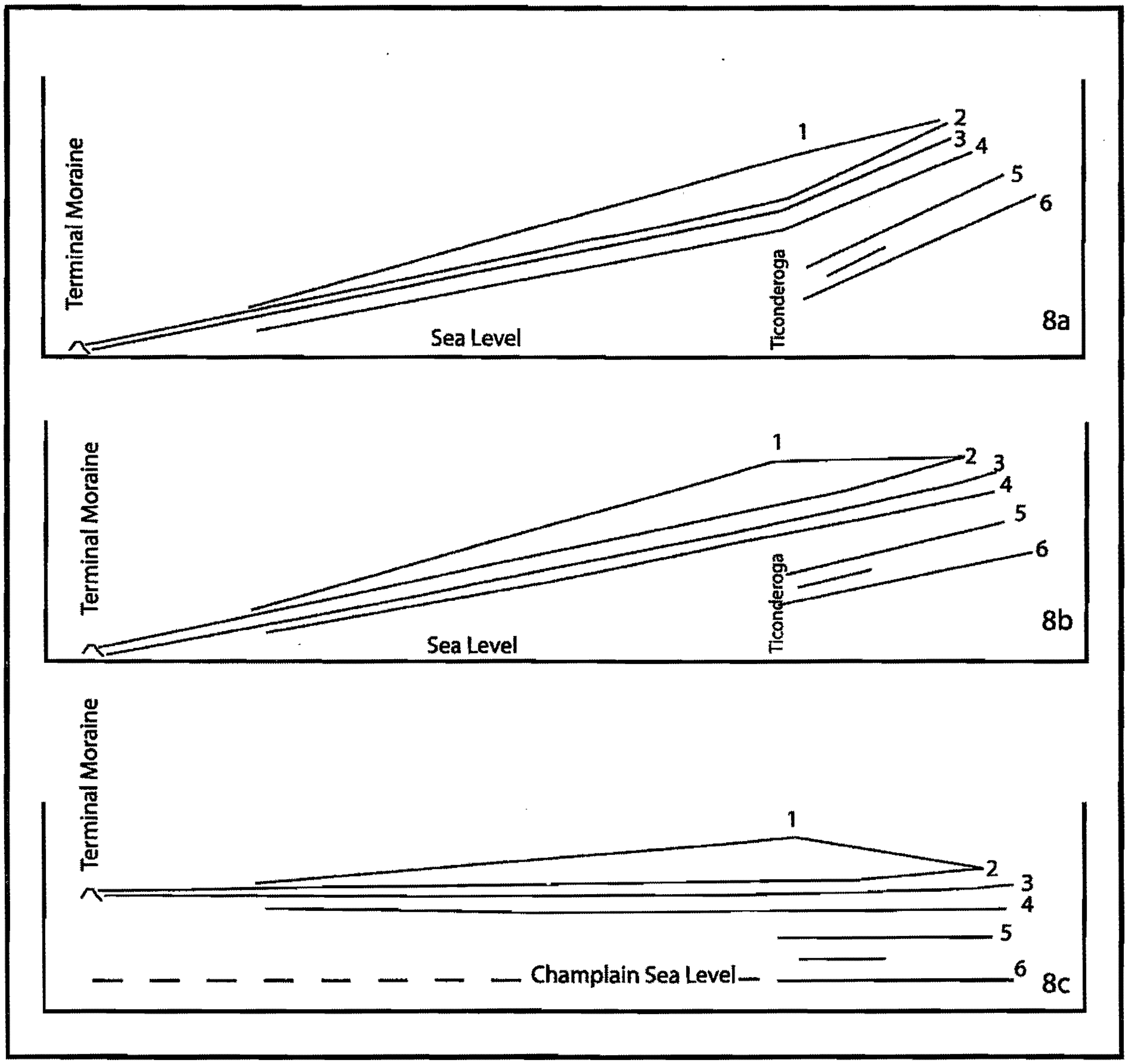


Figure 8: The 2002 model for Rebounded Lake Albany (1), Stable Lake Albany (2), Lake Coveville (3), Lake Fort Ann (4), Lake Greens Corners (5), and the Champlain Sea (6). Connally's data was supplemented with data from Reeds (1927) for the lower Hudson region, LaFleur (1965b) for the Capitol District, and Wagner (1969) for the Champlain Valley. Figure 8a is the actual 1980 model. Figure 8b is the 1980 model with the Ticonderoga hinge line removed. Figure 8c is the 1980 model with the Champlain Sea rotated to a horizontal plane, that should approximate the inferred sea level during that time.

The second question is, why didn't the same thing happen to the other lake levels. The answer almost certainly is time. Time! Glacial Lake Albany existed for 9,000 to 10,000 ^{14}C years. Lakes Coveville and Fort Ann lasted ±2 percent of that time. There is a 400 year period between the Bridport Readvance, at 11.90 ka, and recession into the St. Lawrence Lowland at 11.50 ka. If one half of that is allotted to recession to the Lamoille Valley and the other half to Lakes Coveville and Fort Ann, it only leaves 100 ^{14}C years for each. It does no good to quibble about 11.50 ka. The orders of magnitude remain the same. The time between Lake Albany and the Champlain Sea was comparatively quite short.

Now, to return to the original question, why *rebounded* Lake Albany? Rebounded Lake Albany is marked by a series off large deltas, both east and west in the Hudson and Champlain Valleys. Most, if not all, originated as ice-contact deposits. However, most continued to grow after the ice margin had retreated from each successive position. These deltas have two things in common. They almost all originated in contact with active or stagnant ice and they all are aligned vertically (Figure 9), from south to north. They form what had been called the Lake Albany "water plane". Connally's 1978 title was "Lake Albany: its untimely demise", referring to the probability that it never ever existed as a continuous, horizontal lake body. Whether the water plane marks an actual shoreline, or is an artifact of local rebound, is here immaterial. The important point is that it is a feature that ties all of these deltas to a common origin.

A Proposed Lake History

Lake Albany came into existence shortly after 20.18 ka, a date cited by Reimer (1984) for varves in the southern basin of Glacial Lake Passaic in northern New Jersey. The Terminal Moraine was deposited into Southern Lake Passaic (Stone et al., 1989), so this date probably pre-dates Lake Hudson/Lake Albany inception. Lake Albany continued to exist until about 11.80 ka, as inferred mainly from evidence from the field trip area, summarized in Figure 9.

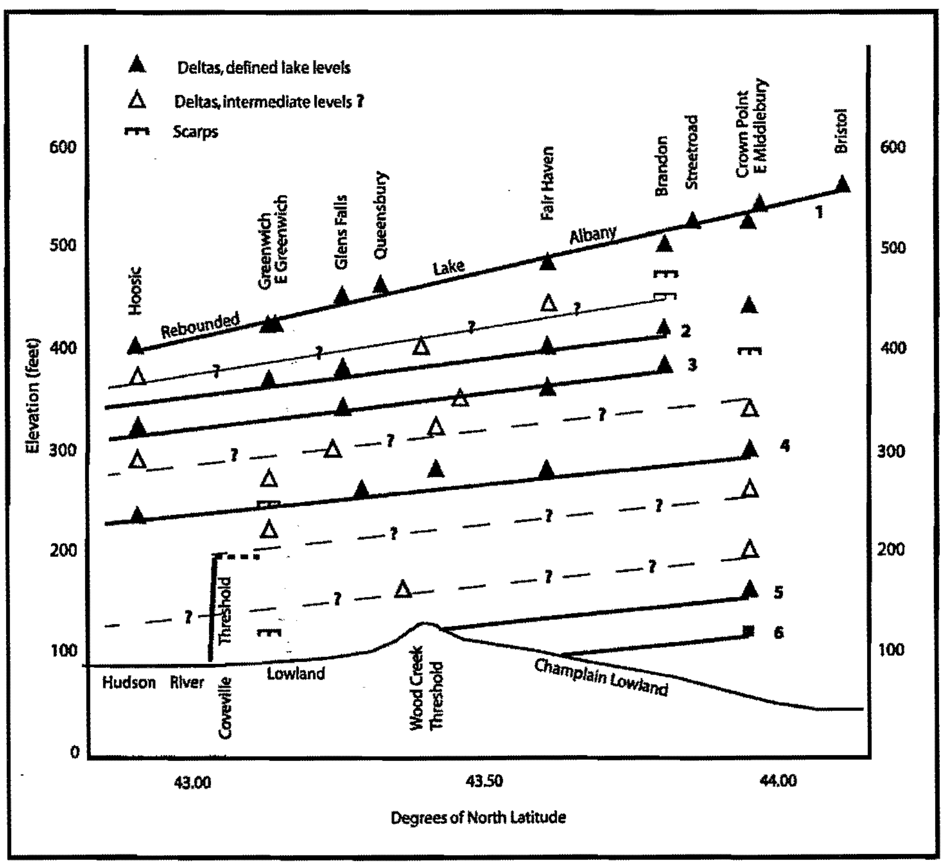


Figure 9. A diagrammatic representation of the inferred "water plane" for Rebounded Lake Albany (1). Also illustrated are the inferred water planes for Stable Lake Albany (2), Lake Coveville (3), Lake Fort Ann (4), Lake Greens Corners (5), and the Champlain Sea (6). The Coveville and Wood Creek Thresholds appear at the base of the diagram. Dashed lines indicate other possible intermediate lake levels.

As the ice margin retreated from the Bridport Readvance, but before it reached the Saranac River (Stevens and Gowan, 1988), the southern threshold for Lake Albany dropped ±40 ft, either due to downcutting at Hell Gate, or to development of a new, slightly lower, outlet. The new threshold controlled Lake Coveville, which became the new stable level, until perhaps 11.80 ka. Then the drift damn at the Staten Island Narrows was breached and Lake Coveville drained. Features in the study area suggest that there may have been a secondary level for Lake Coveville, 40 ft lower than the defined level.

With the draining of Lake Coveville, northern waters were dammed either by the Coveville delta(?) at the Hoosic River, blocking the Hudson River valley, or by the Schenectady delta in the Capitol District. Perhaps Lake Fort Ann waters briefly found an outlet at the Coveville threshold. The 260 ft delta level at Crown Point supports such an interpretation. The 200 ft level at Crown Point suggests a third "Fort Ann" level, perhaps blocked by the Batten Kill delta. We suggest that Lake Fort Ann existed until; ca 11.70 ka. DeSimone (1992, p.4) asked "Can multiple Fort Ann levels be recognized ...?" The answer is that they always have been. A more important question is, could the draining of Lakes Coveville and Fort Ann be the cause of the R6 and R5 freshwater fluxes cited by Clark, et al (2001)?

About 11.60 ka the impediments to the south, whatever they were, were finally breached in the Hudson River channel. Then the Wood Creek channel, north of Fort Ann, served as threshold for Glacial Lake Greens Corners. At 11.50 ka the ice margin cleared the Champlain Valley, creating Glacial Lake St. Lawrence.

CORE INTERPRETATIONS

In August of 2001, we obtained two cores from varved lake deposits east and west of Lake Champlain. An experienced geological consultant extracted the cores using his *geoprobe*. Cores were retrieved in 123 cm segments, in clear plastic tubes. In the lab, each segment was cut in half. Each half was heat sealed in plastic, labeled , and stored. One set of core halves was archived, while the other was transferred to Dr. Jack Ridge's core lab at Tufts University.

Core #3

Core #3 was spudded in Champlain Sea sediment on the St. Pierre Farm, at the southern end of the Crown Point peninsula. The site is 6 km northwest of the type locality for the Bridport Readvance and 7 km northeast of the Crown Point delta. Thus, the varve record was expected to include subsurface evidence for the readvance. The surface elevation is ±13 m above the level of Lake Champlain and 480 m west of the lake shore, where glacially polished and striated limestones are overlain by varved lacustrine clay. The varved clay is capped by shell-bearing marine clay. Marine clam shells were collected by Connally in 1967 from nearby drainage ditches, and by Connally and Sirkin in 1970 from the lake bluffs. The 1970 shells were dated at 14.35 ±0.60 ka (I-4988). Because it was not a reliable date it was never published. The lab description as "... the smallest sample we can measure. We were not able to remove any surface carbonate ... before the analysis." Probably explains the relative antiquity of the date. Wagner (1969, p. 337) obtained a date of 9.62 ±3.5 ka (I-4695) in the Crown Point vicinity.

A 15 m core was retrieved in 20 segments. There was little, if any, stratification evident in the upper 4 m of this core. Below 4.5 m the lacustrine clays are contorted and faulted. As noted during drilling, the top 30 cm of each of the ten lower tubes contained oxidized (5 Y), partly homogenized, lacustrine sediment. We speculated, in the field, that the hole might have partly collapsed after each core segment was withdrawn. During lab inspection, we speculated that the core barrel was pushing a column of compressed air, homogenizing the collapsed(?) sediment as it pushed. If so, then those sediments would be the first cored and would fill the top of each coring tube.

The only usable data from Core #3 came from the upper 4.5 m and is recorded below.

000 – 010 cm	A_p horizon --	truncated, puddled, organic clay
010 – 012 cm	A_1 horizon --	crumb structure, no organics
012 – 023 cm	B_1 horizon --	transitional to B_2, below
023 – 045 cm	B_2 horiizon --	root casts, some red/yellow patches
045 – 105 cm	C_1 horizon --	some frost(?) cracks, prominent faulting
105 – 130 cm	C_2 horizon --	some deep dessication cracks
130 – 380 cm	C_3 horizon --	parent material; unaltered Champlain Sea sediments including concretions and ghosts
380 – 450 cm		transitional zone
450 cm to base		contorted lacustrine clays as reported above

Ridge (2002, oral communication) encountered similar conditions in marine clay near Plattsburgh, New York. Marine clay evidently flocculates, precluding varve formation. We have no way of knowing whether the contorted lacustrine clays are natural or were disturbed during coring. Thus, we are left with a tantalizing 15 m core that is useless for varve interpretation.

Core #2

Core # 2 was spudded in lacustrine sediment on the Champlainside Farm, 200 m east of the Lake Champlain shore, where glacially polished and striated Ordovician limestones are overlain by varved lacustrine clays. This site is almost exactly opposite Core #3. The surface elevation is ±48 m, 19 m above Lake Champlain and at least 6 m above the highest marine sediments. The elevation and location are critical. This core section never was inundated by the Champlain Sea. It lies 2.8 km north of the type locality for the Bridport Readvance and 1 km from the West Bridport multiple till section (Connally, 1970, p. 22) described below and illustrated in Figure 13.

00 – 02 ft	laminated clay with pebbles and boulders
02 – 18 ft	yellow brown lacustrine silt
18 – 22 ft	dark gray (N 3) clay-loam till
22 – 23 ft	oxidized (5 Y) till (?)
23 – 25 ft	gray-black (N 4) till
25 – 29 ft	light-gray (N 2) till

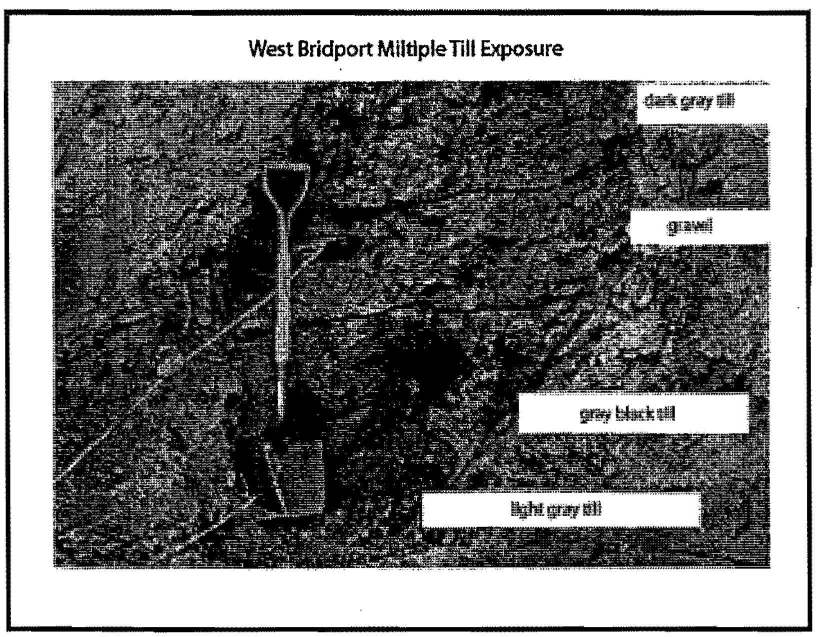


Figure 10. The West Bridport multiple till section, described above, as it was exposed in 1965. Figure reproduced from Connally (1970), with permission.

The basal light-gray till was interpreted as Shelburne till. The gray-black and dark-gray till, including the gravel lens, were interpreted as Burlington till. As in Core #3, the subsurface record should include evidence for the readvance and both preceding and succeeding lacustrine sedimentation. The entire record should be pre-Champlain Sea.

Core #2 is much more coherent than Core #3. It bottoms in 30 cm of dark-gray (N 3) Burlington till, identical to that in the West Bridport section, described above. Immediately on top of the till is a 38.67 cm sequence of 9 varves. Overlying the varves is a 40 cm, oxidized (5 Y) interval consisting of very contorted, mostly homogenized, lacustrine sediment. During drilling, this was interpreted as Bridport Readvance till, consistent with nearby exposures. However, because it is at the top of a core segment, and is so similar to the presumed "collapse" material on Core #3, its identification is problematic. In the overlying core segment, is a 6.1 cm interval of pebbly lacustrine material, overlain in turn by 101 cm yielding 13 distinct varves. There are four additional varves in the next 14 cm that are very disturbed; they were recognized on the basis of fragments of summer layers. The uppermost 246 cm is too disturbed to permit varve identification, even below the solum. A brief description of the core appears below.

000-015 cm	A_p horizon – dark, with organics
015-032 cm	B_2 horizon – red/yellow color patches
032-052 cm	B_{2t} horizon – massive clay, no peds
052-109 cm	B_3 horizon – frost riven with cryoturbation(?)
109-167 cm	C_1 horizon – obvious open dessication cracks
167-246 cm	C_3 horizon – lacustrine parent material
246-260 cm	5 indistinct varves
260-361 cm	13 distinct varves
361-367 cm	pebbly lacustrine sediment
367-407 cm	Bridport Readvance till (or "collapse")
407-446 cm	9 distinct varves
446-476 cm	dark gray (N 3) Burlington till

The varves in Core #2 were counted and calibrated at Tufts University, with the cooperation and guidance of Dr. Jack Ridge. We used his computer program to count and calibrate the two varve sequences illustrated below in Figure 11.

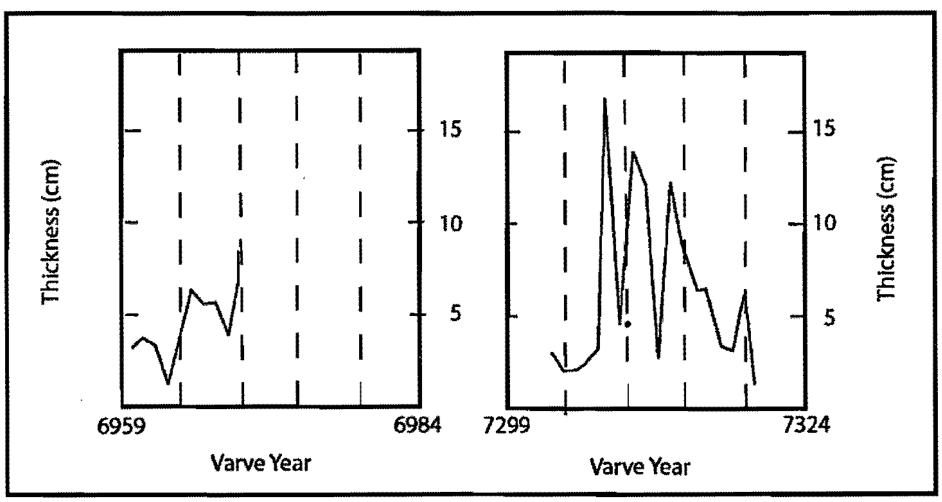


Figure 11. An illustration of the lower 9 varve sequence, on the left, and the upper 17 varve sequence on the right. The preferred match for the lower sequence is shown.

The two varve sequences were matched against the composite record for the upper Connecticut Valley. There were five possible matches for the younger 17-varve (17v) sequence and at least seven for the 9-varve (9v) sequence. Only one match, between varve years 7299 and 7315 is younger than the Bridport Readvance. According to Ridge et al. (1999), the Littleton-Bethlehem/Middlesex Readvance took place between varve years 7200 and 7400; advance no earlier than 7154 and recession no later than 7305. The 9v sequence was deposited between 6717 to 6726 at the earliest and between 6961 to 6970, at the latest. This suggests that a minimum of 230 years, as illustrated, and a maximum of 483 years of varves were removed by the readvance.

THE FIELD TRIP

The field trip will make two stops at the Streetroad delta. Stop #1 will examine the internal sediment and Stop #2 will examine an inversion ridge left by glacial Putnam Creek that delivered sediment to the delta. Then we will descend the Crown Point delta, pointing out the various named lake levels. Stops # 3 and #5 will be brief drive-by stops to point out the localities for Cores #3 and #2, respectively. Stop #4 will be at the Crown Point State Park campground where we will discuss the cores, point out some striae, and have an early lunch. Stop #6 will be a drive-by for the type locality of the Bridport Readvance. There is an alternate Stop #6A, with road log, that visits the East Middlebury delta. Since there is little left to see, we will skip that potential stop. It may be visited later by interested individuals. Stop #7 will be in the Hubbardton River delta for Lake Fort Ann. Stop #8 will be a drive-by on the various surfaces of the Fair Haven delta. Finally, we will traverse Lake Albany, crossing levels of the Glens Falls delta. We will finish at the type locality for the Luzerne Readvance in the Hudson River gorge between Glens Falls and Corinth.

ACKNOWLEDGMENTS

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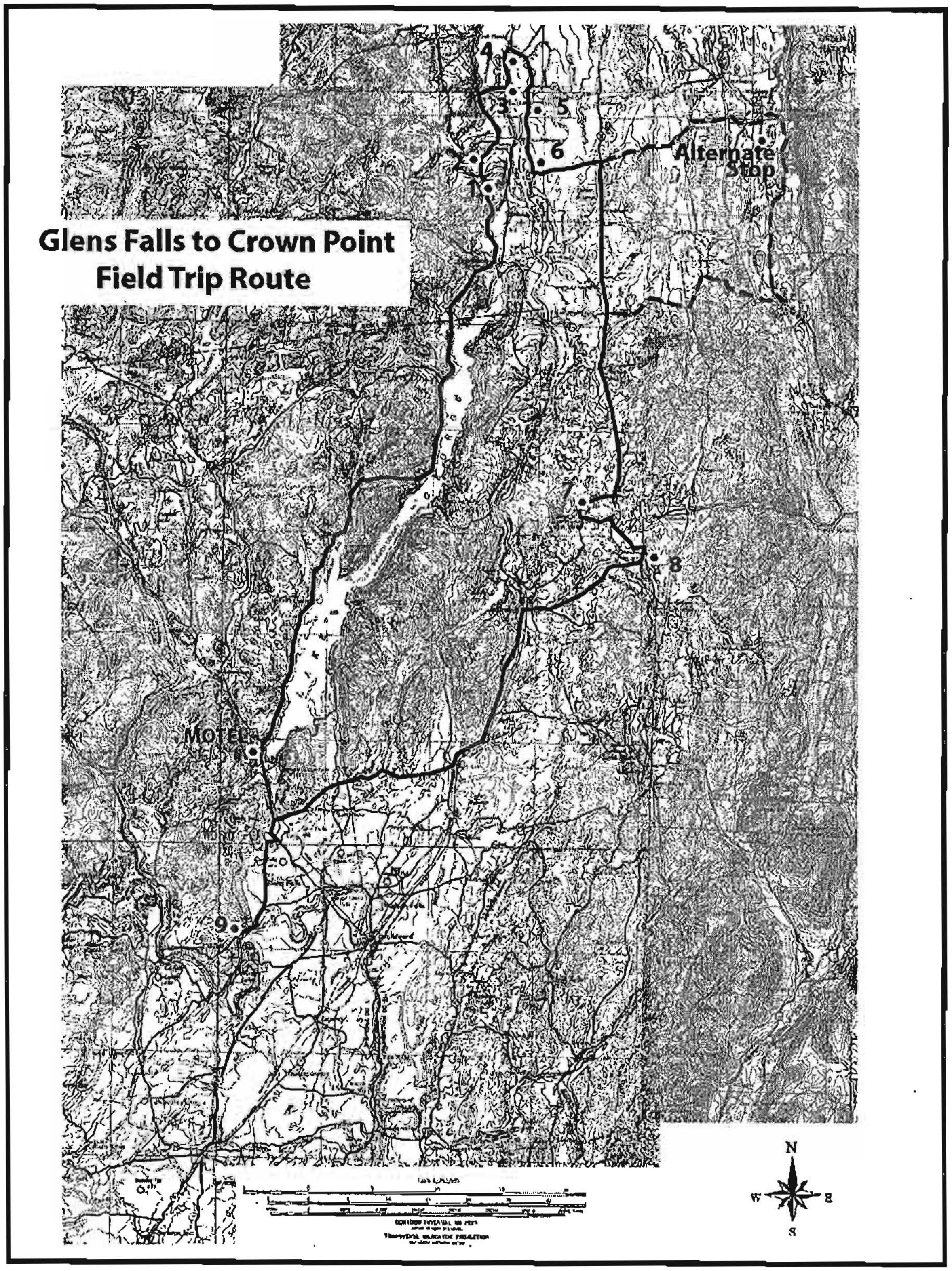
Glacial Lake Albany in the Champlain Valley
Field Trip B 8 Road Log



ROAD LOG

Glacial Lake Albany in the southern Champlain Valley

00.0	0.00	Fort William Henry Motel and Conference Center; proceed north on Route 9 through Lake George Village
00.9	00.9	Bear right on Route 9N
04.7	04.7	Diamond Point Flats are on the Rebounded Lake Coveville "water plane"
10.2	10.2	Bolton Landing, built on a Lake Coveville delta.
23.5	23.5	Picture Stop; view of southern Lake George
23.9	23.9	Sabbath Day Point; pit on left in a Lake Coveville delta.
26.0	26.0	Silver Bay Llake Coveville delta below, on right. Rebounded Lake Albany, Sttable Lake Albany, and Coveville featurues from here to the Hague.
29.8	29.8	The Hague; bear right; Route 8 leaves to left
36.4	36.4	Trout Brook Valley, at left, filled with lake clay
37.8	37.8	Lake Champlain on the horizon, ahead to the left
39.0	39.0	Bear left around statue, Ticonderoga village and Fort Ticonderoga to right
39.8	39.8	TRAFFIC LIGHT Cross Route 74; Route 22 joins from left
41.8	41.8	Bear left onto Co. Route 7 (Vinyard Rd). Rise up the foreset slope of the Streetroad delta
43.5	43.5	Turn Right on Burmbaugh Road and right again into the Heustis Gravel Pit
		STOP #1. This stop is in a gravel pit developed in one of the deep kettle holes in the 520 ft Streetroad Delta (p. B.8-7; Crown Point 7½' Quadrangle) of Rebounded Lake Albany. Obviously this delta was deposited upon or within a large block of stagnating ice. This ice was left behind following the Bridport Readvance. Note the lithologies present and the size, sorting, and degree of abrasion of the clasts. There were no lower erosional or depositional levels on the foreset slope. Thus, the ice margin must have receded before any lower lake levels developed.
43.5	00.0	Turn left out of gravel pit and then right, continuing north on Co. Route 7
45.6	02.1	Turn left into Raffety Sand and Gravel pit
		STOP #2. This stop is in a recently developed gravel pit developed in an inversion ridge. This ridge, originally mapped as a kame terrace, is made of sediment deposited by glacial Putnam Creek, diverted southward by the ice of the Bridport Readvance (p.B.8-5). The sediment was deposited in a low channel held in by high banks of ice. When the ice left, the sediment became the high ridge above the area where ice had been. Thus, the topography is inverted. The inversion ridge is evidence of deposition from higher parts of an ice-free drainage basin, onto, into, or next to the ice. This deflected sediment is part of the evidence for the Bridport readvance.

The 520 ft, Rebounded Lake Albany level, is shared with the Crown Point Delta (p. B8-7; Crown Point 7½' Quadrangle). When the ice margin receded, Putnam Creek again flowed eastward into the lakes of the Champlain Valley. Thus, Rebounded Lake Albany continued to exist for some time after northward withdrawal of the ice margin. We will cross lower levels of the Crown Point delta as we proceed to Stop #3.

45.6	00.0	Turn left out of gravel pit, continue north on Co. Route 7
45.8	00.2	Turn right (east) on Amy Hill Road, cross 440 ft delta flat of Stable Lake Albany
46.5	00.9	Descend to a 360 ft Coveville delta
46.8	01.2	Descend a 260 ft Lake Fort Ann delta, then to a 200 ft Fort Ann delta; exposures of sandy beds on left
47.5	01.9	YIELD and join Co. Route 47, continue east
48.0	02.4	STOP SIGN Turn left (north) onto Route 22/9N
48.1	02.5	Descend to Putnam Creek bridge, then rise back up to the sandy,160 ft, Lake Greens Corners delta inset into lake clays
50.1	04.5	Sandy 340 ft Coveville delta at left against Bulwagga Mt.
51.7	06.1	Turn right (east) to Vermont Route 17 and Crown Point
53.6	08.0	Turn right onto Lake Road
		STOP #3. This is a brief stop to view the St. Pierre Farm where Core #3 was retrieved (p. B.8-14; Port Henry 7½' Quadrangle). The upper 4-4.5 m is Champlain Sea sediment with marine shells. Below this is at least 11 m of varved lacustrine clay.
53.6	00.0	Return to Vermont Route 17, continue north (right) to Crown Point bridge
55.3	01.7	STOP #4. Turn right (east) into Crown Point State Park (Port Henry 7½' Quadrangle). Here we will discuss the results of the coring program (p. B.8-16) and examine the polished, striated limestone bedrock beneath the Crown Point bluffs. After our discussion, this will be our lunch stop.
55.6	02.0	Bridge over Lake Champlain
56.1	02.5	Chimney Point, Vermont to right
56.2	02.6	Turn right (west, then south) onto Vermont Route 125; following winding road
59.4	05.8	Turn right (west) on Lake Street
59.9	06.3	Continue south on Lake Street
61.3	06.7	Pull over to right just past Champlainside Farm

STOP #5. This will be another brief viewing stop to point out the location for Core #2 (p. B.8-15; Bridport 7½' Quadrangle)on Champlainside Farm The West Bridport section (p. B.8-Figure 10) is immediately southwest on the shore of Lake Champlain.

61.3	00.0	Continue south on Lake Street
62.7	01.4	Bear right and then left, follow Lake Street, Middle Road leaves to left. The Jones Dock Road leaves to right. Two (or three) tills over striated limestone at lake level.
64.4	03.1	Turn left (east) on Crown Point Road
65.4	04.1	Pull over to right half way up the hill
		STOP #6. This will be another brief viewing stop (Bridport 7½' Quadrangle) to see the location of the former gravel pit that was the type locality for the Bridport Readvance (p. B.8-4 and Figure 4)
65.4	00.0	Continue east on Crown Point Road
68.1	02.7	Turn left (north) on Happy Valley Road
69.7	04.3	Turn right (west) on main road, then left, then right
69.9	04.5	STOP SIGN Turn right (south) on Route 22A
75.4	11.0	Pass through Shoreham, Vermont
81.6	17.2	Cross Vermont Route 73, continue south
88.9	24.5	Turn right (west) on Lake Road
89.7	25.3	STOP SIGN Turn left (south) towaed Benson on Stage Road
93.5	29.1	Bear left on Stage Road
94.3	29.9	Cross the Hubbardton River; the road climbs and bends to the right and then left
94.9	30.5	Turn right onto Hack Dam Road, continue west on 360 ft Stable Lake Albany delta
95.6	31.2	Turn right (north) on River Road, descend and wind back to the east
96.1	31.7	Pull off opposite Bishops Commercial Sand and Gravel
		STOP #7. At this stop (Thorn Hill 7½' Quadrangle) we will examine the bottomset sands of the 280 ft Fort Ann delta of the Hubbardton River (p. B.8-6) for signs of varves. Then we will climb up to the pit and look for ice-contact structures (and the toe of a Taconian thrust fault).
96.1	00.0	Continue east of River Road
96.7	00.6	STOP SIGN Turn right on Stage Road

98.1	02.0	STOP SIGN Turn right (south) on Route 22A
101.1	05.0	Turn left (east) on Fourth Street, village of Fair Haven. Flat surface is the 380 ft Stable Lake Albany surface of the Fair Haven delta
101.6	05.5	RED BLINKER LIGHT Continue east on Vermont Route 4A
102.5	06.4	Climb to 440 ft Rebounded Lake Albany level of Fair Haven delta of the Castleton River
104.5	08.4	TRAFFIC LIGHT Turn right (south) on Vermont Route 30
104.9	08.8	Cross Castleton River
105.6	09.5	Turn right (west) on Rice Willis Road
105.9	09.8	Pull over to right on Rice Willis Road
		STOP #8. This will be a brief drive-by stop (Poultney and Thorn Hill 7½' Quadrangles) on the 440 and 400 ft levels of the Fair Haven delta (p. B.8-6), unless a recent exposure is available.
105.9	00.0	Continue west on Rice Willis Road
106.3	00.4	Slate Quarry on left
106.6	00.7	STOP SIGN Turn right (north) on ???????????
107.1	01.2	Cross Castleton River
107.4	01.5	STOP SIGN Turn left (west) on Vermont Route 4A
108.0	02.1	BLINKER LIGHT Continue west of Fourth Street
108.5	02.6	Turn right (north) on Route 22A, travers 360 ft Coveville delta
109.9	03.2	Turn left (west) on Route 4
111.7	05.0	NY/VT State line. To the left is the Lake Coveville delta, to the right is the Poultney River. Large logs in the alluvium date at 5,580 yrs BP
118.0	11.3	Cross the Hudson-Champlain Canal
118.3	11.6	TRAFFIC LIGHT Whitehall, NY, Turn left (south) on Route 4/22
125.2	18.5	TRAFFIC LIGHT Route 22 leaves to left (stay on Route 4)
129.1	22.4	TRAFFIC LIGHT Turn right (west) on Route 149 (Anne Street) in the village of Fort Ann
136.5	29.8	TRAFFIC LIGHT Continue west across Route 9L
138.0	31.3	TRAFFIC LIGHT Continue west across Bay Road
141.1	34.4	TRAFFIC LIGHT Turn left (south) on Route 149/9

141.6	34.9	TRAFFIC LIGHT Continue south on Route 149
141.9	35.2	Turn right (west) to Route 87 south
142.1	35.4	Turn left (south) on Route 87 South
146.5	39.8	Exit right at Interchange 18 (mile 54)
146.8	40.1	STOP SIGN Turn right (west) on Corinth Road; cross 450 ft delta of Rebounded Lake Albany.
149.5	42.8	West Mountain Road joins from right
150.0	43.3	Enter the Hudson River Gorge
159.8	44.1	Pull into left should of road
		STOP #9. This is the type locality for the Luzerne Readvance (p. B.8-2 and Figure 3; Glens Falls 7½' Quadrangle). Compare the texture, color, and clast lithologies between the lower grayish-black till and the overlying readvance till. Many times in the past it has been possible to observe a stone line at the base of the readvance till. This has been interpreted as a thin layer of lodgement facies beneath the subglacial meltout till.
159.8	00.0	Turn around and proceed east on Corinth Road
163.5	03.7	Turn left to Route 87 North, traverse 360 ft Coveville delta
165.6	05.8	Ascend to the 460 ft Stable Lake Albany delta of the Hudson River (Glens Falls delta)
173.2	13.4	Exit right at Interchange 21
173.8	13.6	STOP SIGN Turn right (east) on Route 9H
173.9	13.7	TRAFFIC LIGHT Turn left (north) on Route 9 into Lake George Village
175.1	14.9	END OF TRIP, Fort William Henry Motel

BELOW IS A ROADLOG FOR AN ADDITIONAL STOP AFTER STOP #6.
The roadlog begins at mile 69.9 and re-joins the fieldtrip at Stop #7.

69.9	04.5	STOP SIGN Turn left (north) on Route 22A
70.1	04.7	BLINKER LIGHT Turn right (east) on Route 125 east
73.6	08.2	Turn left (east) with Route 125 after crossing the Lemon Fair River
74.9	09.5	Route 125 bends left, then climb through The Ledges
76.0	10.6	Route 125 bends right and straightens to Middlebury
77.6	12.2	Middlebury College on left
78.2	12.8	Cross Otter Creek falls, then turn right (east) on Route 7

78.3	12.9	Turn left around Middlebury Inn on Princess Street
78.4	13.0	Turn right (south) following Route 125/7
82.3	16.9	Bear left (east) on Route 125
82.8	17.4	Continue east on Route 125, Route 116 leaves to left. Drive up alluvial fan surface graded to 420 ft Lake Coveville
83.6	18.2	Turn right (south) on Lower Plains Road; cross the Middlebury River, then climb to 540 ft Rebounded Lake Albany delta
84.2	18.8	Ice-contact inversion ridge on left; marks channel that carried Middlebury River waters south to the delta; ice must have blocked westward drainage
85.2	19.8	Abandoned gravel pit to left; in 1965 showed ice-contact deposits at proximal end of Lake Albany delta as a mirror image of the Streetroad/Crown Point deltas on the west side of the Champlain Valley
85.4	20.0	Turn right (west) on Beaver Pond Road
85.8	20.4	Descend the foreset slope of the East Middlebury delta. Abandoned pits on left and right displayed the foreset slope in 1965; mirror image of foreset slope of the Streetroad delta of New York
86.1	20.7	STOP SIGN Turn left (south) on Route 7
96.2	30.8	Turn right to Route 73. A left turn would have taken you into Brandon and the 460 ft Stable Lake Albany delta of the Neshobe River
102.2	36.8	STOP SIGN Turn left (south) on Route 73/30
104.4	39.0	Turn right (west) on Route 73 into Orwell, Vermont
109.8	44.4	STOP SIGN Turn left (south) on Route 22A, rejoin main fieldtrip road log at mile 81.6
117.1	51.7	Turn right (west) on Lake Road
117.9	52.5	STOP SIGN Turn left (south) on Stage Road
121.7	56.3	Cross Hubbardton River; the road climbs and bends to the right and then left
122.3	56.9	Turn right onto Hack Dam Road, continue west on 340 ft Stable Lake Albany delta
123.0	57.6	Turn right (north) on River Road, descend and wind back to the east
123.5	58.1	Pull off opposite Bishops Commercial Sand and Gravel
		STOP #7