ASPECTS OF THE GLACIAL GEOLOGY OF KEENE AND LOWER AUSABLE VALLEYS, NORTHEASTERN ADIRONDACK MOUNTAINS, NEW YORK

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INTRODUCTION

The existence of Late Quaternary proglacial lakes in the Adirondacks has long been suspected (Taylor, 1897; Kemp, 1898; Ogilvie, 1902; Alling, 1916, 1919; Denny, 1974; Craft, 1976; Gurrieri, 1983; Diemer, et al., 1984; Gurrieri and Musiker, 1988). Sedimentary deposits interpreted as dropstone-bearing varves and landforms interpreted as incised outlet channels, deltas and wave-formed beaches have been used as evidence for the existence of these intermontane proglacial lakes. On this trip, we propose to document some of these features in Keene and lower Ausable Valleys of the northeast Adirondacks. We will also discuss some constraints on the history of deglaciation of this region. Much work on the glacial geology of the northeast Adirondacks remains to be done and we hope you find this trip to be provocative.

FIELD AREA

Keene Valley extends northward 35 km (22 mi) from St. Huberts to Au Sable Forks (Figure 1). Waters from the Upper and Lower Ausable Lakes feed the East Branch of the Ausable River which flows northward through Keene Valley. The elevation of the valley floor is 340 m (1117 ft) at St. Huberts (Figure 2), 254 m (833 ft) at Keene (Figure 3), and 170 m (558 ft) at Au Sable Forks (Figure 4). The West Branch of the Ausable River originates to the south of Lake Placid (Figure 1). It drops in elevation from 488 m (1600 ft) to 305 m (1000 ft) as it flows through Wilmington Notch. At Haselton (Figure 5), the elevation is approximately 254 m (832 ft). The confluence with the East Branch of the Ausable River is at the town of AuSable Forks. Below the confluence, the Ausable River flows east-northeast for 25 km (15.5 mi) through the lower Ausable Valley and empties into Lake Champlain (elevation 29 m (95 ft)) at Ausable State Park.

The mountains bordering Keene Valley are highest at the southern end (e.g. Giant Mountain to the east of St. Huberts is 1410 m (4627 ft)) and decrease in elevation northward (e.g. Bald Mountain southeast of Au Sable Forks is 652 m (2139 ft) (Figure 1)). Major cols along the drainage divides separating Keene Valley from adjacent watersheds occur along lineaments. Two prominent sets of lineaments trend approximately NE-SW and NW-SE. The elevations of the cols decrease northward.

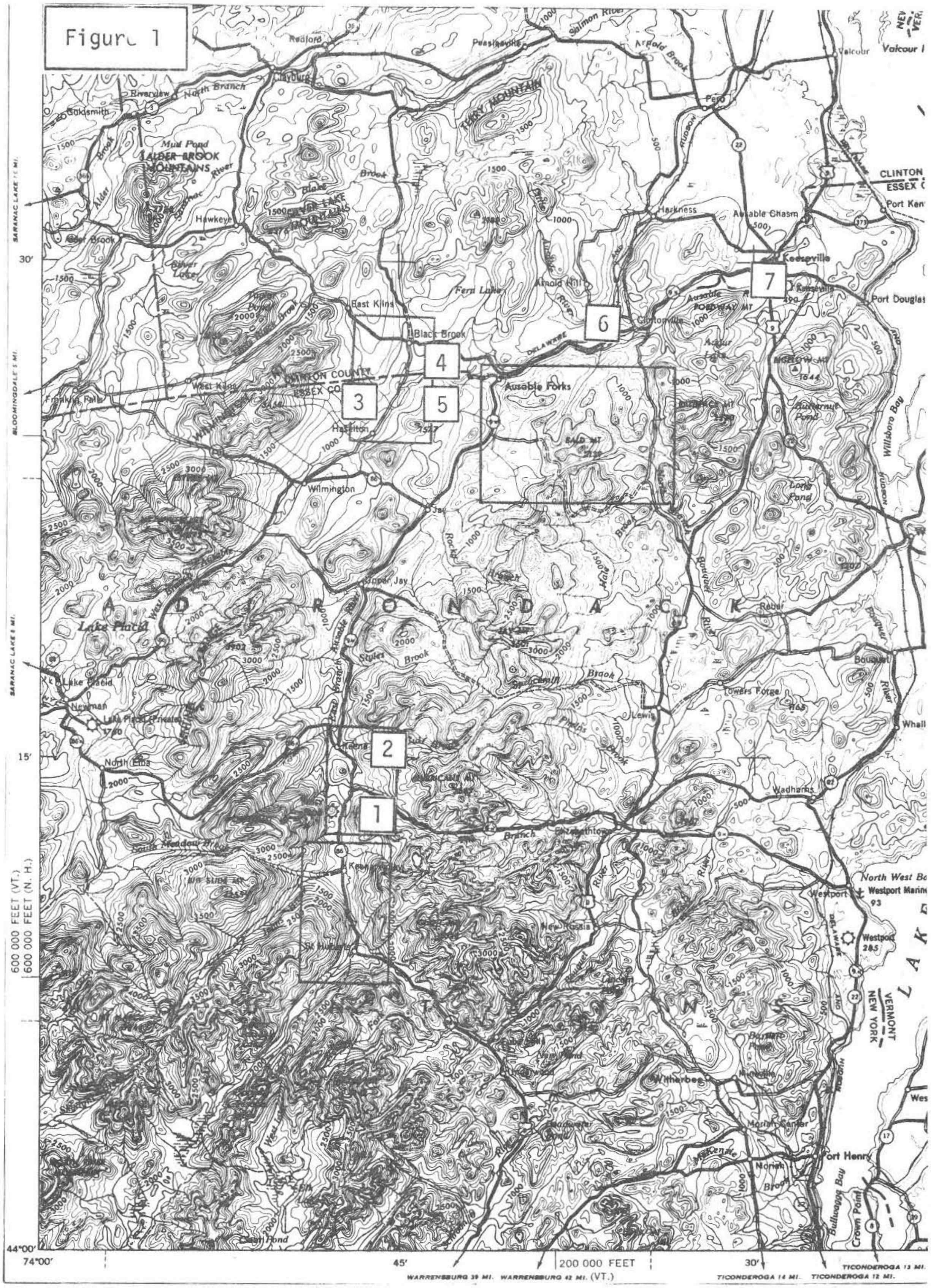


Figure 1. Location map taken from Lake Champlain 1:250,000 contour map, USGS (1949). Field trip stops are numbered. The areas covered by Figures 2 (St. Huberts), 3 (Keene), 4 (Au Sable Forks), and 5 (Black Brook) are indicated.

Figure 2

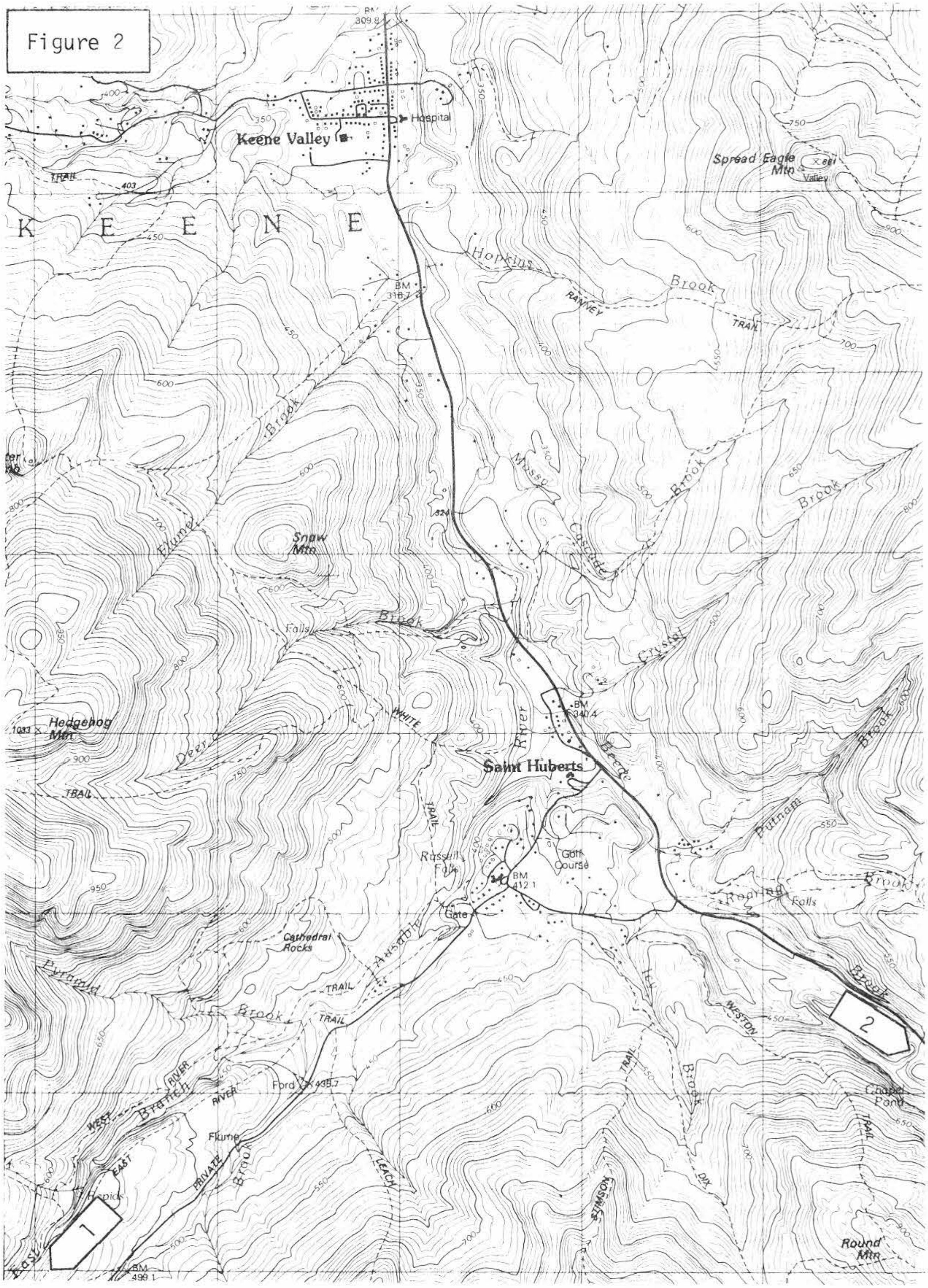


Figure 2. St. Huberts area in south end of Keene Valley, from Keene Valley, NY 1:25,000 metric map, USGS (1979). Grid overlay is 1 km by 1 km. Possible outlet channels and paleoflow directions are indicated by arrows.

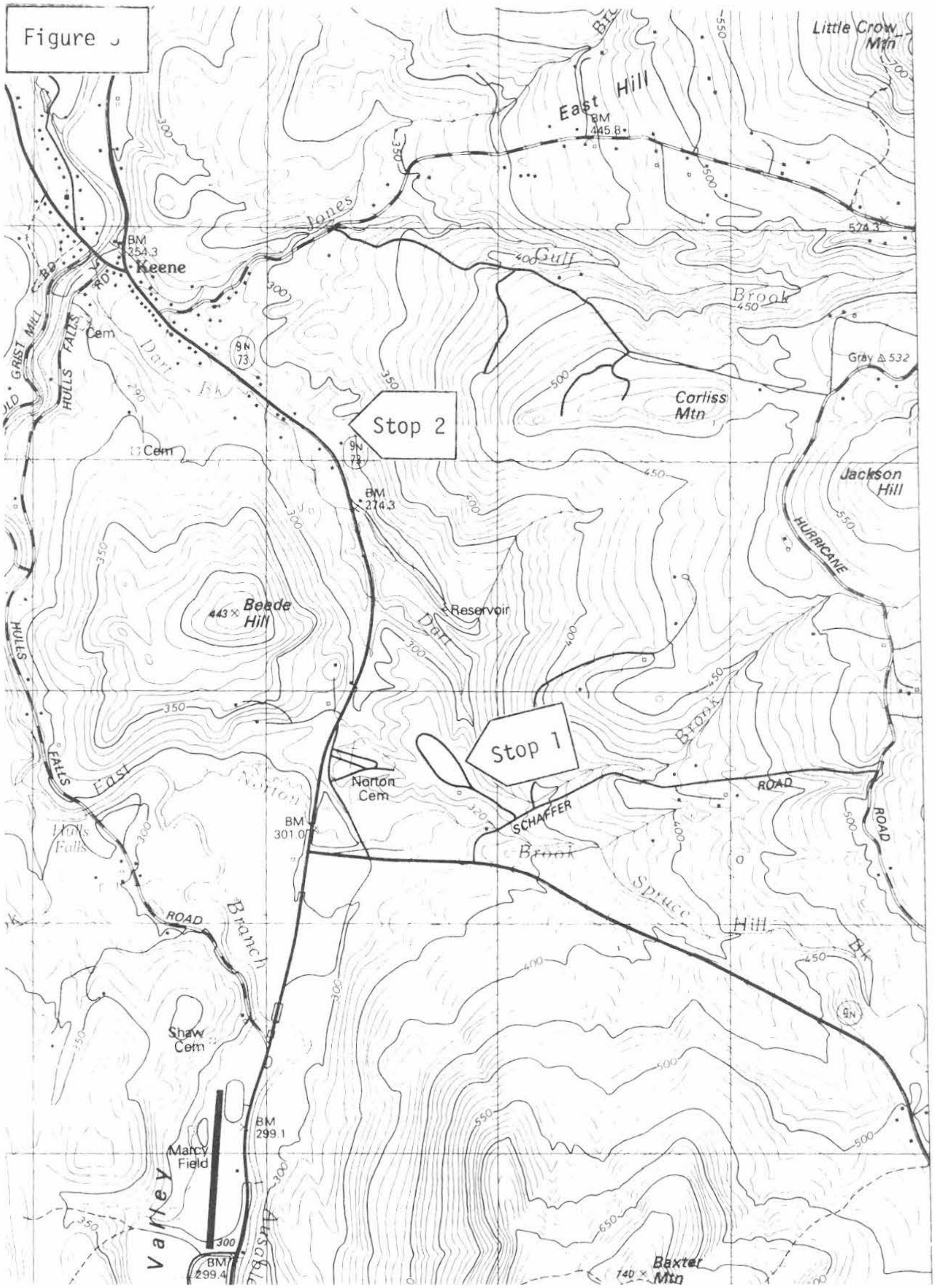


Figure 3. Keene area including Norton Cemetery, from Keene Valley, NY and Lake Placid, NY 1:25,000 metric maps, USGS (1979). Grid overlay is 1 km by 1 km. Stops 1 and 2 are indicated by large arrows.

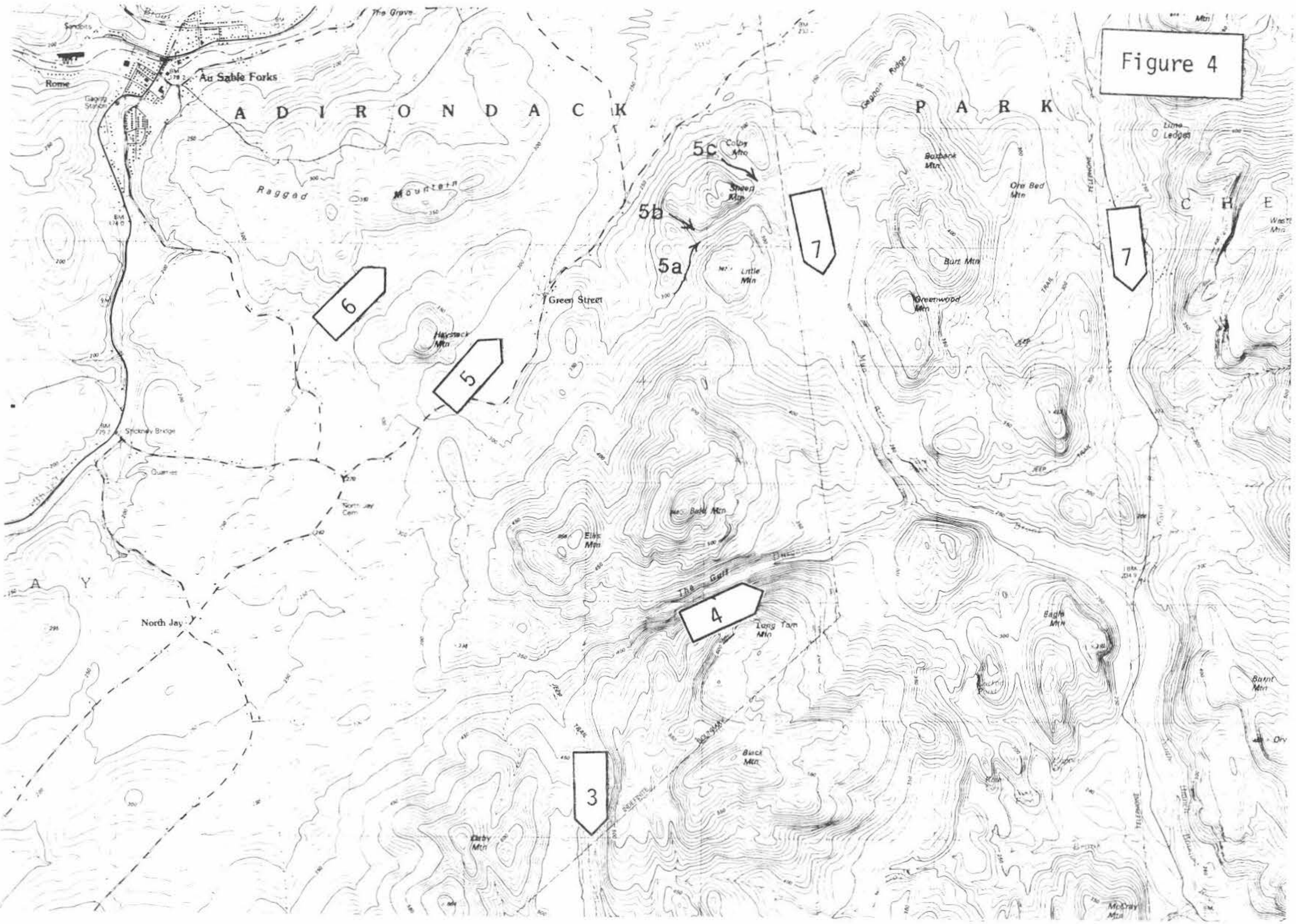


Figure 4. Ausable Forks area in northeastern Keene Valley, from Au Sable Forks, NY 1:25,000 metric map, USGS (1978). The grid overlay is 1 km by 1 km. Possible outlet channels and paleoflow directions are indicated by arrows.

Figure 5

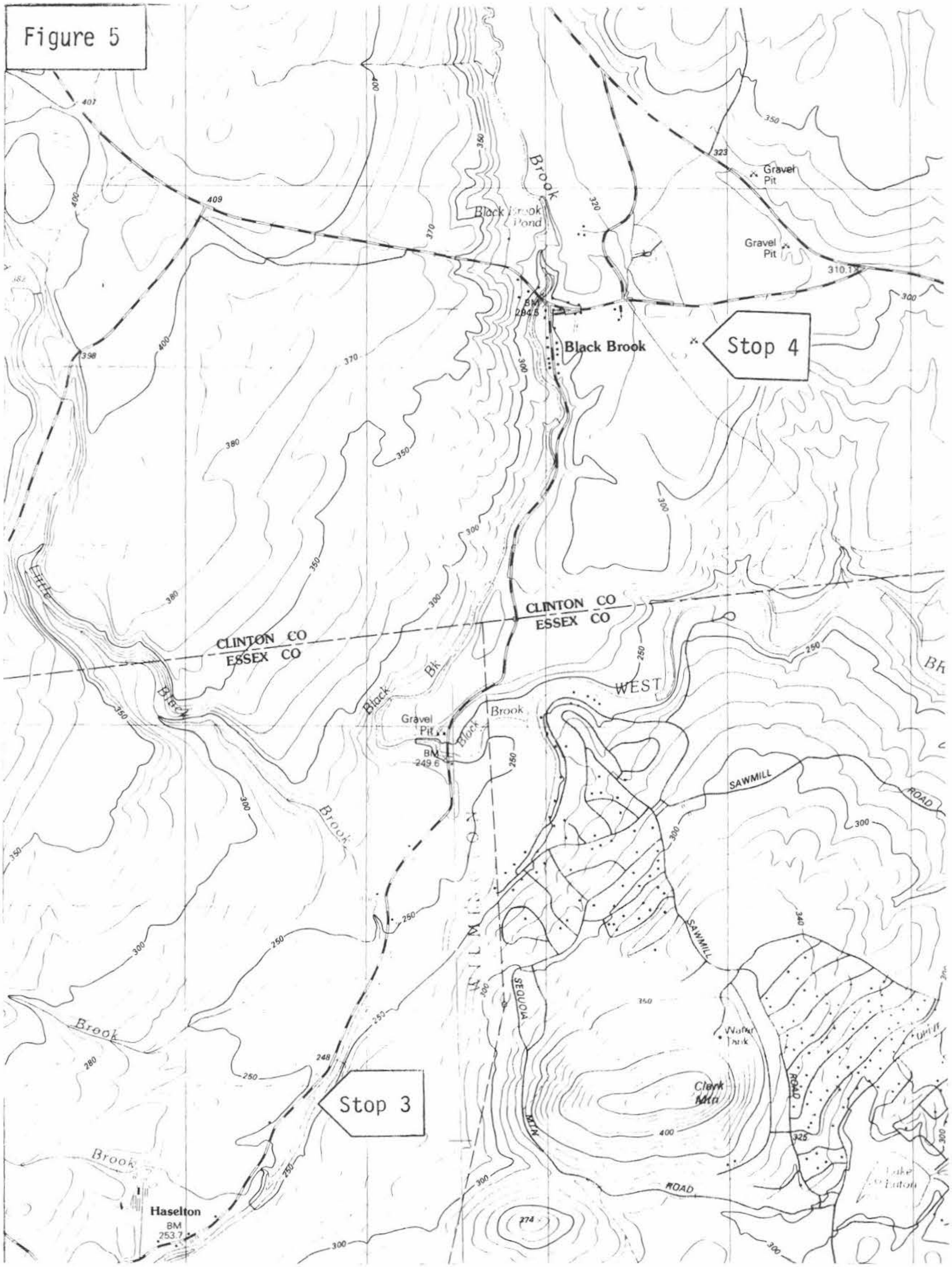


Figure 5. Black Brook and Haselton area in northwestern Keene Valley, from Au Sable Forks, NY and Wilmington, NY 1:25,000 metric maps, USGS (1978). Grid overlay is 1km by 1 km. Stops 3, 4 and 5 are indicated by large arrows.

PREVIOUS WORK

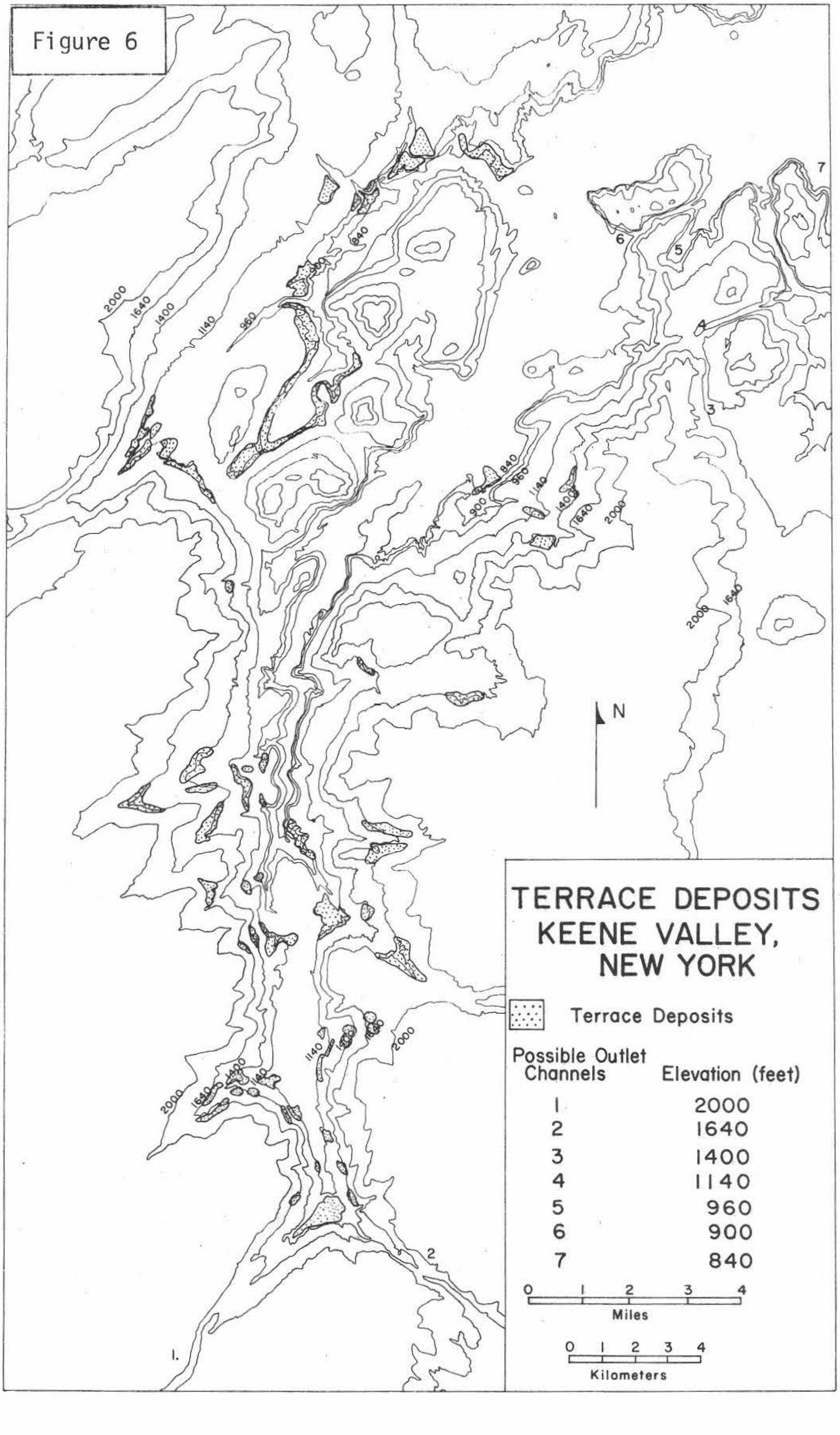
Alling (1916) argued that proglacial lakes existed in the central Adirondacks. Using altimeters to measure elevations, he correlated shoreline features such as deltas, wave-cut notches, beach ridges and lake outlet channels throughout Keene, Elizabethtown and Lake Placid valleys. He identified several lake stages, and proposed outlet channels for the Keene Valley lakes through the Ausable Lakes to the southwest (drainage channel 1 of Figures 2 and 6), Wilmington Notch and Newman Pass to the west, Chapel Pond to the southeast (drainage channel 2 of Figures 2 and 6), the South Gulf and Gulf to the east (drainage channels 3 and 4 of Figures 4 and 6), and several channels in the vicinity of Haystack and Ragged Mountains to the east (drainage channels 5, 6 and 7 of Figures 4 and 6). Alling (1916) proposed that outlet channels opened (in the order presented above) at progressively lower elevations as ice tongues occupying Keene and Elizabethtown Valleys retreated northward.

Denny (1974) worked mainly to the north of the area of this field trip. However, he mapped two ice front positions that trend southeast to the lower Ausable River Valley (ice-front positions 2 and 3,; Denny, 1974). He argued that these NW-SE trending ice fronts resulted in ice-contact glaciofluvial deposits (e.g. at Black Brook), incised channels and proglacial lakes in northward draining valleys (e.g. Keene Valley). Denny (1974) proposed that Saranac River waters were diverted southward by the ice front (position 2) into the lower Ausable River Valley and were responsible for large deltaic deposits between the towns of Ausable Forks and Clintonville. He tentatively correlated these deltaic deposits to Lake Coveville. Denny (1974) identified broad terraces along the Ausable River at Keeseville and interpreted them as deltaic deposits that were built into Lake Fort Ann and the Champlain Sea.

Craft (1976) addressed the question of whether there was local glaciation in the Adirondacks during the Late Wisconsinan. He worked primarily in the High Peaks region at elevations above 610 m (2,000 ft). He found evidence for local glaciation in the form of striations and pebble orientations at high angles to regional ice flow directions, numerous cirques and associated moraines, and locally derived tills. Craft (1976) identified several high-elevation moraines produced by local valley glaciers in the High Peaks. He mapped only one moraine below an elevation of 610 m (2,000 ft). According to Craft (1976), part of this moraine can be traced northwestward from an elevation of 732 m (2400 ft) in Roaring Brook Valley (on the west side of Giant Mountain) down to an elevation of 366 m (1200 ft) near the village of Keene Valley (Figure 2). He interpreted the moraine complex as a product of a local glacier flowing west down Roaring Brook into the Keene Valley. Craft (1976) included a prominent bench at St. Huberts (approximate elevation 412 m (1350 ft), Figure 2) as part of the moraine complex.

Craft (1976) also noted the presence of lacustrine sediments, deltas and beaches at various locations in Keene Valley. An example of a delta mapped by Craft is at the outlet of Johns Brook on the north side of the village of Keene Valley (Figures 1 and 2). He proposed that local glaciers, including the one which occupied Johns Brook valley, flowed into the lake in Keene Valley and produced icebergs. He suggested this calving-terminus mechanism to explain the scarcity of local-glacier moraines at elevations below 610 m (2000 ft) in Keene Valley.

Figure 6


TERRACE DEPOSITS
KEENE VALLEY, NEW YORK
Terrace Deposits
Possible Outlet Channels
Elevation (feet)
1 2000
2 1640
3 1400
4 1140
5 960
6 900
7 840
0 1 2 3 4
Miles
0 1 2 3 4
Kilometers
N
2000
1640
1400
1140
960
900
840
1.
2
3
4
5
6
7

THIS STUDY

Terraces

Working from topographic maps and aerial photographs, Diemer et al. (1984) mapped constructional terraces on the side walls of Keene Valley (Figure 6). The purpose of the study was to evaluate whether the terraces recorded proglacial lake levels in Keene Valley as proposed by Alling (1916). The terraces are gently sloping features of variable size, commonly located along tributaries to both branches of the Ausable River. The range of surface elevations of some deposits with multiple terraces is large (e.g. the deposits at St. Huberts, Figures 2 and 6), however, relief on individual terrace treads is generally less than 10 meters. The surfaces of major terraces cluster near elevations of approximately 500 m (1640 ft), 427 m (1400 ft), 348 m (1140 ft), 293 m (960 ft), 274 m (900 ft) and 256 m (840 ft) (Figure 6). The maximum and minimum terrace elevations decrease northward (Figure 6). Terraces in the Ausable River floodplain (presumably Holocene in age) were not mapped.

Outlet Channels

Diemer et al. (1984) identified several deeply incised cols along the Ausable River drainage divide (Figure 6; Table 1), which they interpreted as outlet channels for proglacial lakes in the Keene Valley. Additional cols near Colby, Sheep, and Little mountains, which have threshold elevations of approximately 315 m (1033 ft), 308 m (1010 ft) and 296 m (970 ft), probably also acted as outlet channels (Figure 4). The distal ends of most of the outlet channels open onto broad, gently sloping sand plains (e.g. The Plains in the North Branch of the Bouquet River valley, 5 km (3 mi) north of Exit 32 on I-87). The distal ends of other channels are characterized by bedrock-lined lakes, interpreted by Alling (1916) as plunge pools (e.g. Copper, Nesbit and Round Ponds on the east flank of Black Mountain, Figure 4). The elevations of the outlet-channel thresholds generally correspond to the elevations of the terraces and also decrease northward (Figure 6; Table 1).

Facies

The terraces that have been examined contain a variety of facies (Diemer et al., 1984). In places, horizontally bedded, interlaminated muds and clays in millimeter to centimeter thick laminae (i.e. rhythmites) occur at the bases of terrace deposits. Rhythmites are most common at elevations near the floor of Keene Valley. The overlying terrace deposits are composed of stratified sand and gravel that show a general increase in grain size and scale of sedimentary structures up-section. Near the base of the sand and gravel facies, the grain size is generally fine to very fine sand, sorting is moderate, and sedimentary structures include planar bedding, climbing ripple cross-laminations, and deformed bedding. In the upper part of the section, moderately well-sorted, planar bedded and trough cross-stratified, fine to medium sands are common. Climbing ripple cross-laminations and soft sediment deformation features are locally abundant. At the top of terrace deposits, trough cross-stratified and channelized, poorly sorted, coarse sands to gravels are common.

Table 1. Outlet channel locations and threshold elevations (from Diemer, et al., 1984; see Figure 6).

Drainage Outlet	Location	Elevation (meters)	Elevation (feet)
1	Upper Ausable Lake	610	2000
2	Chapel Pond	500	1640
3	South Gulf	427	1400
4	Gulf	348	1140
5	Southeast of Haystack Mountain	293	960
6	Between Haystack & Ragged Mts.	274	900
7	Mud Brook/Trout Pond	256	840

The coarse-grained deposits are typically separated from underlying fine-grained deposits by major erosion surfaces. Decimeter-scale, rounded, laminated mud clasts occur locally in the coarse-grained, channelized facies and in the underlying moderately sorted, medium sand facies.

Rhythmite exposures on the floor of Keene Valley that are not associated with terraces were also examined (Diemer, et al., 1984). These rhythmites contain dropstones, soft sediment deformation features, and laminated sand layers. The latter have sharp basal contacts and grade upward from horizontally bedded sand to cross-laminated sands and asymmetrical ripples. The ripples are commonly draped by rhythmites. The rhythmites conformably overlie diamictons, composed of mud to boulder-size material, at some localities.

Origin of Terraces and Channels

The terraces examined to date are interpreted as deltaic deposits that prograded into proglacial lakes. The rhythmites found at the base of some terraces are interpreted as proximal lacustrine deposits. The moderately to well sorted, fine-grained sand deposits represent deltaic foreset beds. The poorly sorted, coarser-grained, upper portions of terraces are interpreted as fluvial topset beds, possibly formed in braided stream. The rounded mud clasts are reworked rhythmites from higher elevation lacustrine deposits, or reworked fine-grained floodplain material. The rhythmites which are not associated with terrace deposits are interpreted as distal glaciolacustrine deposits, possibly varves. The laminated sand beds within some rhythmite sequences are interpreted as tubidites. The diamictons underlying the rhythmites are either glacial tills or debris-flow deposits associated with a retreating ice front.

It is important to note that not all stratified terrace deposits are deltaic in origin. For example, some terraces are not located along side valley tributaries. An alternative depositional environment is subaqueous or subaerial glacial outwash, possibly in contact with ice. These deposits may resemble deltas, and thus, the sedimentology of the deposits must be understood to correctly interpret their origin. Distinguishing features of ice-contact outwash deposits are faults (due to melting of buried or adjacent ice), coarse grain size, and interbedded diamictons (interpreted as glacial tills or sediment gravity flows originating from a nearby ice front). Furthermore, paleoflow indicators of glacial outwash would tend to be parallel to valley trend whereas paleoflow indicators of delta deposits would tend to be normal to the main valley trend.

If it is assumed that most of the mapped terraces are deltaic in origin, the northward decrease of terrace elevations can be interpreted as a product of ice front retreat of an ice lobe in Keene Valley. As the ice front retreated, progressively lower outlet channels were opened, allowing drawdown of the lake level to the elevations of the outlet channels. The falling lake levels controlled the elevations of active delta construction at the mouths of side valley streams. Deltas at higher elevations would therefore be older than deltas at lower elevations.

Outlet channels deeply incised into bedrock probably carried large (catastrophic?) discharges immediately after the channels opened. Sand plains at distal ends of outlet channels probably formed where flow diverged, either on outwash plains or into proglacial lakes.

The sequence of channels which opened as the ice front retreated as interpreted here is similar to the sequence proposed by Alling (1916). The first outlet channel drained southwestward through the valley presently occupied by the Ausable Lakes (drainage channel 1, Figure 2). Although we have not mapped terraces at the 610 m (2000 ft) level anywhere in Keene Valley, Alling (1916) does report the existence of terraces at that elevation restricted to the valley occupied by the Ausable Lakes. When the ice front retreated sufficiently to open the valley presently occupied by Chapel Pond, drainage switched to a southeastward flow (drainage channel 2, Figure 2). The lake elevation presumably dropped from 610 m (2000 ft) to 500 m (1640 ft) (using present-day elevations and not correcting for isostatic rebound).

The 500 m (1640 ft) lake level persisted until the ice front retreated northward sufficiently to open a channel through the South Gulf (drainage channel 3 (427 m (1400 ft)), Figure 4) and then the Gulf (drainage channel 4 (348 m (1140 ft)), Figure 4). The ice front then retreated to positions east of Au Sable Forks where outlets near Colby, Sheep, Little and Haystack mountains (drainage channels 5a (315 m (1030 ft)), 5b (308 m (1010 ft)), 5c (296 m (970 ft)) and 6 (274 m (900 ft)), Figure 4) controlled lake levels. Meltwater from proglacial lakes in the Saranac River watershed may have built the terraces in the vicinity of Black Brook (Figure 5) at the time the ice occupied these positions.

The ice front then retreated down the lower Ausable River Valley sufficiently so that the drainage channels along Mud Brook and Trout Pond (drainage channel(s) 7 (256 m (840 ft)), Figure 4) controlled the lake level. Ice recession from the highlands south of Keeseville allowed the regional proglacial lakes (and later the Champlain Sea) in the Champlain Valley to inundate the lower Ausable Valley. Terraces at 195 to 207 m (640 to 680 ft) near Clintonville and 152 to 165 m (500 to 540 ft) near Keeseville correspond to lakes Coveville and Fort Ann, respectively (Denny, 1974). Terraces at elevations below 107 m (350 ft), northeast of Keeseville, were graded to levels of the Champlain Sea (Chapman, 1937; Denny, 1974).

DISCUSSION

We agree with Alling (1916) that the cols near Ausable Lakes and Chapel Pond were early outlet channels for proglacial lakes in the Keene Valley. We have not, however, found evidence for westward drainage of the Keene Valley lakes through Wilmington Notch. The ice tongue occupying the West Branch of the Ausable River may have prevented westward drainage until after lower outlet channels opened at Chapel Pond, the South Gulf and the Gulf. A single lake occupying both the South Meadows/Lake Placid region and Keene Valley with a connection through Wilmington Notch, as proposed by Alling (1916), probably did not exist.

Westward drainage through Wilmington Notch was restricted to discharge from local, high-level proglacial impoundments or ice-marginal meltwater streams in the upper West Branch of the Ausable River when ice occupied the eastern end of the notch. This drainage interval is recorded by meltwater channels with plunge pools (e.g. Marsh, Winch, Cooperas, Warren, Coldspring and Owens ponds) east of Lake Placid. Ice recession from Wilmington Notch initiated eastward drainage from the Lake Placid area to proglacial lakes in the Keene Valley.

In contrast to Craft (1976), we interpret the terraces in the vicinity of St. Huberts as deltaic in origin rather than part of a moraine complex (Figures 2 and 6). These terraces could have been built where northward-flowing streams from the Ausable Lakes valley entered Keene Valley. The South Gulf outlet channel may have controlled the lake level into which the deltas were built. We did not recognize terraces above the 500 meter (1640 foot) level in the St. Huberts area. The features mapped by Craft (1976) at elevations above 500 meters in the Roaring Brook Valley on the west side of Giant Mountain may be debris-slide levees or lateral moraines associated with local alpine glaciation. The calving terminus mechanism proposed by Craft (1976) may have prevented the formation of alpine glacier moraines at lower elevations along Roaring Brook.

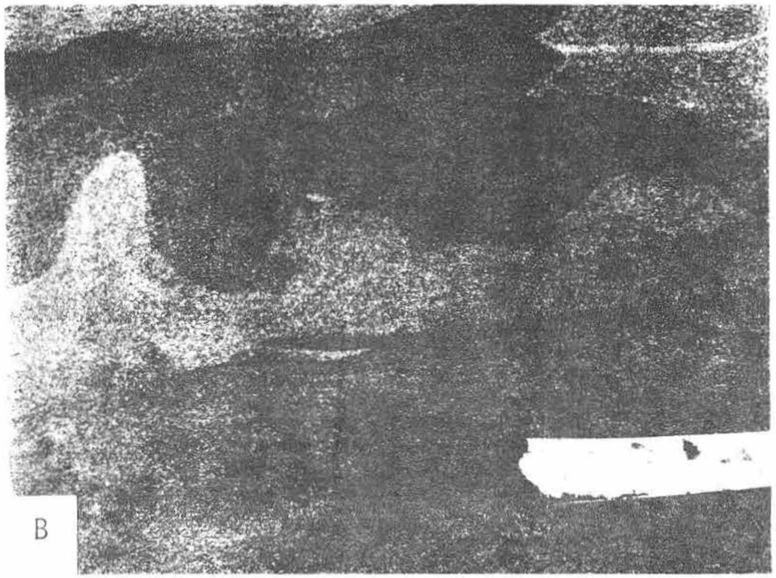
The evolution of the proglacial lakes occupying Keene and lower Ausable Valleys as interpreted here is based upon data acquired primarily from aerial photographs and topographic maps. Only a few terraces have been field-checked to date. Additional terraces need to be examined in order to determine their sedimentology. Only when the sedimentology is known can confident interpretations be made concerning the origins of the terraces and the deglaciation history of the region.

DESCRIPTIONS OF FIELD TRIP LOCALITIES

STOP 1. NORTON CEMETERY (Figures 1 and 3)

The borrow pits in the eastern part of the Norton Cemetery terrace contain stratified sand and gravel deposits. In the lower parts of the pits, horizontally stratified, trough cross-stratified and cross-laminated fine to medium sands in bedsets decimeters thick are common (Figure 7A). Soft sediment deformation features are locally abundant (Figure 7B). The terrace deposit coarsens upward to trough cross-stratified and channelized sands and gravels (Figure 7C). Channels are decimeters to a meter or so deep and meters wide. Channels are filled with either stratified or massive sands and gravels (e.g. Figure 7C). Channel margins have variable dips including nearly vertical (Figure 7C).

A



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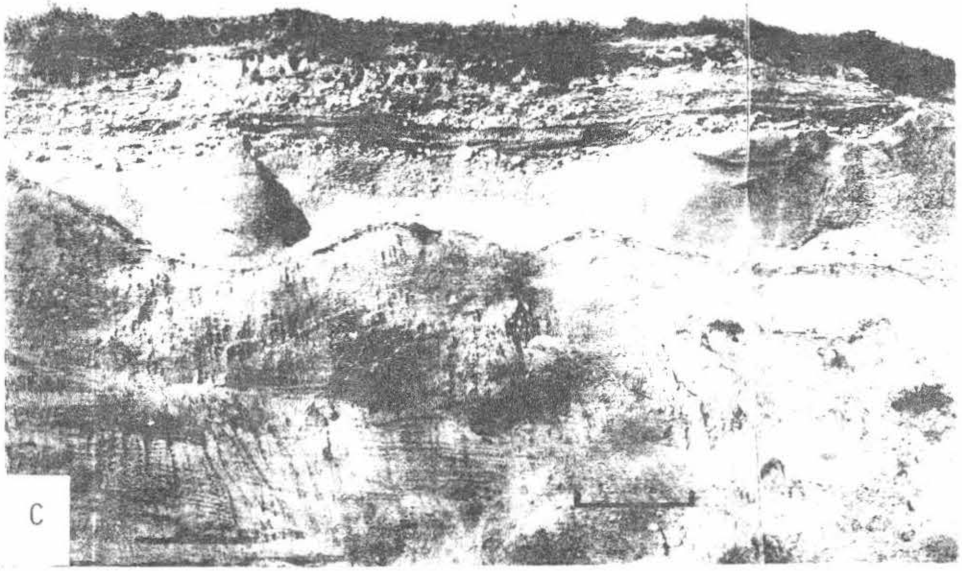

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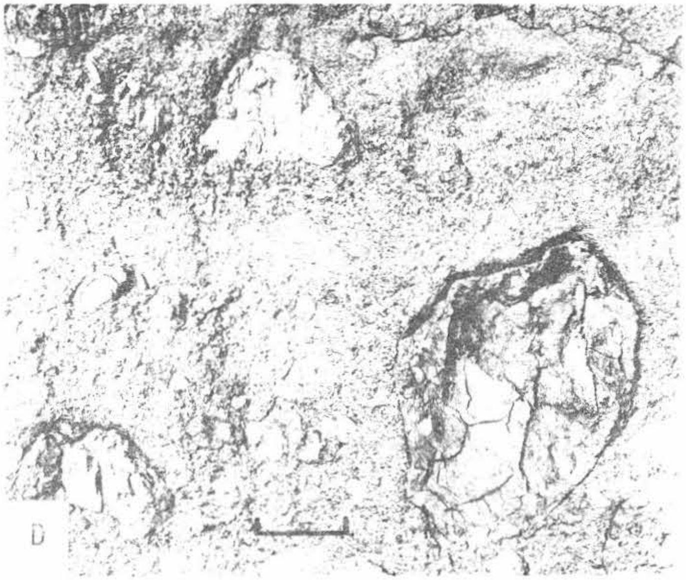


D

Near the top of the Norton Cemetery terrace deposit, a sharp erosion surface is overlain by trough and planar cross-stratified sands and boundary gravels filling small channels. The channels intercut and are decimeters deep and meters wide. A concentration of boulders occurs immediately above the sharp erosion surface. Rounded, laminated, mud clasts occur locally both above and below the sharp erosion surface (Figure 7D).

The terrace deposits are interpreted as a upwardly coarsening delta deposit. The lower part of the sequence consists of delta foreset beds with subaqueous channels, partly filled by sediment gravity flow deposits, at their upper ends. Steeply dipping channel margins may be due to channel incision into a frozen substrate. The prominent erosion surface is interpreted as the contact between delta foreset and fluvial topset beds. The trough and planar cross-stratification above the erosion surface are interpreted as the product of deposition by migrating dunes and small bars. The abundant intercutting channel forms and bar remnants suggest a braided stream origin. Rounded, laminated mud clasts are interpreted as either reworked, higher-level, lacustrine rhythmites or as floodplain muds.

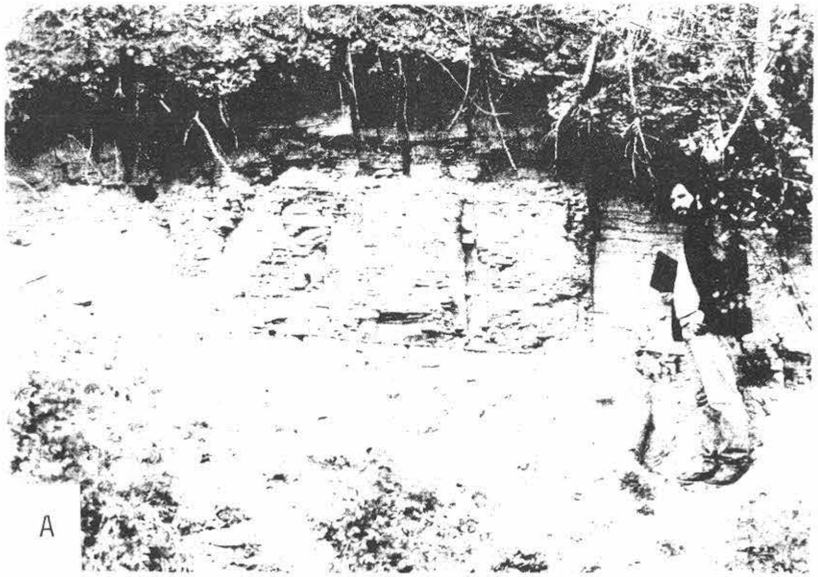
A second locality at Stop 1 is at the end of the access road to Norton Cemetery. The access road to the south of the cemetery entrance has been closed as a result of slumping. In the landslide scar, climbing ripple cross-laminated very fine sand with abundant mud drapes can be seen. The bedding has been disturbed, either by soft-sediment deformation or by road construction. These sediments are the lowest accessible terrace deposits and are interpreted as the distal portion of delta foresets. A spring line marking the contact with underlying interlaminated muds and clays (rhythmites) is located a few meters downslope. The rhythmites are centimeter-scale and interpreted as lacustrine deposits formed in a setting close to a sediment source (i.e. a side valley tributary). Hence the rhythmites are interpreted as delta toeset beds.

Figure 7A: Horizontally stratified, trough cross-stratified and cross-laminated fine to medium sand coarsening up to stratified very coarse sand and gravel. Photo is from lower part of borrow pit, east side of Norton Cemetery terrace. Scale bar is 10 cm.

Figure 7B: Soft sediment deformation features in fine to medium sands. Location and scale is the same as for Figure 7A.

Figure 7C: Coarsening upward sequence in borrow pit, east side of Norton Cemetery. Note cross-stratified fine sand at base of outcrop, large channel form midway up outcrop, and stratified sand and gravel near top of outcrop. The channel form has low slope margin on left and steep margin on right. A prominent erosion surface truncates the massive channel fill and is overlain by a concentration of rounded boulders. Scale bar is 1 m.

Figure 7D: Rounded, mud clasts in a stratified sand and gravel deposit. Location is a small pit used as a trash dump to the north of the borrow pit in Figures 7A, 7B and 7C. Scale bar is 10 cm.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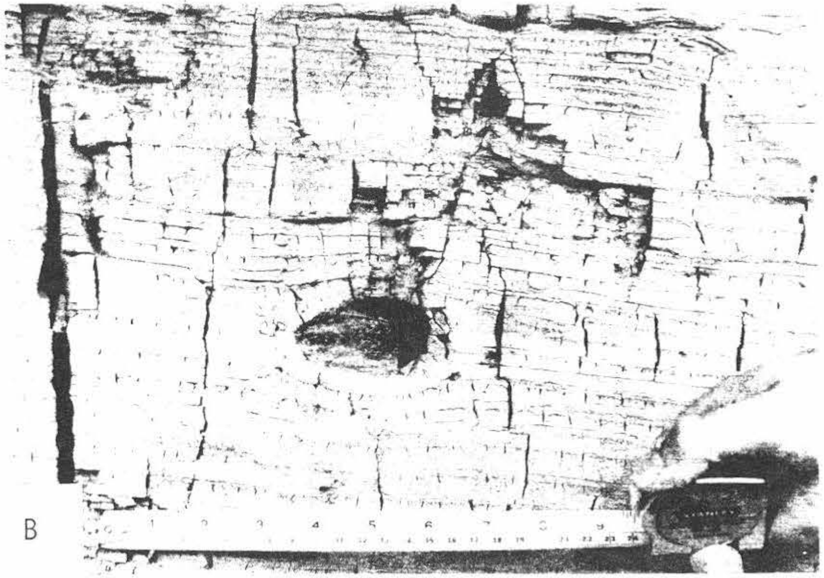
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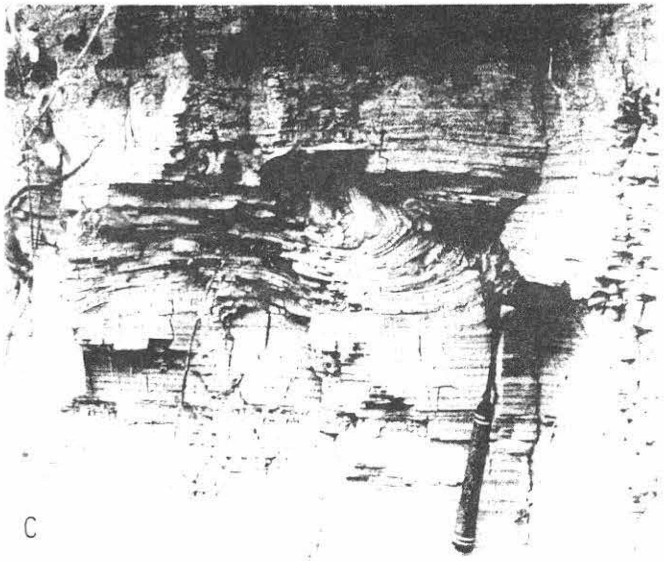
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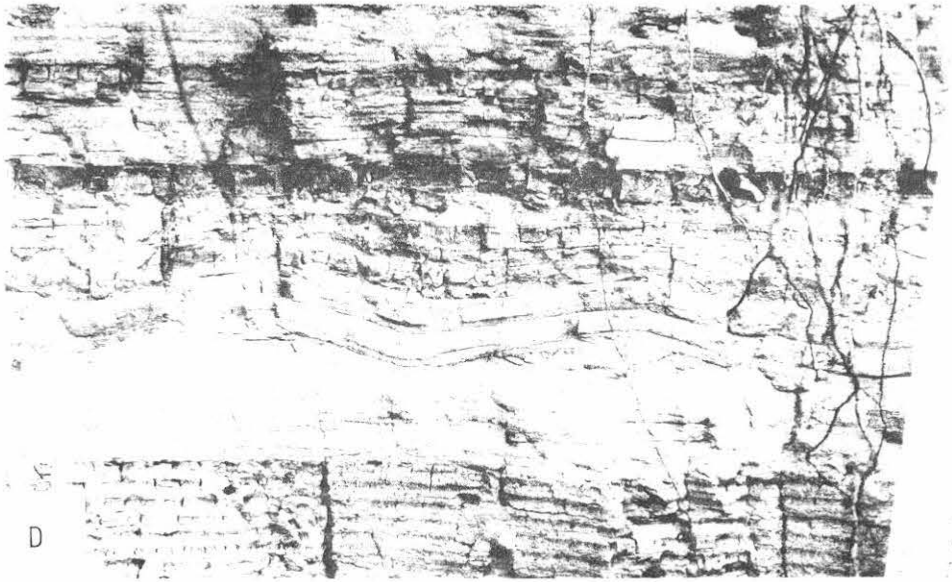
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STOP 2. D.O.T. SAND AND GRAVEL PIT, KEENE, N.Y. (Figure 3)

The Department of Transportation operates a sand and gravel pit 1 km to the south of Keene, N.Y. The sediments are composed of stratified sands and gravels interbedded with diamictons. Grain size ranges from sand to boulders in both the stratified gravels and the diamicton. These sediments are interpreted as ice-contact glacial outwash in origin.

STOP 3. RHYTHMITE SEQUENCE AT HASELTON, N.Y. (Figure 5)

The sediments at Stop 3 are composed of a diamicton overlain by a rhythmite sequence. The diamicton contains boulders as large as 1 meter (Figure 8A). The top of the diamicton has decimeters of relief and is conformably overlain by millimeter to centimeter thick interlaminations of mud and clay (rhythmites). Dropstones are common (Figure 8B). The rhythmites are typically horizontally bedded, but may be locally deformed (Figure 8C). In places, rhythmites are interbedded with cross-laminated sands which have sharp basal contacts and grade upward to asymmetrical ripple forms draped by mud laminations (Figure 8D). The sediments at this stop are interpreted as glacial till or debris-flow deposits at the base (diamicton), overlain by lacustrine sediments (rhythmites). The rhythmites may have accumulated in a setting distant from a sediment source as they are fine grained. The interbedded cross-laminated sand layers may be due to turbidity currents. The deformed bedding may be a result of soft-sediment deformation on a low slope.

Figure 8A: Roadcut on Black Brook Road 100 meters south of private airfield. Sequence comprises diamicton (at feet of geologist) overlain by rhythmite sequence (at knees of geologist). Rhythmites are horizontally bedded and approximately 1 meter thick at this locality.

Figure 8B: Dropstone in rhythmites. Same location as Figure 8A. Scale is in inches and centimeters.

Figure 8C: Deformed bedding in rhythmite sequence. View is parallel to the fold axis. Overlying rhythmites are undeformed. Same location as Figure 8A. Hammer for scale.

Figure 8D: Laminated sand bed interbedded with rhythmites. Base of sand is sharp. Sand is horizontally laminated at base and grades up to cross-laminations and asymmetrical ripple forms. Rhythmites drape ripple forms. Same location as Figure 8A. Scale is in inches and centimeters.

STOP 4. BLACK BROOK SAND PLAIN (Figure 5)

The Black Brook sand plain is a terraced accumulation of stratified drift at the distal end of a bedrock gorge north of the village of Black Brook. The surface of the sand plain is roughly triangular in map view and ranges in elevation from 329 m (1080 ft) at the mouth of the gorge to 275 m (902 ft) at the West Branch of the Ausable River.

The exposures in a gravel pit 0.64 km (0.4 mi) east of Black Brook contain meter-scale beds of coarse sandy gravel to boulder gravel (Figure 9). The working face of the pit is oriented east-west and is approximately 40 m (130 ft) long and 4 to 6 m (13 to 20 ft) high. The surface elevation of the sand plain at this location is approximately 315 m (1033 ft). The lower unit consists of horizontally stratified, and trough and planar cross-stratified sandy gravel, the base of which is obscured by slumping. The sandy gravel is overlain by a 2.0 to 2.5 m (6.6 to 8.2 ft) thick, massively bedded, very coarse boulder gravel layer. The gravel contains boulders over 1.5 m (5.0 ft) in diameter, some of which are crudely imbricated. The gravel unit can be traced laterally across the working face of the pit. The gravel is overlain by 1.0 to 1.2 m (3.0 to 4.0 ft) of cross-stratified sandy gravel. The cross strata are centimeters to decimeters thick and commonly extend from the top to the bottom of the unit. Paleocurrent indicators indicate southward to southeastward flow throughout the section.

The Black Brook terrace deposits are interpreted as a fluviodeltaic complex that was built into falling levels of proglacial lake in the lower Ausable Valley (Figure 10). Base level was probably controlled by the outlet channels in the vicinity of Colby, Sheep, Little, and Haystack mountains (outlet channels 5a, 5b, 5c, and 6, Figure 4).

The sand and gravel deposits at Stop 4 are probably glaciofluvial in origin and may represent deltaic topset beds. The sandy gravel facies probably represents fluvial deposition under near average meltwater discharges through the bedrock channel north of Black Brook. The boulder gravel facies is interpreted as a high-energy, catastrophic flood deposit. Discharge of this magnitude may have been produced by the diversion of outflow from lakes in the Saranac Valley through the Black Brook channel (i.e. a limnic hlaup).

STOP 5. (OPTIONAL) DIAMICTONS NEAR AUSABLE FORKS (Figure 5)

This stop includes roadside exposures along Ausable Drive, approximately 2.4 km (1.5 mi) southwest of Ausable Forks. The sediments consist of massive to crudely stratified diamicton with thin sand, gravel and silt interbeds. The diamicton beds are commonly decimeters to meters thick, light colored and have sandy matrices. The sandy interbeds are thin (centimeter-scale) and discontinuous and are either nonstratified or contain horizontal or ripple-drift laminations. The bedding is subhorizontal but may be deformed locally. These deposits probably accumulated in a ice-marginal, subaqueous environment.

STOP 6. DELTAIC DEPOSITS NEAR CLINTONVILLE (Figure 1)

The gravel pit at Stop 6 is located on an extensive sand plain on the north side of the Ausable Valley between Clintonville and Ausable Forks (Figure 1). The surface of the sand plain slopes southward from approximately 204 m (670 ft) at its northern margin to 198 m (650 ft) near the Ausable River.

The lower portion of the pit contains approximately 5 to 6 m (16 to 20 ft) of southwardly dipping, fine to medium sand and sandy silt foreset beds. The bedsets are centimeters to decimeters thick and commonly contain horizontal laminations

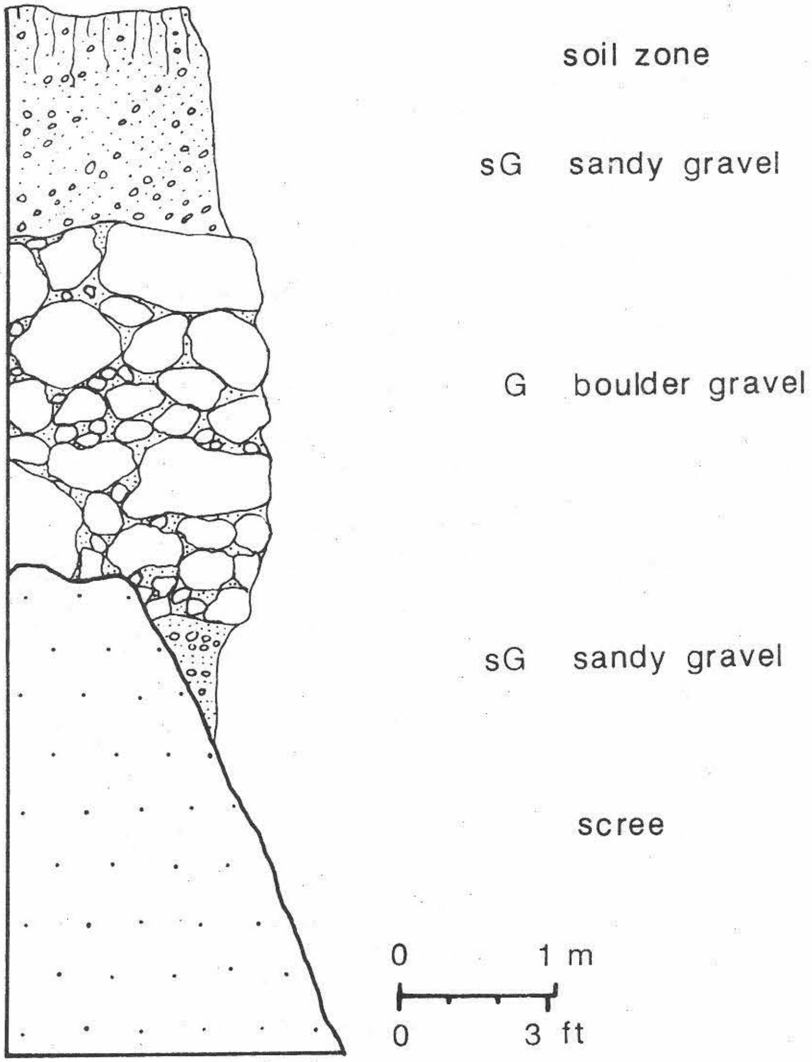

Figure 9. Stratigraphy at the gravel pit near Black Brook.

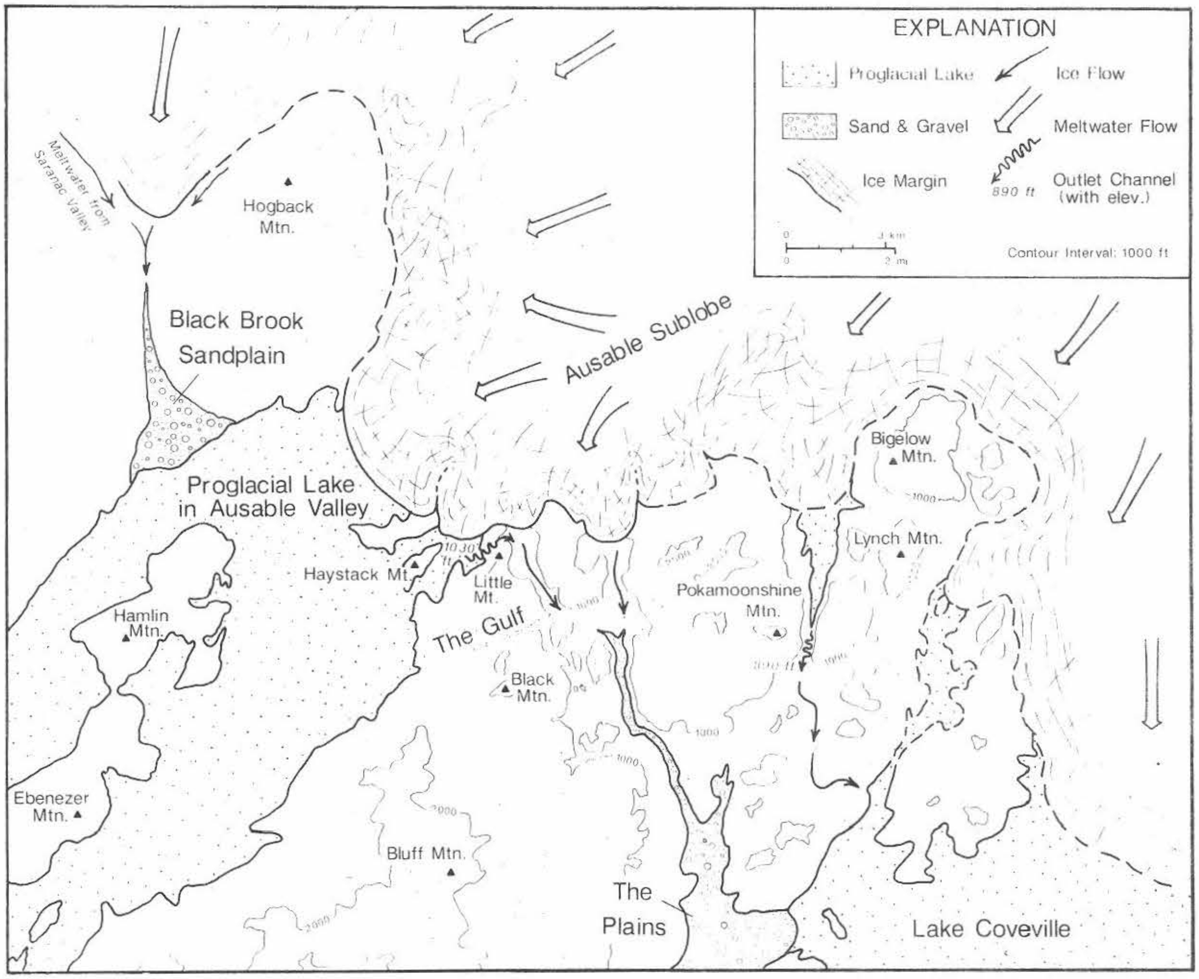

Figure 10. Inferred distribution of proglacial lakes and ice margins during the deposition of the Black Brook sand plain. Lake level in the Ausable Valley is controlled by an outlet channel north of Little Mountain. Meltwater from lakes in the Ausable Valley probably contributed to deltaic sedimentation at The Plains in the North Branch of the Bouquet River Valley.

and ripple-drift cross-laminations. Thin silty deposits occur locally as draped laminae over ripple forms. The upper portions of the foreset beds are truncated and overlain by 1.0 to 1.5 m (3.0 to 5.0 ft) of horizontally stratified and trough and planar cross-stratified sand and gravel.

The sediments at the Clintonville gravel pit are interpreted as deltaic in origin. The erosional surface between the lower sandy facies and the upper gravel facies represents the contact between the subaqueous foreset beds and the fluvial topset beds. The elevation of the topset-foreset contact is approximately 198 m (650 ft) which indicates that deltaic sedimentation was graded to the level of Lake Coveville in the Champlain Valley (Denny, 1974). Southward-flowing meltwater streams from ice in the Little Ausable drainage basin north of Arnold Hill (Figure 1) provided much of the deltaic sediment in the eastern portion of the sand plain. The western portion of the sand plain was probably built by eastwardly flowing streams from the upper Ausable drainage basin. Southward drainage from proglacial lakes in the Saranac River Valley into the lower Ausable Valley via the Black Brook channel (Stop 4) may have contributed to delta construction near Ausable Forks (Denny, 1974).

STOP 7. LANDSLIDE SCAR ON THE AUSABLE RIVER AT KEESEVILLE (Figure 1)

The section at Keeseville is exposed in a landslide scar on the south bank of the Ausable River at Keeseville. The river is deeply incised into deltaic terrace deposits which Denny (1974) correlated with Lake Fort Ann in the Champlain Valley. The surface elevation of the terrace is approximately 155 m (510 ft).

The base of the section consists of massive, compact, calcareous, gray diamicton with a silty to clayey silt matrix. The base of the diamicton is obscured by colluvium. The upper surface of the unit has a few centimeters of relief and is draped by 0.3 to 0.5 m (1.0 to 1.5 ft) of silt and clay rhythmites. The rhythmite sequence contains 11 silt-clay sediment couplets. The rhythmites are conformably overlain by approximately 6 m (20 ft) of fine to medium sand which coarsens upward to gravelly sand near the terrace surface. Spring sapping at the sand-rhythmite contact is responsible for slumping in the overlying sand unit.

The sediments at the Keeseville section record the ice recession from the mouth of the Ausable Valley. The diamicton is interpreted as a basal till and thus represents an interval of ice cover. The rhythmites are interpreted as varved lacustrine deposits that record the initial, deglaciation of the lower Ausable Valley and its subsequent inundation by Lake Coveville. The rhythmites, therefore, were probably deposited contemporaneously with the Lake Coveville deltas near Clintonville (Stop 6).

The overlying sandy deposits represent deltaic sedimentation by eastward-flowing streams from the Ausable Valley into Lake Fort Ann. Regional lake level fell approximately 43 m (140 ft) in the Champlain Valley with the initiation of Lake Fort Ann. If the rhythmites are assumed to be Lake Coveville varves and the overlying sandy facies to be part of the Lake Fort Ann delta, then the time between the deglaciation of the mouth of the Ausable Valley and the initiation of Lake Fort Ann was about 11 years. The ice-front in the Champlain Valley may have receeded northward to the mouth of the Saranac River at the time Lake Fort Ann was established (Denny, 1974).

ACKNOWLEDGEMENTS

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ROAD LOG

CUM. MILES	MILES F.L.P.*	DESCRIPTION
0.0	0.0	Assemble in the west parking lot of Hudson Hall on the P.S.U.C. campus. Leave the parking area, turn right at the entrance and proceed northwestward on Broad St.
0.4	0.4	Intersection of Broad and Cornelia streets. Bear left onto Cornelia and proceed westward.
1.1	0.7	Junction I-87 (Northway) North; Continue westward on Cornelia St. under Northway overpass.
1.3	0.2	Junction I-87; Turn left onto entrance ramp and follow the signs for I-87 South. Proceed southward on I-87 to Exit 31 at Elizabethtown (Approximately 45 mi). Turn right onto the exit ramp and proceed to Route 9N. Reset road log at the junction of the Exit 31 ramp and Route 9N.
0.0	0.0	Turn right at the end of the exit ramp and proceed westward on Route 9N toward Elizabethtown.
3.8	3.8	Cross Bouquet River.
4.2	0.4	Intersection of Routes 9N and 9 in Elizabethtown. Continue westward on Route 9N.
14.1	9.9	Intersection of Route 9N and Schaffer Rd. Turn right onto Schaffer Rd. and proceed northward for 0.2 mi to the entrance of the gravel pit (STOP 1) on the west side of the road.
14.3	0.2	STOP #1. Norton Cemetary. Following the discussions turn around and proceed southward on Schaffer Road to Route 9N.
14.5	0.2	Intersection of Schaffer Rd. and Route 9N. Turn right onto Route 9N and proceed westward.
14.9	0.4	Intersection of Routes 9N and 73. Turn right and proceed northward on Routes 9N and 73 (combined).

*From last point

CUM. MILES	MILES F.L.P.	DESCRIPTION
16.1	1.2	STOP #2. D.O.T. Gravel Pit. Continue northward on Routes 9N and 73 following the discussions at this stop.
16.7	0.6	Routes 9N and 73 diverge. Bear right and proceed northward on Route 9N.
19.7	3.0	Cross Styles Brook. Continue northward on Route 9N.
22.7	3.0	Enter the village of Upper Jay. Follow Route 9N through the village.
25.8	3.1	Enter the village of Jay. Continue northward on Route 9N.
26.2	0.4	Intersection of Routes 9N and 86. Turn left onto Route 86 and proceed northwestward toward Wilmington.
28.2	2.0	View of Beaver Bk. Valley and Whiteface Mt. Continue northwestward on Route 86.
29.1	0.9	Intersection of Route 86 and Bilhuber Rd. Turn right onto Bilhuber Rd. and proceed northward.
30.9	1.8	Intersection of Bilhuber Rd. and unmarked road. Turn right onto unmarked road and proceed northeastward. The road follows the West Branch of the Ausable River.
32.6	1.7	STOP #3. Rhythmites at Haselton. This will also be the LUNCH STOP. Continue northeastward toward Black Brook after lunch.
33.9	1.3	Cross Black Brook. Thr road turns northward to the village of Black Brook.
35.6	1.7	Intersection of unmarked road and Silver Lake Rd. at Black Brook. Turn right and proceed eastward on Silver Lake Rd.
35.7	0.1	Stop sign, continue eastward on Silver Lake Rd.
36.1	0.4	STOP #4. Black Brook sand plain. The entrance to the gravel pit is on the south side of the road. Continue eastward on Silver Lake Rd. to Ausable Forks after the discussions at this stop.

CUM. MILES	MILES F.L.P.	DESCRIPTION
39.6	3.5	Intersection of Silver Lake and Golf Course roads. Follow inset road log to optional stop #5 or turn left onto Golf Course Rd. and follow main road log.

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CUM. MILES	MILES F.L.P.	DESCRIPTION
0.0	0.0	Turn right onto Golf Course Road and proceed southward.
0.2	0.2	Intersection Golf Course Road and Route 9N at Ausable Forks. Continue southward on Route 9N.
0.4	0.2	Intersection of Route 9N and Church St. Turn right and proceed westward on Church St.
1.2	0.8	Intersection Church St. and Ausable Drive. Turn left and proceed southward on Ausable Drive.
2.0	0.8	STOP #5. (OPTIONAL) Diamicton Exposures. Turn around and follow the inset road log in reverse order to the intersection of Golf Course and Silver Lake roads.

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41.5	1.9	Intersection of Golf Course and Palmer Hill roads. Bear right and proceed eastward on Palmer Hill Road. The road traverses the Lake Coveville deltas described by Denny (1974).
43.4	1.9	STOP #6. Lake Coveville Delta. The entrance to the gravel pit is on the south side of the road. Continue eastward on Palmer Hill Rd. after the discussions at this stop.
44.4	1.0	Intersection of Palmer Hill and Harkness-Clintonville roads. Turn right (sharply) and proceed southward to Clintonville.
45.6	1.2	Intersection of the Harkness-Clintonville Rd. and Route 9N. Turn left and proceed eastward on Route 9N.
45.8	0.2	Intersection of Route 9N and small road to the village of Clintonville. Turn right onto the side road and proceed to the bridge across the Ausable River.

CUM. MILES	MILES F.L.P.	DESCRIPTION
46.2	0.4	Bridge across the Ausable River at Clintonville. Turn right across the bridge to the Dugway Road intersection (0.1 mi).
46.3	0.1	Dugway Road Intersection. Turn left and proceed eastward on Dugway Road.
51.3	5.0	Intersection of Dugway and Augur Lake roads. Turn left and continue eastward on Augur Lake Road.
51.6	0.6	I-87 overpass. Continue eastward on Augur Lake Rd. to the entrance of Keeseville Industrial Park (0.1 mi) on the north side of the road.
51.7	0.1	STOP #7. Landslide scar on the Ausable River. Continue eastward on Augur Lake Rd. after the discussions at this stop.
52.0	0.3	Intersection of Augur Lake Road and Route 9. Turn left and proceed northward on Route 9 to Plattsburgh.
54.7	3.0	Ausable Chasm
55.1	0.4	Surface of Champlain Sea delta (upper marine limit).
55.7	0.6	Surface of Champlain Sea delta (Port Kent Stage).
56.9	1.2	Entrance to Ausable Point State Park on the delta of the present Ausable River.
64.7	7.8	Skyway Plaza and Plattsburgh Air Force Base. Continue on northward on Route 9 to next traffic light.
65.0	0.3	Intersection of Route 9 and Elizabeth St. Turn left onto Elizabeth St. and proceed westward for 0.1 mi. Bear right onto Platt St. and continue westward.
65.4	0.4	Intersection of Platt and South Catherine streets. Turn right onto Catherine St. and proceed northward across the Saranac River.
65.9	0.5	Intersection of South Catherine and Broad streets. Turn left onto Broad St. and proceed westward toward the P.S.U.C. campus.
66.3	0.4	Intersection of Broad and Beekman streets. Hudson Hall is on the northwest corner of the intersection.
		END LOG