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Glacial Features in East-Central New Hampshire

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The east-central area of New Hampshire has numerous glacial and glaciofluvial landforms that were developed during more than one Pleistocene glaciation. These include ice erosional features, such as through valleys and stoss and lee topography, as well as meltwater erosional features such as lateral and col channels. Glaciofluvial depositional features are particularly extensive and include kames, kame terraces, large outwash plains, and esker systems. Excellent exposures of at least two different tills are found in the area.

The deglaciation of this area was controlled by the topography. The area lies at the southern edge of the White Mountains, whose summits range from less than 4000 ft to 6288 ft at Mt. Washington (highest point in northeast North America). During deglaciation the thinning of the ice over the mountains resulted in stagnation of the ice immediately to the south.

The surficial geology of the Wolfeboro and Winnipesaukee quadrangles has been mapped by R. P. Goldthwait (1968). The dominant glaciofluvial feature in this area is the Pine River esker system, which extends from the southern margin of the Ossipee Lake quadrangle southward 12 miles to Pine River Pond in the Wolfeboro quadrangle. Goldthwait (1968) determined from data on crossbedding, pebble imbrication, and pebble counts that this esker was formed by meltwater flowing south (uphill) under hydrostatic pressure. He suggests that this esker is part of a larger system extending north to the eskers north of Silver Lake in the Ossipee Lake quadrangle.

The surficial geology of the Ossipee Lake quadrangle was mapped by Newton (1974). He considers the eskers of the Ossipee Lake quadrangle to be a separate system, younger than the Pine River esker system. These eskers are thought to be associated with meltwater flowing out the Ossipee River valley, rather than out through the Pine River esker system.

It is suggested that during deglaciation of this region there were three major outlets for meltwater. In chronological order these are:

1) through the Pine River esker system, 2) the Ossipee River valley, and 3) the Saco River valley.

Examples of meltwater erosional channels are particularly impressive in the Ossipee Lake quadrangle. A 60-100-ft channel was cut between Chase Hill and Bald Hill about 2 mi west of Conway (Stop 2), and a second channel approximately 1 mi further west contains an abandoned 100-ft waterfall complete with plunge pool. Near Mt. Chocorua several lateral meltwater channels occur at elevations ranging from 700 ft to 1300 ft. The meltwater channels suggest stagnation of a large ice mass south of the Saco River valley.

The Saco River valley makes a 90° change in direction from a north-south orientation to an east-west orientation at the village of Conway. The north-south portion of the valley has been extensively eroded by glacial ice. The ice streaming down this portion of the valley continued southward rather than follow the valley in its eastward turn. In moving out of the valley the ice cut three through valleys, later choked with glaciofluvial debris, across the hilly upland to the south.

Many of the bedrock hills in the area have been asmmetrically eroded. The stoss or up-ice side is commonly less steep than the lee or down-ice side. This is presumably due to stoss-side abrasion vs. lee-side joint-block removal.

The bedrock in this area is primarily intrusive granite and high grade metamorphics and can be divided into 3 groups: 1) the early Devonian Littleton Formation, which here consists chiefly of mica schist, 2) intrusives associated with the middle Devonian New Hampshire Magma Series, which includes the Winnipesaukee Quartz Diorite and Concord Granite, and 3) intrusives associated with the early Jurassic White Mountain Magma Series, which includes Mount Osceola Granite and Conway Granite.

The structure of the Ossipee Mountains is a classic example of a ring-dike complex developed as a result of cauldron subsidence. In this case the ring dike is composed of Albany Porphyritic Quartz Syenite. The indicator fan derived from this syenite has been used to determine the northeast to southeast direction of ice movement over the area.

Most of the numerous outcrops in this area are fresh and show only minor amounts of weathering due to postglacial processes. There are, however, a number of outcrops which are extensively weathered. These have been called "rottenstone" by Goldthwait and Kruger (1938). In some areas the rottenstone is overlain by relatively fresh till and contains clastic dikes of till-like material. This suggests that "rottenstone" is the result of weathering prior to the last glaciation.

At least two texturally distinct tills are exposed in this area. The upper unit is characteristically a loose sandy gray till; the lower unit is much more compact clay-rich till of olive to olive-brown color. There has been some controversy over the origin of these two tills. Goldthwait (1971) and Drake (1971) have studied the tills in this area and concluded that they represent an ablation and lodgement till of a single glaciation. Pessl (1971) and others, on the contrary, have come to the conclusion that the sandy upper till and clay-rich lower till in southern New England represent two separate glaciations. Goldthwait (1971) has suggested that there are three tills in New England and that the "lower till" of Pessl does not correspond to the "hard till" of Drake. Drake (1971) did not find any outcrops that he considered would correspond to Pessl's "lower till".

Nevertheless, recent study of till outcrops in the Ossipee Mountains revealed many outcrops of a brown to olive compact clay-rich till that is similar to Pessl's "lower till". These tills averaged 52 percent sand, 29 percent silt, and 19 percent clay. The till is jointed and has well-developed fissility. In some outcrops the overlying brown or "oxidized" zone is in sharp contact with the olive or "unoxidized" zone. Numerous small clastic dikes have also been noted in some of the exposures. A detailed study of the mineralogy and chemistry of this till has shown that the brown or "oxidized" zone represents a weathered zone. As this is in places overlain by unweathered loose sandy gray till, it can be concluded that this brown till is older than the loose upper till. A statistical analysis of the grain-size parameters indicates that the clay-rich till is equivalent to the clay-rich "lower till" of Pessl at Thomaston Dam, Connecticut.

Since it is possible to divide the "lower till" into an upper "oxidized" zone and a lower "unoxidized" zone and since the "upper till" has been subdivided into two units by Drake (1971) and three units by Pessl (1971), it is suggested that the terms "upper till" and "lower till" be dropped from usage. It is further suggested that formational names be applied to the different tills in New England and that type sections be established for each unit, to which correlations may then be made. It is suggested that the term Thomaston Till replace the term lower till and that the exposure at Thomaston Dam, Connecticut, be used as the type section for this formation. In using this terminology, the clay-rich till in the Ossipee Mountains would correspond to the Thomaston Till.

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ROAD LOG

Saturday Field Trip

MILEAGE

0.0	Red Jacket Motor Inn
1.7	Drive off valley train onto side of drumlin
4.3	Cross Saco River
4.5	Junction Routes 113 and 16; turn right on Route 16
4.6	Traffic light in Conway village at; Junction of Routes 153 and 16 Turn right
4.8	Bear left (west) on the West Side Road
5.1	Cross Swift River
5.6	Turn left (west) on the Passaconaway Road
5.8	Cross railroad tracks of the North Conway Scenic Railroad
6.1	Intersection with Allens Siding Road; continue on Passaconaway Road
6.7	Turn right on gravel road
7.7	Access road to rottenstone quarry on left (west) just beyond small cemetery. Extensive rottenstone quarry operation .2 mi up this road.

STOP 1

"Rottenstone" is the term used by Goldthwait and Kruger (1938) for deeply weathered bedrock. The bedrock here is Conway granite and it is weathered to considerable depth (>20ft). Weathering is concentrated along joint planes and in some areas has resulted in rottenstone completely surrounding relatively fresh granite boulders. Till overlies the rottenstone in at least one area of this exposure. Clastic dikes, presumably due to downward injection of till matrix, can be seen below the till-rottenstone contact. This phenomenon was also noted by Goldthwait and Kruger (1938). The weathering is characterized by an alteration of biotite to vermiculite; the accompanying hydration tends to break up the rock. Chemically the rottenstone is depleted in Ca and Mg compared to the unaltered parent material. The rottenstone is thought to be the result of preglacial or interglacial weathering.

Turn around and return to Conway

8.7	Turn left on the Passaconaway Road
9.8	Turn right on the West Side Road
19.8	Traffic light in Conway; intersection with Routes 153 and 16; turn right (west) on Route 16 through town of Conway
11.3	Scenic view of Mt. Washington to north (weather permitting)
11.5	Intersection of Route 16 and Kancamagus Highway continue south on oute 16
11.8	Road cut through large kame terrace
12.6	Intersection with Route 113; continue south on Route 16
13.3	Top of Kame terrace; view of Silver Lake through valley to left (southeast)

14.2 Intersection with Bald Hill Road; turn right (north) on Bald Hill Road
15.1 Intersection with dirt road; bear right on tarred road
15.6 Cross bottom of Chase Hill meltwater channel
15.9 Turn left (north) on dirt road
16.3 Deep valley on left (west) is the Chase Hill col channel
16.8 STOP 2 Parking Lot of the Darby Field Inn

The Chase Hill col channel was formed by meltwater flowing off the ice and through the saddle between Chase Hill and Bald Hill. At its northern end it is fed by a short westward-trending lateral channel. On aerial photographs the channel can be seen quite clearly to extend down the valley of Cream Brook to a kame terrace on the side of the Silver Lake through valley. The average gradient of this channel is approximately 100 ft/mile to the south.

The Sugarloaf col channel is located about 1 mile west. It apparently is fed by an esker located on the north slope of the divide and contains a large abandoned waterfall and plunge pool at the divide. A channel can be followed from the plunge pool to a kame located behind the Albany Chapel.

A series of tiered meltwater channels found on the east side of Mt. Chocorua extends to an elevation of 1300 ft.

Continue down the hill

17.1 STOP 3

Small till cut on left (west) side of road. At least two tills are found over much of this area. This small outcrop contains two tills in contact. The uppermost till is sandy, with generally less than 8 percent clay; the lower till contains more clay (>15 percent)

17.2 Turn right (east) at intersection with the Kancamagus Highway
17.8 Ski jump on right (south)
18.9 Intersection with Route 16; turn right (south) on Route 16
20.0 Turn left (east) on Route 113
20.1 Gravel pit on left (east) in kame terrace and esker
20.2 Gravel pit on left (east) in kame terrace
20.3 Gravel pit on left (east) in kame terrace
20.4 Gravel pit on left (east) in kame terrace
20.6 Gravel pit on left (east) in kame terrace
20.8 STOP 4

Short walk up gravel road on left (east) side of road to top of kame terrace.

This kame terrace is located on the east side of the Silver Lake through valley. The contact between the till-covered hillside and the terrace is clearly visible. The surface of the kame terrace slopes southward, indicating meltwater flow in that direction. Sedimentary structures within the kame suggest that it is at least partly partly deltaic.

Looking west across the valley, one can see the Pequawket esker in the foreground and Whitton Ledge and Mt. Chocorua in the background. Whitton Lodge is a good example of stoss and lee topography. Return to bus and continue south on Route 113.

21.2 Kettle-hole pond on right (west) with the Pequawhet esker in the background

21.5 STOP 5

Conway Aggregate sand and gravel pit on right (west).

The Pequawket esker was formed by meltwater flowing north through the Silver Lake through valley. Present drainage in the valley is to the north, suggesting that this esker may be of the hydrostatic type.

Return to Route 113 and continue south

22.3 Loose sandy till exposed in roadcut on left (east)

22.6 Turn right on the Madison boulder road

23.0 Madison dump sandpit on left. This pit contains fine sand and silt with widely spaced clay beds (varves?) indicating lacustrine deposition. Climbing ripples indicate an easterly flowing current

23.3 Sand pit on right (north) is at the downstream end of the Pequawket esker.

23.5 Sandpit on right (north) in kame terrace

23.6 Bear right on Madison Boulder road

23.9 STOP 6 The Madison Boulder

The Madison Boulder is a large (83x37x23 ft) erratic thought to have been transported by glacial ice from Whitton Ledge to its present location. The bedrock in this area has been mapped by Wilson (1969) as Concord Granite. Since the boulder is composed of Conway Granite it can be considered a true erratic. Return to Route 113

25.2 Turn right (south) on Route 113

27.3 Turn right at the intersection with the East Madison Road. Continue west on Route 113

27.7 Cross possible outlet for meltwater emerging from the Silver Lake through valley

29.0 Village of Silver Lake

29.2 Turn left (south) on Rt. 41

29.7 Cross railroad tracks

30.0 Ice-channel filling on left (east)

30.8 Drive up onto Silver Lake outwash fan

31.4 Gravel pit on right (west) side of road; note coarse material

32.0 East Shore Drive

32.8 Small kettle-hole pond on left (south)

33.0 Turn left (south) on dirt road parallel to lumber mill

33.3 Turn right (west) on Ossipee Lake Road
33.4 STOP 7

Sand pit in the Silver Lake outwash fan. This pit is typical of many of the pits in this area. Festoon cross-bedding overlies deltaic foreset bedding. The outwash here is uniform sand with very little gravel. Exposures at the northern part of the fan are much coarser, usually up to 50 percent gravel. Wells in the area indicate that the sand is more than 150 ft thick over much of the area.

Continue west on Ossipee Lake Road

33.8 Turn left (west) on Route 41
34.1 Cross railroad track
34.3 Turn left (south) on Route 16
34.5 Turn right (west) on Route 25
34.7 Cross Bearcamp River
35.2 Note high-level outwash on left and alluvium on right
35.7 Leave alluvium; drive up onto outwash plain.
36.0 Turn left (south) on dirt road (Gilman Notch Road)
36.3 STOP 8

This till can be classified as oxidized Thomaston (Lower) Till. The average grain-size distribution of the matrix of this till is 56 percent sand, 28 percent silt, and 16 percent clay. The brown color of the till is the result of interglacial weathering. The weathering involves the alteration of both dioctahedral and trioctahedral illite to vermiculite and to a mixed layer illite/vermiculite of the alevardite type. Chlorite is also weathered to vermiculite and there is extensive alteration of heavy minerals. The heavy mineral alterations probably account for the brown color through the release of ferric iron. Chemical analyses of samples taken at various depths show significant decreases in K, Mg, and Si with depth. Total Fe remains constant or increases slightly with depth while ferric iron decreases with depth.

Many exposures of Thomaston Till show evidence of glacio-tectonic activity. At this outcrop some vertically oriented clastic dikes contain pieces of brecciated Thomaston Till.

In the northern part of the exposure some upper till contains pieces of Thomaston Till within it. This also suggests that the Thomaston Till is older than the overlying till. It is interesting to note that chattermarked garnets are very common in the overlying tilland yet are practically nonexistent in the Thomaston Till. Also microfabric analyses of the Thomaston Till show only weakly developed north-south maxima.

Return to Route 25

36.5 Turn right (east) on Route 25
38.0 Turn left (north) on Route 16

39.8 Note high-level outwash surface
42.1 Junction with route 113 in Chocorua. Continue north on Route 16
43.2 Scenic vista of Mt. Chocorua and Chocorua Lake on left (northwest)
46.4 Cross Chocorua River. A series of lateral meltwater channels occurs in woods on left (west)
49.3 Albany Chapel on left (north). Kame behind Chapel is at the end of the Mt. Sugarloaf meltwater channel
53.8 Turn left (north) on Route 16
54.0 Cross Saco River
58.3 Return to Red Jacket Motor Inn

END OF SATURDAY TRIP

SUNDAY FIELD TRIP

0.0 Leave Red Jacket Motor Inn. Turn right (north) on Route 16
.9 Traffic light in North Conway; continue straight on Route 16
1.1 Turn left on River Road
1.5 Cross Saco River
2.0 Intersection with West Side Road; continue straight on River Road
2.5 Turn left on Cathedral Ledge Road
3.4 Start of steep hill
3.5 "Upper till" outcrops on left and right
4.3 Top of Cathedral Ledge

STOP 1

Short walk in woods to the edge of ledges. View north of Evans Notch and Mt. Washington (through the trees). The Saco River valley train is clearly visible. Note that the Saco River passes to the west of Pine Hill at the south end of the valley while the valley train passes to the east. Drumlins are also visible: Birch Hill, Pine Hill, and the Red Jacket drumlin. The Saco River valley turns sharply east at Conway. The highland to the south is cut by three through valleys. Note peculiar channels on topo map west of the ledges.

Return to River Road

CAUTION Use Lower Gear Descending Hill!

6.0 Turn right (south) on River Road

Note sharp right on Echo Lake Road

6.5 Turn right (west) on West Side Road
8.2 Birch Hill Drumlin on right (west)
10.6 Cross railroad track
11.2 Pine Hill drumlin on other side of valley to left
12.4 Cross Swift River
12.8 Traffic Light in Conway; continue straight (south) on Route 153
13.1 Bear left on Route 153 at intersection with Tasker Hill Road
17.0 Enter Eaton through valley; drainage here is to the north
17.9 Bear right at intersection with Brownfield Road; continue on Route 153.
18.4 Bear left in Eaton village; continue southward on Route 153
19.0 Cross kame terrace
19.7 Pond on left drains north; thus we have crossed the divide in through valley
21.4 Kames and kame terraces in area of King Pine Ski Area
22.0 Intersection with Madison Village Road; continue south on Rt. 153
22.2 Eskers in pond on left
23.2 Esker on right
25.0 Intersection with Ossipee Lake Road; continue south on Rt. 153. Road construction in this area
27.3 Cross the Ossipee River; note the river is flowing across till in this area

27.4 Junction with Route 25; turn right (west) on Rt. 25
27.6 Turn left on Mountain Road
28.4 A meltwater channel flows eastward from this flat sand plain. The channel may represent the spillway for a small glacial lake associated with some kame deltas to the north
28.7 Till on both sides of road
30.0 Bear left at intersection with Pequawket Trail Road
31.7 Outcrop of medium to fine sand

STOP 2

There are a number of low ridges of fine sand in this area which lack stratification. Ventifacts are common in these outcrops and some of the sediments may represent sand dunes.

Turn Around

32.4 Turn left (north) on Pequawket Trail Road
33.2 Turn left (west) on Route 25
33.6 Turn right on Long Sand Road
33.8 Bear right at fork in road
33.9 Turn right into sand pit

STOP 3

Kame delta. There is a series of flat-topped kame deltas in this area. The surfaces of the kame deltas are at approximately the same elevation as the meltwater channel on the north side of Green Mountain. It is suggested that these represent a lake that developed before a lower outlet was exposed at Effingham Falls

Return to Route 25

34.2 Turn right (west) on Rt. 25
34.9 Large swamp (quaking bog) on left
36.0 Cross Pine River
36.5 Intersection Route 16

OPTIONAL NORTH on Route 16 to special part of field trip. Walk through five successive lateral meltwater channels on Mt. Chocorua. Park where directed by leader. Walk will take about 2 HOURS at most; probably shorter. The traverse is in the woods; mosquitos and black flies may be fierce.