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Hartshorn, Joseph H.

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GLACIAL GEOLOGY OF SOUTHEASTERN MASSACHUSETTS

by

Joseph H. Hartshorn
Department of Geology and Geography
University of Massachusetts
Amherst, Massachusetts

Introduction

By the time the retreating late Wisconsinan glacier began to uncover the area northwest of Buzzards Bay, it had melted down to a surface that resembled a small-scale combination of karst and a mature stream-carved landscape of debris-covered ice with relief of several hundred feet. Along the irregular front, meltwater streams poured from subglacial tunnels or through superglacial valleys carved in the ice, leaving as legacies the proglacial outwash plains and the many forms of ice-channel fillings. In long openings between the rapidly melting ice and low till hills or drumlins, the streams laid down ponded and fluvial deposits that were to become kame terraces as the glacier finally melted away. Further back, large depressions in the ice were occupied by through-flowing streams or by impounded water bodies, thus producing kames of many shapes that rise above today's landscape and that show either stream or quiet-water deposits. By the time the large proglacial lake that occupied the lowest land drained away, the glacier had melted completely away from the area we are interested in and the geologic agent that took over was the wind. It picked up the fine-grained portion of newly exposed till and outwash and deposited a layer of silty sand that overlies nearly all of the glacial features in the landscape and is commonly filled with wind-carved pebbles. This eolian mantle, called loam, is what enables the New England farmer to survive on the otherwise infertile stony sandy till or the sterile pebbly and cobbly outwash bodies.

The Field Trip

The constant change brought about by the demand for sand and gravel as construction material, as landfill around building sites, and as cover in large sanitary landfills means that it is impossible to set up an itinerary in the spring and see the same features at the scheduled stops on the itinerary in October. Indeed, new environmental regulations mean that more gravel pits are now being graded and covered, removing some outcrops completely. Thus, this field trip will have no published itinerary in the Guidebook. Instead, a general description of the landforms we will see (they can't disappear entirely) and the glacial features of the area will give the setting for the field trip. A final itinerary, map, and road log will be distributed on the field trip.

Glacial Geology

The physiographic setting of the glacial geology is the Narragansett Basin and the granitic low areas south of the Basin. Total relief in the area is generally low, and hills that rise more than one hundred feet above their base are uncommon. Thus, the glacial geologist looks for scarps that may be less than 10 feet high, or kames that rise 20 feet above the surrounding area, or deltas that may be as little as 15 feet above the lake bottom (Hartshorn, 1960 , 1967).

The till that is the substrate on which all other glacial features are formed and from which the stratified glacial sediments were derived is greatly influenced by the bedrock in the area. The Dedham Granodiorite is a light-colored granodiorite to quartz monzonite and contains quartz, microcline, plagioclase, and biotite (Koteff, 1964). The Rhode Island Formation is a light- to medium-gray sandstone, siltstone, and conglomerate with quartz, sericitized clay minerals, and feldspar. These rocks, and a few other varieties, generally produce a light- to medium-gray till, although other shades of gray, pale yellowish brown, or similar light colors can also be found. The till, a mixture of grain sizes ranging from clay through boulders as much as 20 feet in diameter, is commonly sandy, loose, and very stony. Outcrops at which to see a good till section are nearly non-existent, for till has little market value and is generally not quarried.

A particular kind of till, derived entirely from superglacial debris, can be found in many of the ice-contact features, particularly in kames, kame terraces, and ice-channel fillings. This flowtill (Hartshorn, 1958) occurs as lenses or beds of till a few feet thick that flowed as a muddy watersoaked mass from surrounding glacial hills onto sediments in the glacier's topographic lows. The composition of the flowtill differs from the till generally mapped as ground moraine, because the farthest travelled rocks, from north of the Basin, tend to be concentrated on the surface of the ice as it melts away and so the flowtill contains more non-Basin rocks than the subglacial till that makes up the general till blanket on bedrock. The flowtill is easily recognized in the various ice-contact features, for it is commonly interbedded with the sand and gravel or forms the last episode in the buildup of the deposit and hence is the uppermost sediment in the landform.

As shown by the flowtill, the surface of the glacier was partly covered with superglacial debris picked up from the ground just to the north and carried to higher altitudes in the ice by glacier shear or by streams flowing under hydrostatic head and emerging as fountains or from tunnels a few hundred feet above the base of the ice.

As the margin of the ice thinned, it developed an irregular surface characterized by hills of ice with some superglacial debris cover and by depressions that ranged from sinkholes only a few tens of feet in diameter to larger depressions and integrated valleys carrying large meltwater streams and mantled with stratified debris tens of feet thick. This ice topography was first formed many hundreds of feet above the bedrock or till-covered floor under the glacier. As the glacier melted further, the ice topography constantly changed as hills lost their protective cover of debris, melted away, and became hollows, and as former low areas with their deposits of sediments resisted melting and became temporary hills. Only when the underlying ice was nearly gone would the first of the ice-contact deposits be preserved; some would be let down the last few feet and would contain some disturbed beds, others would be formed on the ground and would show disturbance only at the margins.

The numerous hummocks, hillocks, mounds, mesas, hills, or flat tablelands made of stratified debris are arbitrarily divided into landform classifications - kame, kame terrace, kame plain, esker or ice-channel filling, outwash plain, and undifferentiated stratified drift. Reconstruction of the original landform shows that the present form is a result of the positioning of remnant blocks and masses of ice during deglaciation and not the result of different processes. The average grain size of many landforms, so differently named but closely related in space, may turn out to be nearly similar, as may the internal structure. On the other hand, it is clear that not all kames or kame terraces, for instance, were formed the same way. Some, which consist of stream gravels from bottom to top, show that streams poured through the depressions in the ice. Others show evidence of deposition in standing water, either by deltaic foresets and topsets or by the characteristic structures and fine-grained texture of the sediments. Thus the map units are not inflexibly defined, and discussions of the glacial history need not be limited by landform names on the surficial map.

Evidence of ice-marginal positions is common, though not in the form of moraines, as is usual in the Midwest. Moraines are rare, linear kames or lines of kames are more common but their origin and meaning are a puzzle, a few lines of kame deltas are known, and heads of outwash are most common.

An end moraine composed of a line of irregular hills as much as 100 feet high, trending east-west, has been mapped south of Great Quittacas Pond. The end moraine contains sand and gravel, but no till, and is thought to be a push moraine formed by a minor readvance of the glacier over previously deposited glaciofluvial sediments (Koteff, 1964). A kame in Berkley, about 2400 feet long in an east-west direction, about 900 feet wide, and about 85 feet high, shows evidence of either minor readvance of the glacier or most unusual slump deformation. Here beds of varved sand and clay form an anticline and other beds are found vertical positions with apparent shear zones cutting off the upper parts of the beds. No till is found overlying the contorted sediments.

Other forms of glacial deposits can be used to infer temporary stopping places for the ice margin. Perhaps the most striking feature, one which allows the geologist to separate out minor phases in the deglacial history, is the head of outwash -- a northerly facing ice-contact slope that marks either a temporary halt in the retreat of the ice margin, a place where a large block of ice remained for some time, or a place where deposition was so swift and overwhelming for a short period before the stream was diverted elsewhere or stopped flowing that it gives the impression of a halt in the ice-marginal retreat. Many such heads of outwash can be seen in southeastern Massachusetts; usually they are more clearly visible on topographic maps than in the field because of heavy forest cover. They are commonly characterized by low-lying swamps or outwash to the north, a scarp of from 10 to 100 feet high whose outline is scalloped, digitate, or broadly irregular, the presence of kettles and hummocky topography near the scarp or on it, isolated kames north of the scarp, ice-channel filings trending into the scarp, and a broad, moderately smooth fluvial plain trending away from the scarp. The glaciofluvial plain, commonly broken by kettle holes and large depressions into a series of kames and kame plains, declines gently in a southerly direction and may abut against yet another ice-contact scarp to the south.

At the same time, and ranging over a span of time from when the glacier was still thick and perhaps still actively advancing to very late in the glacial history, ice-channel fillings or eskers were forming. Glacial streams, flowing on the subglacial floor or just above the floor in ice tunnels, aggraded their channels to a depth of several tens of feet. These early subglacial forms are difficult to distinguish from similar linear ridges that were formed in ice-walled valleys open to the sky, except that where lenses of flowtill are present in or on the ice-channel filling it may be inferred that a valley slope existed down which the till moved, for there is little chance of masses of till falling from subglacial tunnels into the stream channel.

As the ice margin retreated to the north and northwest, it became more nearly a straight, solid glacier front where it ended in standing water. In some places the topography forced the meltwater to become ponded in large proglacial lakes instead of flowing directly away from the ice as proglacial streams. Where this occurred, low-lying areas were filled with as much as 100 feet of lake sediments, commonly varved clay, and the temporary northern shores of these lakes were formed of rows of kame deltas that trend east-northeast. These kame deltas are commonly very well developed, with free-standing frontal slopes, an ice-contact slope at the rear, and a clear indication of the water level, either from the intersection of topset-foreset beds or from the break in slope at the front of the delta. Many of the larger flat-topped bodies of stratified drift seen in southeast Massachusetts are deltas, but the first of a series of clearly defined deltas in irregular rows starts with the Pine Swamp delta near Taunton and the line of deltas with a water level of about 65 feet altitude extending eastward from Bridgewater. The last line north of this row includes the deltas along Route 106 south of Brockton, which stretch east-northeast for 7 1/2 miles.

In front of most of these deltas, and irregularly interspersed between them, are the deposits of varved clay. Estimates of the length of time that the largest water body remained in existence are from at least 100 years (Antevs, 1928) to 250 years (Hartshorn, 1960).

The northern margins of the lakes, where not marked by kame deltas, cannot be distinguished except perhaps by the boundaries of low-lying areas of fine-grained sediment such as clay, silt, or very fine sand. The now-vanished ice front was the margin elsewhere, and it is generally not possible to reconstruct that front except at the kame deltas. The non-glacier perimeters of the lakes likewise are difficult to delineate. The margins seem to have been a combination of higher topography, mostly till hills, higher heads of proglacial glaciofluvial bodies, and detached remnants of ice, some of which were wholly or partly buried by sediment.

The lakes were nearly the last of the direct glacial landforms to be deposited in any area. When the lakes drained, the proglacial meltwaters spread outwash over the lower parts of the lake bottoms and quickly became established in streams that are the direct ancestors of the larger streams in the area today.

The eolian mantle is a layer of silty sand to sand found nearly everywhere in the area, which contains windcut stones, or ventifacts, from bottom to top and hence must have been deposited primarily by the wind. The rocks of southeastern Massachusetts seem to make good ventifacts and both the topography and the early postglacial climate must have been conducive to wind work, for it is difficult to see a section without the eolian mantle, or the eolian mantle without several dozen ventifacts. The granitic and volcanic rocks more readily take a cellophanelike polish and are best fluted and pitted by wind abrasion because of their composition and texture. Very few ventifacts have the classic faceted form of the Dreikanter; most are merely polished and etched on one or more sides. The eolian mantle is mostly mixed with the underlying glacial deposits and hence partakes of the stoniness of those materials.

The last geologic agent to affect the area is humanity. Bulldozers for moving sand and gravel, dynamite for blasting rocks, and the construction of homes, sanitary landfills, school complexes, highways, and cities change the landscape as surely as any "natural" agent. No quotation marks are needed - all humanity acts as a geologic force, and here in southeastern New England the glacial geologist who has a special interest in the landforms can see them change, diminish, and disappear over a few decades.

References Cited

Antevs, Ernst, 1928, The last glaciation: Am. Geog. Soc., Research Ser. no. 17, 292 p.

Hartshorn, J.H., 1958, Flowtill in southeastern Massachusetts: Geol. Soc. America Bull., v. 69, p. 477-482.

_____, 1960. Geology of the Bridgewater quadrangle: U.S. Geol. Survey Geol. Quad. Map GQ-127.

_____, 1967, Geology of the Taunton quadrangle, Bristol and Plymouth Counties, Massachusetts: U.S. Geol. Survey Prof. Paper 1163-D, 67 p.

Koteff, Carl, 1964, Geology of the Assawompsett Pond quadrangle, Massachusetts: U.S. Geol. Survey Geol. Quad. Map GQ-265.

Probable 1:24,000 Topographic Quadrangle Maps

Assawompsett Pond
Assonet
Bridgewater
Brockton
Fall River East
New Bedford North
Taunton
Whitman