DEPARTMENT OF CONSERVATION
Maine Geological Survey

Robert G. Marvinney, State Geologist

OPEN-FILE NO. 04-41

Title: *Surficial Geology of the Readfield 7.5-Minute Quadrangle, Kennebec County, Maine*

Author: *Carol T. Hildreth*

Date: *2004*

Financial Support: Funding for the preparation of this map was provided in part by the U.S. Geological Survey STATEMAP Program, Cooperative Agreement No. 03HQAG0068.

Associated Maps: Surficial geology of the Readfield quadrangle, Open-File 04-40
Surficial materials of the Readfield quadrangle, Open-File 04-39

Contents: 5 p. report

Maine Geological Survey
Open-File 04-41

Surficial Geology of the Readfield 7.5-Minute Quadrangle, Kennebec County, Maine

Carol T. Hildreth
CTH Enterprizes
135 Washington Street
Holliston, MA 01746

INTRODUCTION

This report describes the surficial geology and Quaternary history of the Readfield quadrangle in southwestern Maine. Surficial earth materials include unconsolidated sediments (sand, gravel, etc.) of glacial and nonglacial origin. Most of these deposits formed during and after the latest episode of glaciation in Maine, called the Wisconsinan glaciation, during the last 25,000 years.

Surficial sediments cover the bedrock over most of the quadrangle and are subject to many uses and environmental considerations. These include sand and gravel extraction, development and protection of ground-water supplies, siting of waste disposal facilities, and agriculture.

The fieldwork for this study was carried out in 2003 for the STATEMAP cooperative between the Maine Geological Survey and the U.S. Geological Survey (USGS). Two maps are associated with this report. The *surficial geologic map* (Hildreth, 2004c) shows the distribution of sedimentary units and indicates their age, composition, and known or inferred origin. It also includes information on the geologic history of the quadrangle, such as features indicating the flow direction of glacial ice. This map provides the basis for the following discussion of glacial and postglacial history.

The *materials map* (Hildreth and others, 2004) shows specific data used to help construct the surficial geologic map. These data include observations from gravel pits, shovel and auger holes, construction sites, and natural exposures along stream banks. The materials map also shows boring and well logs.

Geographic Setting

The Readfield 7.5-minute quadrangle has an area of about 133 km^2 (52 mi^2). It is located in southwestern Maine, in the southern part of the New England Central Upland physiographic province. It includes parts of the towns of Readfield, Belgrade, and Mount Vernon. Altitudes range from 211 feet (64 m), the level of Lake Maranacook at the south edge of the map, to over 780 feet (237 m) on Bowen Hill in the northwest part of the quadrangle. Thus, topographic relief in the map area is about 570 feet (173 m).

A few till hills in the Readfield quadrangle were shaped by glacial ice flowing southeast to south and have been elongated in that direction. Most of these streamlined hills are not true drumlins; the majority are bedrock-cored hills that were plastered by till, particularly on their north and northwest sides. The major trend in the topography, however, especially that of stream valleys, is controlled by structures in the underlying bedrock, which generally strike north-northeast to northeast.

Lake Maranacook and its south-flowing eastern tributary, Tingley Brook, at the southern edge of the map area, drain southward through Lake Annabessacook, thence into Cobbosseecontee Lake and Stream, and then eastward to the Kennebec River at Gardiner. On the west side of the map area, Desert Pond and Intervale Brook flow south into Torsey Lake, which drains southward to Readfield at the western head of Maranacook Lake. At the northwest edge of the map area, Minnehonk Lake drains south to Hopkins Pond, thence south-southwest via Hopkins Stream to Echo and Androscoggin Lakes, and then west via the Dead River to the south-flowing Androscoggin River. Most of the rest of the quadrangle is drained by various tributaries of the east-flowing Belgrade Stream -- including south-flowing Long Pond and its tributaries, such as Moose Pond and Ingham Streams which flow south then northeast, and Bog Stream and Hoyt Brook which flow northeast from the southern parts of the map area to join the southeast-flowing Belgrade Stream near the east edge of the map. Belgrade Stream flows eastward into Belgrade Bog and thence into Messalonskee Lake, whose outlet drains northward to Messalonskee Stream, which joins the Kennebec River just south of Waterville.

Bedrock Geology

Most of the quadrangle is underlain by nearly vertical, tightly isoclinal-folded, north-northeast-trending, high-grade metasedimentary rocks of Silurian age. The axial traces of the folds trend about 40° azimuth; "the fold patterns are symmetrical and elongated indicating upright folds with gentle plunges" (Osberg, 1968). The majority of the Sangerville Formation consists of interbedded metapelite and metalimestone or metadolostone; it includes two distinctive members that cover parts of the Readfield quadrangle. The Patch Mountain Member outcrops in two relatively narrow strips that commonly form lowlands in the southeast part of the quadrangle: it has thin interbeds of calc-silicate assemblages and biotite granofels (Creasy, 1979); outcrops and detached fragments of this rock unit weather unevenly, producing a distinctive ribbed surface ("ribbon rock"). The Limestone Member of the Sangerville Formation covers much of the northwest part of the quadrangle, beginning along the east shore of Torsey Lake and extending into the northeast-trending valley of Ingham Stream. The main body of Sangerville is generally more resistant to weathering and erosion and generally underlies the highlands, including the northeast-trending hills immediately south of Ingham Stream and the ridge west of Minnehonk Lake at the northwest corner of the map. The Waterville Formation, which consists of interbeds of metapelite and metasandstone, underlies the extreme southeast corner of the map area. The extreme northeastern part of the quadrangle is underlain by the Lower Devonian Rome pluton composed of binary quartz monzonite (Osberg, 1968; Osberg and others, 1985).

PREVIOUS AND CURRENT WORK

Early work on the surficial geology in this part of Maine was done generally at a reconnaissance level and at a smaller scale (Thompson, 1977; Thompson and Borns, 1985). The soil survey of Kennebec County (Faust and LaFlamme, 1978), and the recent surficial materials map (Locke, 1999), facilitated the present author's fieldwork. Surficial geologic mapping at 1:24,000 scale has been completed in the Winthrop (Thompson, 2004b), Augusta (Thompson, 2004a) and Belgrade quadrangles (Hildreth, 2004a).

GLACIAL HISTORY AND LATE- GLACIAL HISTORY

Southwestern Maine probably experienced several episodes of glaciation during the Pleistocene Ice Age, but virtually all evidence of previous glaciations in the Readfield area was obliterated during the last (late Wisconsinan) episode, when the Laurentide ice sheet advanced from the northwest to a terminal position on the continental shelf.

Evidence of glacial erosion within this area is noticeable mainly as southeast- to south-trending glacial striations on freshly exposed bedrock surfaces. Further, more detailed, investigations of these striations, in this and adjoining areas, may help in efforts to decipher the changes in glacial flow more precisely during the last stages of glaciation in this part of Maine.

In the Readfield area there are few, if any, true drumlins. However, several streamlined hills coated with till have bedrock cores and are elongated in a southeast- to south-trending direction. Some of these have glacially plucked bedrock outcrops on the south to southeast end. Examples include unnamed hills in the extreme northwestern and southeastern corners and in the central part of the map area.

After reaching its terminal position on the continental shelf, the late Wisconsinan ice sheet began to recede between 15,000 and 17,000 years ago. Shells collected from glaciomarine sediments deformed by ice shove in the Freeport area (about 20 miles [12 km] south-southwest of Readfield) have a radiocarbon age of 14,045 yr B.P. (Weddle and others, 1993). The ice sheet terminus is inferred to have reached the Readfield area a short time after that. As the ice sheet melted northward, sea level rose and inundated the entire Maine coastal zone, including much of the area in the Readfield quadrangle lying below a current elevation of approximately 350 feet (160 m) above sea level, which is the approximate limit of marine submergence for this part of Maine. The ice-front in the Readfield area therefore terminated in the late-glacial sea and meltwater streams flowing into the sea deposited a wide variety of stratified deposits that represent time-transgressive proglacial marine environments during glacier retreat through the area. As summarized by Thompson and Borns (1985), the marine submergence reached its maximum extent at about 13,000 yr B.P., and regressed from the area somewhat before 11,450 yr B.P. (Smith, 1985; Thompson and Borns, 1985), based on shells that indicate the approximate offlap of the late-Wisconsinan sea at Little Falls, Gorham, about 35 miles (56 km) southwest of the Readfield quadrangle.

A radiocarbon date of 13,300 ± 50 yr B.P. (OS-4419) on *Mytilus edulis* from nearshore deposits in a pit at approximately 200 feet (61 m) asl in the North Pownal quadrangle records the earliest date for marine regression in the state. A younger date (12,820 ± 120 yr B.P., SI-7017) on *in-situ* intertidal fauna is reported by Retelle and Bither (1989) from nearshore deposits at an elevation of 152 feet (46 m) asl in a gravel pit in Topsham, in the Brunswick 7.5-minute quadrangle. An uncorrected date of 13,315 ± 90 yr B.P. (AA10162: Weddle and others, 1993) from the same pit in Topsham, on *Portlandica arctica* shells found in Presumpscot Formation mud approximately one meter below the nearshore deposits containing the interidal fauna, supports the older offlap dates (Weddle, 1997, p. 8).

As the glacier melted northward through the Readfield area, the sea kept apace, lapping against the ice front; here, meltwater streams flowing out of the glacier deposited two small proglacial subaqueous marine fans and slightly more extensive marine bottom sediments (Presumpscot Formation of Bloom, 1960) in contact with or beyond the ice front. Also, two small areas of marine shoreline deposits were identified.

Elevations above sea level (asl) of topset-foreset bedding contacts for two ice-contact deltas in the adjoining Belgrade quadrangle have been measured: one in the Summerhaven delta at 356 ft (108.5 m) asl; and the other in the Belgrade delta at 359 ft (109.4 m) asl (Thompson and others, 1989). These record a minimum elevation for sea level at the time of their deposition. The elevations of glaciomarine deltas in southwestern Maine indicate that the land surface rose following their deposition and experienced a tilt of 2.82 ft/mi (0.53 m/km), higher to the northwest (Thompson and others, 1989, p. 58). The rise in the land surface was due to glacial rebound of the lithosphere following the gradual relief of the great weight of the glacier as it melted northward. Concomitant with rebound of the land surface, relative sea level gradually fell and appears to have reached the modern-day shoreline by about 11,000 years ago.

As sea level dropped, many of the materials deposited below the level of the late-glacial sea in the Readfield area became reworked by wave action as their surfaces passed through the swash zone; they formed characteristic nearshore and shoreline deposits (Pmn) in places. Further lowering of sea level led to downcutting of earlier glaciomarine deposits by the late-glacial streams in the area. At approximately the same time, and probably somewhat later, the now-exposed fine-grained marine bottom sediments became eroded by wind action, which transported and sorted them into various dune and loess deposits, which are too thin to map in the Readfield area.

Variously boulder-strewn, hummocky ridges primarily composed of till and poorly sorted stratified diamicton occur in the Readfield quadrangle. These till ridge deposits are interpreted herein as end moraine segments but are not subdivided as a separate Pt unit on the map; instead, they marked by a symbol that identifies the ridges as parts of ice-marginal positions. As stated by Caldwell and others (1985), these ridges suggest ice was active during their deposition. Further discussion of the relation of associated till ridges and submarine fan, marine delta and esker deposits are given in the report on the surficial geology of the adjoining Belgrade quadrangle (Hildreth, 2004b).

GLACIAL AND POSTGLACIAL DEPOSITS

As the ice sheet melted in the Readfield area, it dropped much of the debris incorporated within it in the form of till. Glacial meltwaters took some of the debris within the glacier, sorted it, carried it some distance and finally deposited it as stratified sediments in various physiographic settings within the quadrangle. These settings are referred to as environments of deposition. Most of the deposits delineated on the map (Pleistocene and Holocene) are characterized on that basis. A few deposits are distinguished by the agent of deposition, such as till (Pt), which was deposited from glacial ice. Postglacial deposits include materials laid down since the glacier melted north of the Readfield area and sea level receded from the quadrangle. These

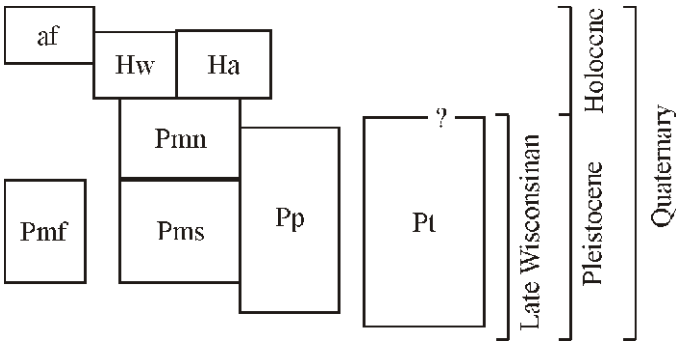

Figure 1. Correlation of map units, Readfield quadrangle, Maine.

Holocene deposits are commonly referred to as recent or modern deposits; they were laid down within the last 12,000 years and most are still in the process of deposition.

The succession of Pleistocene and Holocene surficial deposits in the Readfield area is given in the correlation chart (Figure 1), showing the relative ages of the map units.

Till (unit Pt)

Till occurs throughout the Readfield area. Its thickness is variable, as is its composition. The till was deposited from the glacial ice sheet and forms a blanket over the underlying bedrock; it is inferred to underlie younger deposits throughout the area. In most exposures in the quadrangle, this till is light olive-gray, sandy, stony, and moderately compact, showing weathering only in the uppermost few feet.

Relatively narrow, hummocky, boulder-strewn, fairly short ridges composed mostly of till are found in several locations in the area. A few are associated with the heads of outwash of adjacent stratified deposits. The till ridges are interpreted as end-moraine segments, and are identified on the map as unit Pt marked by an ice-margin position symbol.

Some drumlins are found in the area, but most hills that are drumlin-shaped (and oriented in the expected direction for drumlins relative to the direction of striations in the area) have bedrock cores that have been plastered with till. Many more of these rock-cored hills exist in the quadrangle than do true drumlins. The map area also contains narrow till ridges that are elongate parallel to ice flow; these are mapped as grooved till surfaces. Though most till is less than 6 meters (20 ft) thick in the area, two wells west of Kents Hill penetrated around 75 meters (250 feet) of probable till, and a few others penetrated more than 30 meters (100 feet) in the southern part of the quadrangle; examples include one near the intersection of Plains and Quimby Roads and one along North Road south of the intersection with Dunns Corner Road.

Glaciomarine bottom deposits (Presumpscot Formation) (unit Pp)

Materials consisting of predominantly silt and clay with locally sandy beds are interpreted here as late-glacial submarine fine-grained (marine mud) bottom deposits of the Presumpscot Formation (Bloom, 1960). These deposits were derived from glacial meltwaters and laid down at the bottom of the late-glacial sea following the retreat of the ice sheet from the area and prior to uplift of the area above the sea. The silt and clay deposits commonly lie below about the 300-foot contour-and in many places, beneath units Ha, Hw, and Pmn in the quadrangle. Subsuface data and exposures indicate that Pp overlies Pt, bedrock, fans, and end moraines and can be interbedded with subaqueous outwash materials. It is generally thin (less than 10 feet [3 m] thick) in this quadrangle, which is near the marine limit. In places throughout the map area, Pp is overlain by thin unmapped dune or loess deposits.

Marine fan deposits (unit Pmf)

Fan-shaped deposits consisting mostly of sand and silt and some gravel were laid down in glacial submarine fans. The apex of the fan begins at the head of outwash, where meltwater streams exiting the ice spread out onto the late-glacial sea floor. Some marine fan deposits may contain kettle holes, and they may also include esker or bottom deposits (Pp). Most fan deposits were laid down in the late-glacial sea directly in contact with or just beyond the ice front by meltwater streams; the fan deposits consist mainly of the inclined foreset beds of an incomplete delta (one which has not aggraded to sea level); deposits containing internal collapsed bedding would signify an ice-contact setting. Marine fan deposits in the Readfield quadrangle consist of two separate deposits: one is located northeast of Readfield Cemetery and the other is in the Readfield Depot area; they are rather small and thin deposits that range in thickness from 0 to about 9 m (0-30 ft). In places, they are overlain by marine bottom deposits (Pp) or have been reworked to form marine nearshore deposits (Pmn). In some places they may also be overlain by unmapped thin dune or loess deposits.

Marine shoreline deposits (unit Pms)

At least two small isolated gravelly deposits were laid down in contact with or beyond the ice front at or near the shoreline of the maximum extent of late-glacial sea level. One in the southern part of the map area is located northeast of Readfield Cemetery and the other in the northern part of the map area is east of Bean Road. These deposits may be as much as 10 m (30 feet) thick.

Marine nearshore deposits (unit Pmn)

Materials consisting of waterlaid sediments that range from clay to gravel are inferred to have been deposited as a result of wave action in nearshore and shallow marine environments throughout the map area. Pmn deposits are thin (commonly less than 10 feet [3 m] thick) and generally overlie till or high-level marine fan or bottom deposits; some Pmn materials are associated with or overlain by unmapped thin dune or loess deposits.

Wetland deposits (unit Hw)

Freshwater swamp deposits characterized by accumulations of fine-grained organic-rich sediments, deposited in low, flat, poorly drained areas are scattered throughout the quadrangle. Little information is available on the thickness of these deposits in the Belgrade area, though Cameron and others (1984) report that peat deposits in southwestern Maine generally average less than 20 ft (6 m) in thickness. In places the unit is indistinguishable from, grades into, or is interbedded with alluvium (Ha). It should be noted that both swamp (Hw) and alluvial deposits (Ha) are coincident along many stretches of flood plains in this area.

Stream alluvium (unit Ha)

Sand, gravel, silt, and organic material deposited by modern streams in their flood plains is mapped as stream alluvium. The extent of alluvium indicates areas that flooded in the past that may be subject to flooding in the future. In places the unit is indistinguishable from, grades into, or is interbedded with wetland deposits (Hw). It should be noted that both swamp (Hw) and alluvial deposits (Ha) are coincident along many stretches of flood plains in this area.

Artificial fill (unit af)

Areas where the original ground surface is covered by a substantial thickness of imported material, both man-made and natural, are mapped as artificial fill (unit af). The material varies from natural sand and gravel to quarry waste to sanitary landfill. The thickness varies, but usually doesn't exceed 20 ft (6 m).

ACKNOWLEDGMENTS

The author heartily thanks Woodrow B. Thompson for his patient assistance in completing this project. He contributed advice, support, background materials, field notes and maps, and had several consultations. Regardless, the author is wholly responsible for the interpretations given herein.

REFERENCES

Bloom, A. L., 1960, Late Pleistocene changes of sea level in southwestern Maine: Maine Geological Survey, 143 p.

Caldwell, D. W., Hansen, L. S., and Thompson, W. B., 1985, Styles of deglaciation in central Maine, *in* Borns, H. W., Jr., Lasalle, P., and Thompson, W. B. (editors), Late Pleistocene history of northeastern New England and adjacent Quebec: Geological Society America, Special Paper 197, p. 45-58.

Cameron, C. C., Mullen, M. K., Lepage, C. A., and Anderson, W. A., 1984, Peat resources of Maine -Volume 4: southern and western Maine: Maine Geological Survey, Bulletin 31, 123 p.

Creasy, J. W., 1979, Reconnaissance bedrock geology of the Poland quadrangle, Maine: Maine Geological Survey, Open-File Report 79-15, 18 p. and map.

Faust, A. P., and LaFlamme, K. J., 1978, Soil survey of Kennebec County, Maine: U.S. Department of Agriculture, Soil Conservation Service, 87 p., scale 1:20,000

Hildreth, C. T., 2004a, Surficial geology of the Belgrade quadrangle, Maine: Maine Geological Survey Open-File Map 04-37, scale 1:24,000.

Hildreth, C. T., 2004b, Surficial geology of the Belgrade 7.5-minute quadrangle, Kennebec County, Maine: Maine Geological Survey Open-File Report 04-38, 7 p.

Hildreth, C. T., 2004c, Surficial geology of the Readfield quadrangle, Maine: Maine Geological Survey Open-File Map 04-40, scale 1:24,000.

Hildreth, C. T., Locke, D. B., and Thompson, W. B., 2004, Surficial materials of the Readfield quadrangle, Maine: Maine Geological Survey, Open-File Map 04-39, scale 1:24,000.

Locke, D. B., 1999, Surficial materials of the Readfield quadrangle, Maine: Maine Geological Survey Open-File Map 99-67, scale 1:24,000.

Osberg, P. H., 1968, Stratigraphy, structural geology, and metamorphism of the Waterville-Vassalboro area, Maine: Maine Geological Survey, Bulletin 20, 64 p., map, scale 1:62,500.

Osberg, P. H., Hussey, A. M., II, and Boone, G. M. (editors), 1985, Bedrock geologic map of Maine: Maine Geological Survey, scale 1:500,000.

Retelle M. J., and Bither, K. M., 1989, Late Wisconsinan glacial and glaciomarine sedimentary facies in the lower Androscoggin River valley, Topsham, Maine, *in* Tucker, R. D., and Marvinney, R. G. (editors), Studies in Maine geology: Volume 6 - Quaternary geology: Maine Geological Survey, p. 33-51.

Smith, G. W., 1985, Chronology of late Wisconsinan deglaciation of coastal Maine, *in* Borns, H. W., Jr., Lasalle, P., and Thompson, W. B. (editors), Late Pleistocene history of northeastern New England and adjacent Quebec: Geological Society America, Special Paper 197, p. 29-44.

Thompson, W. B., 1977, Reconnaissance surficial geology of the Augusta quadrangle, Maine: Maine Geological Survey, Open-File Map 77-23, scale 1:62,500.

Thompson, W. B., 2004a, Surficial geologic map of the Augusta quadrangle, Maine: Maine Geological Survey Open-File Map 04-31, scale 1:24,000.

Thompson, W. B., 2004b, Surficial geologic map of the Winthrop quadrangle, Maine: Maine Geological Survey Open-File Map 04-34, scale 1:24,000.

Thompson, W B., and Borns, H. W., Jr. (editors), 1985, Surficial geologic map of Maine: Maine Geological Survey, scale 1:500,000.

Thompson, W. B., Crossen, K. J., Borns, H. W., Jr., and Anderson, B. G., 1989, Glaciomarine deltas of Maine and their relation to late Pleistocene-Holocene crustal movements, *in* Anderson, W. A., and Borns, H. W., Jr. (editors), Neotectonics of Maine: Studies in seismicity, crustal-warping, and sea-level change: Maine Geological Survey, Bulletin 40, p. 43-67.

Weddle, T. K., 1997, Surficial geology of the Lisbon Falls South 7.5-minute quadrangle, Androscoggin, Cumberland, and Sagadahoc Counties, Maine: Maine Geological Survey Open-File Report 97-64, 12 p.

Weddle, T. K., Koteff, C., Thompson, W. B., Retelle, M. J., and Marvinney, C. L., 1993, The late-glacial marine invasion of coastal central New England (northeastern Massachusetts-southwestern Maine): Its ups and downs, *in* Cheney, J. T., and Hepburn, J. C. (editors), Field trip guidebook for the northeastern United States: 1993 Boston GSA: University of Massachusetts, Department of Geology and Geography, Amherst, MA, Contribution No. 67, p. I-1 to I-31.