DEPARTMENT OF CONSERVATION
Maine Geological Survey
Robert G. Marvinney, State Geologist

OPEN-FILE NO. 97-74

Title: *Surficial Geology of the Mousam Lake 7.5-minute Quadrangle, York County, Maine*

Author: *Andres Meglioli and Woodrow B. Thompson*

Date: *1997*

Financial Support: Funding for the preparation of this report was provided in part by the U.S. Geological Survey Cooperative Geological Mapping (COGEO-MAP) Program, Cooperative Agreement No. 14-08-0001-A0868.

Associated Maps: Surficial geology of the Mousam Lake quadrangle, Open-File 97-59
Surficial materials of the Mousam Lake quadrangle, Open-File 98-172

Contents: 6 p. report

Surficial Geology of the Mousam Lake 7.5-minute Quadrangle, York County, Maine

Andres Meglioli
Geraghty & Miller, Inc.
4853-Z East Euclid Ave.
Phoenix, Arizona 85044

Woodrow B. Thompson
Maine Geological Survey
22 State House Station
Augusta, Maine 04333-0022

INTRODUCTION

Mapping of the surficial geology of the Mousam Lake quadrangle was carried out during the summer of 1991, as part of the COGEOMAP program of the Maine Geological Survey and the U. S. Geological Survey. Field checking and updating of the maps was done in 1997. Two 1:24,000 maps were prepared: a surficial materials map (Meglioli and Thompson, 1998) which shows the thickness, texture, and composition of surficial materials at points where observations were made; and a surficial geologic map (Meglioli and Thompson, 1997) which shows the distribution of geologic units and features that can help to reconstruct the geologic history of the quadrangle. The surficial deposits mapped in the Mousam Lake quadrangle are described in this report.

PREVIOUS WORK

Surficial deposits in the Mousam Lake quadrangle were mapped at a scale of 1:62,500 by Smith (1977) based on reconnaissance-level field work and air photo interpretation. This information was used to prepare a surficial geologic map of the Newfield 15-minute quadrangle, and was incorporated in the Surficial Geologic Map of Maine (Thompson and Borns, 1985a). Mapping of adjacent quadrangles has been completed by Boothroyd (1997a,b - Great East Lake), Neil (1997a,b - Sanford), Meglioli (1999a,b - Waterboro), and Wilch (1999a,b - Limerick).

INVESTIGATION PROCEDURES

Field observations were made in numerous active and inactive gravel pits, building excavations, and road cuts throughout the quadrangle. Subsurface information was obtained through the use of hand augers and shovels, from an aquifer map of the study area (Lanctot and Tolman, 1985), and from test-boring logs provided by the Maine Department of Transportation. Bedrock outcrop areas, glacially streamlined hills, and ice-contact deposits (including deltas and esker ridges) were inferred partly from the analysis of air photos and topographic maps. The air photos also aided in the delineation of terrace scarps and contacts between map units.

The National Wetlands Inventory map of the Mousam Lake quadrangle, prepared by the U.S. Dept. of the Interior - Fish and Wildlife Service (1992), provided the basis for many of the wetland boundaries shown on the geologic map. Much useful information on the distribution of surficial materials and bedrock outcrops in areas of poor access was obtained from the York County soil maps by Flewelling and Lisante (1982).

LOCATION AND TOPOGRAPHY

The study area is the Mousam Lake 7.5-minute quadrangle, located in York County, southwestern Maine (Figure 1). The Mousam Lake quadrangle extends in latitude from 43° 30' to 43° 37' 30" N, and in longitude from 70° 45' to 70° 52' 30" W. It cov-

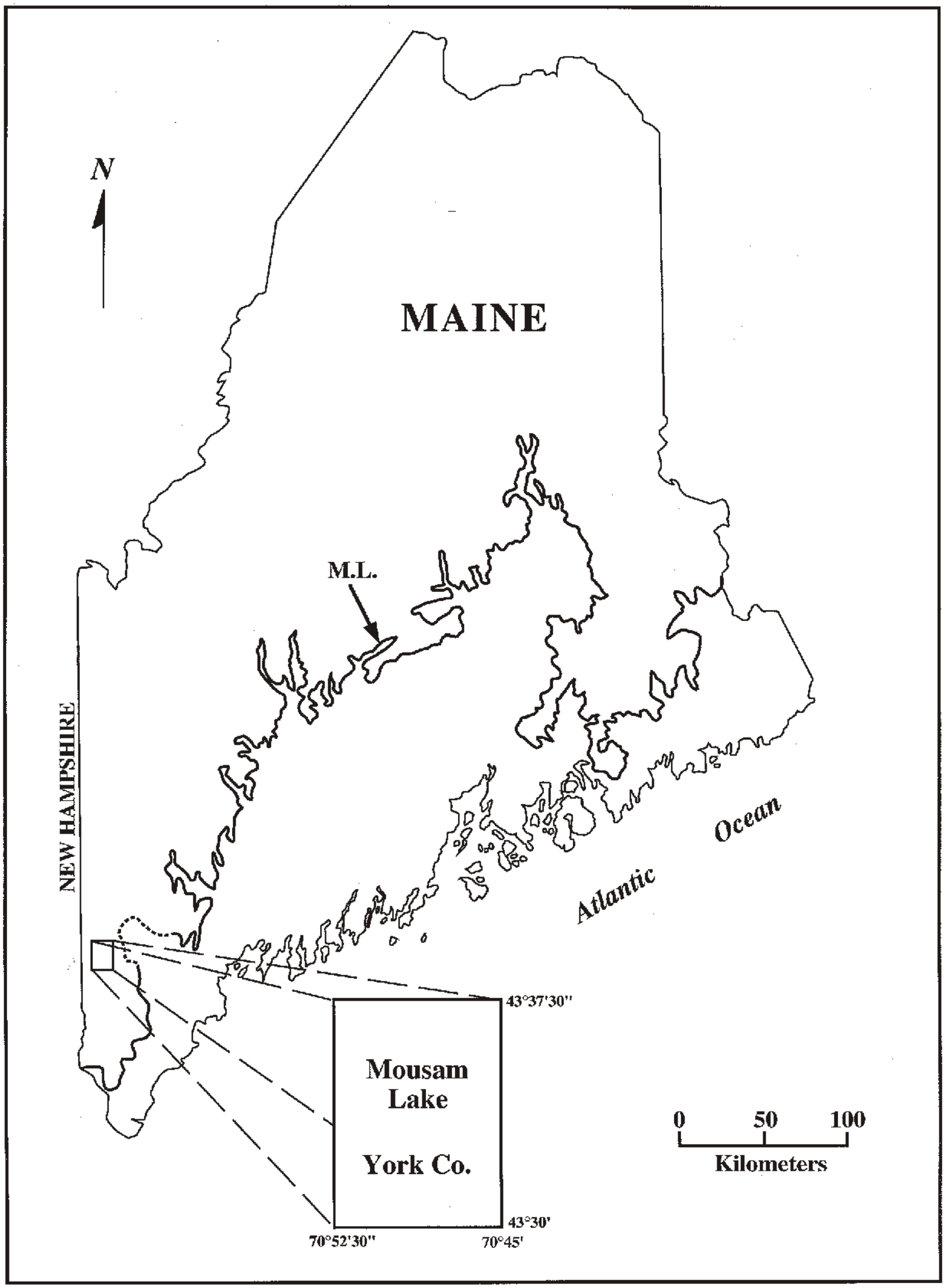

Figure 1. Location map of the Mousam Lake quadrangle, York County, Maine. Line marked M.L. indicates the limit of marine transgression.

ers an area of 54 square miles (approximately 142 square kilometers).

Elevations in the study area range from approximately 350 ft above sea level (asl) in the vicinity of North Alfred, in the southeast corner of the quadrangle, to 1,100 ft asl at Fort Ridge in the central portion of the study area. Most of the quadrangle is characterized by moderate and hilly topography. Maximum local relief is approximately 700 ft, between the summit of Fort Ridge Mountain and Middle Branch Pond in the eastern portion of the quadrangle. There are several glacially streamlined northwest-southeast trending bedrock and till ridges. Bedrock outcrops are scattered throughout the area, but they are particularly abundant in the central and southern parts of the quadrangle.

The southwestern corner of the quadrangle includes Mousam Lake. Surficial deposits around this lake are characterized by an abundance of sand and gravel forming flat-topped glacial-lake deltas and elongated esker ridges. Deltaic sand and gravel is also very abundant in the northern part of the quadrangle. In many places these deltas and related deposits are pockmarked by depressions (kettles) left by the melting of glacial ice remnants. The remainder of the quadrangle is dominated by a glacial till cover on the underlying bedrock.

The study area includes parts of two major river basins. The southern half of the area drains southward into the Mousam River, while the northern half of the quadrangle drains northward into the Little Ossipee River. The elevation of the drainage divide, an almost straight line from east to west, is about 650 ft asl. The network of rivers and streams draining to the north is better developed than its counterpart to the south. Erosion and sediment deposition by glacial ice has played a major role in shaping the drainage networks that we see today.

BEDROCK GEOLOGY

The distribution of the bedrock units in the Mousam Lake and neighboring quadrangles was mapped by Hussey (1985), and by Gilman (1972, 1991). Bedrock outcrops exposed in the study area include a variety of igneous and metamorphic rocks. Most of the quadrangle is underlain by stratified Silurian-Devonian rocks of the Shapleigh Group. Igneous lithologies are represented by biotite and two-mica granite and granodiorite of Mesozoic age. The rocks found in the area and their ages are:

Shapleigh Group (Hussey, 1968)

The Shapleigh Group is represented by a lower unnamed member at the base of the lower Rindgemere Formation. It is described as a thin, discontinuous quartz-feldspar-biotite and calc-silicate granofels. In several small outcrops throughout the study area, calc-silicate gneiss and marble, part of the lower member of the Rindgemere Formation, were also recognized.

Abbott Mountain Stock (Gilman, 1972, 1991)

The Abbott Mountain stock is an oval pluton occupying an area 2 x 3 km just east of the village of North Shapleigh. It is primarily composed of coarse-grained brownish-gray alkaline syenite. It has a reported K/Ar age of 221 8 Ma.

Unnamed Pluton

A small pluton in the southwestern part of the study area is composed of fine-grained, gray, foliated granodiorite to quartz diorite. It has been assigned to the New Hampshire plutonic series of Devonian to Carboniferous age (Gilman, 1991).

BEDROCK OUTCROPS

Bedrock outcrops are widely distributed in the Mousam Lake quadrangle. A few large individual outcrops are mapped as unit "rk," while small outcrops seen in the field are indicated by dots on the map. Many others (often too numerous to map individually) occur in the thin-drift areas designated by the ruled-line pattern. Some of these outcrops have been smoothed by glacial erosion, and they may show scratches (striations and grooves) produced by rock debris being dragged across ledge surfaces at the base of glacial ice.

Most of the mapped thin-drift areas occur in uplands where there is a thin, patchy cover of glacial till (unit Pt). The surficial sediments in these areas generally are less than 10 ft thick. In the field, the thin-drift areas are characterized by an abundance of bedrock outcrops. Often the underlying structure of the bedrock is distinguishable on air photos.

SURFICIAL DEPOSITS

The quadrangle is covered by a blanket of glacial, glaciolacustrine, and glaciofluvial sediments, which are mainly the products of the last glacial advance and retreat across the area during late Wisconsinan time, approximately 25,000 to 10,000 years ago. The composition and distribution of the units shown on the geologic map are described in the following paragraphs.

Till (units Pt, Phm)

Till consists of heterogeneous rock debris that was deposited directly from glacial ice. It is a mixture of clay to gravel-size sediment, locally with large boulders. Till occurs at the ground surface over much of the quadrangle, especially in the uplands, and probably underlies many of the other mapped surficial deposits. It is usually a poorly-sorted, weakly or non-stratified, loose, sandy, light olive-gray sediment.

Two kinds of genetically different till deposits were recognized in the study area. Lodgement till, consisting of gray, compact silty diamicton, was found in a few localities in the quadrangle. The more common type of till is loose to moderately

compact sandy-silty diamicton of light olive-gray to brownish-gray color. The morphology and sedimentary characteristics of the latter till (which commonly contains lenses of washed sand and gravel) suggest that it can be classified as an ablation deposit. Both types of till are included in map unit Pt.

Unit Phm includes areas of thick hummocky till deposits, which may be very bouldery and contain variable amounts of water-laid silt, sand, and gravel.

Glaciofluvial Deposits

Glaciofluvial sediments were deposited by glacial meltwater streams during the recession of the last ice sheet. In the Mousam Lake quadrangle, they include eskers (Pge), some otherwise unclassified ice-contact deposits (Pgi), and portions of deposits mapped by Boothroyd (1997a,b) as the Square Pond fans in the adjacent Great East Lake quadrangle.

Eskers (unit Pge). Elongate gravelly ridges in the study area were mapped as eskers. These ridges formed in tunnels within or beneath glacial ice, where there were fast-moving streams capable of transporting coarse gravel. A prominent esker system passes through the Mousam Lake valley in the western part of the quadrangle. This discontinuous series of esker ridges trends north-south. Its total length in the quadrangle is over 7 mi, and individual ridges stand as high as 65 ft above the surrounding terrain. A second esker system is located in the eastern part of the quadrangle, and can be traced discontinuously from Ross Corner southward for over 6 mi along the valley that contains the Middle Branch of the Mousam River.

A few exposures found in pits in the eskers revealed well-bedded gravel with variable percentages of sand. In general, gravel probably forms a large part of the esker deposits, but sand may be abundant locally. High-angle normal faults were observed in the flanks of the eskers. Collapse topography (kettles) and other ice-disintegration features are commonly present in the other glacial sediments adjacent to the eskers.

Ice-Contact Deposits (unit Pgi). This unit includes sand and gravel that was deposited on the sides or bottoms of valleys by glacial streams in close association with remnants of decaying ice. These deposits typically include coarse, poorly-sorted gravel, and show uneven surface topography. The principal occurrence of unit Pgi in the Mousam Lake quadrangle is along the Middle Branch of the Mousam River, in the southeastern part of the map area.

Square Pond Fan Deposits (units Pgfsp$_{1\text{-}2}$). The Square Pond fans were deposited in front of the glacier margin as it receded from the Square Pond basin in the Mousam Lake and adjacent Great East Lake quadrangles. They consist of sand and gravel that is probably quite thick in the area between Square Pond and Mousam Lake. Unit Pgfsp$_1$ shows many kettles that formed where ice blocks were buried by the rapid build-up of the fan and later melted out. The Square Pond fans may be partly deltaic; and the streams that deposited them ultimately discharged into glacial Lake Mousam and built the large irregular delta associated with the highest stage of this lake (unit Plmd$_1$, described below).

Glacial Lake Mousam Deposits (units Plmd$_{1\text{-}3}$)

Glaciolacustrine deltas were deposited into ice-dammed lakes that existed in the study area during deglaciation. These deltas have flat tops that were graded to the lake surfaces, but in places they exhibit very irregular topography with mounds, ridges, and depressions resulting from deposition in contact with remnant ice masses. Further irregularities have resulted from erosion by postglacial streams.

Though the deltas are composed largely of sand, exposures were found showing lenses of fine gravel interbedded with the sand. There is typically a gravel layer on delta tops, formed where glacial streams washed across them, but this gravel usually has been removed in pit areas. The sand beds within deltas dip in various directions, depending on local conditions when each delta built out into its associated lake.

The lacustrine deltas in the quadrangle were deposited into a succession of three closely related lakes that are collectively called “glacial Lake Mousam.” This series of lakes was impounded between the glacier margin to the north and topographic barriers to the south. As the ice retreated northward, new spillways were uncovered and the lake level changed. The evolution of glacial Lake Mousam is discussed below in the section on the glacial history of the quadrangle.

Undifferentiated Glaciolacustrine Deposits (unit Pl)

A small area of sand and minor gravel in the upper Buff Brook valley (northeast part of map) probably formed in a glacial lake when ice blocked the northern portion of the valley. The environment of deposition and relation to glacial Lake Mousam are not well understood, so these deposits are simply mapped as lake sediments (unit Pl).

Stream Terrace Deposits (unit Qst)

In late-glacial to early postglacial time, the modern drainage network became established as streams began to erode the previously deposited glacial sediments. Rivers and brooks cut downward and eventually reached their present levels. In some places this process has created terraces on the sides of valleys, resulting from the abandonment of earlier and higher flood plains. Some terraces may be strictly erosional, but usually there is a veneer of alluvial sand and gravel on their surfaces.

There is a conspicuous terrace system in the northwest corner of the Mousam Lake quadrangle, at elevations of about 460-480 ft, which formed as the Little Ossipee River cut down through the deltaic deposits of glacial Lake Mousam. A less extensive terrace was noted along the upper part of Davis Brook, likewise in the northwest portion of the quadrangle.

Eolian Deposits (unit Qe)

Eolian (windblown) sand deposits have been mapped on the east sides of the Buff Brook and Northwest Pond valleys in the northeastern part of the quadrangle. These deposits are presumed to have formed mainly during late-glacial time, where there was little vegetation cover on the freshly deglaciated landscape. The prevailing winds blew from west to east, as they do today, picking up sand from the surfaces of glacial lake deltas and blowing it onto the valley sides.

Eolian sand forms both mounds and ridges (dunes) and blanket deposits. The sand is generally well sorted and may show thin planar bedding. Wind-polished stones (ventifacts) commonly are associated with these sands. The areal distribution of eolian deposits is irregular and difficult to map in wooded areas where exposure is poor. Some of the small examples seen on till slopes were not shown on the geologic map, and it is likely that eolian sand is considerably more common than we have indicated.

Holocene Alluvium and Wetland Deposits (units Ha and Hw)

Alluvial deposits (unit Ha) were identified along several streams in the quadrangle. They have accumulated on the flood plains of modern brooks and rivers, and were derived from reworking of glacial sediments. Most of these deposits are fine-grained (silt and sand), but gravel and organic material may also be present. Wetlands have often developed on flood plains along low-gradient streams in the quadrangle, so the mapped boundaries between alluvial and wetland units are somewhat arbitrary.

Extensive Holocene wetland deposits (unit Hw) are present in the Mousam Lake quadrangle. They form in areas with poor drainage, and in the uplands are likely to be underlain by low-permeability till. Some of these wetland areas hold standing water during rainy periods or after snow melt, and thus change their aspect over the course of the year. Many of the wetland boundaries on the geologic map were derived from the wetlands inventory map for the Mousam Lake quadrangle, produced by the U. S. Fish and Wildlife Service (1992).

GLACIAL AND POSTGLACIAL HISTORY

Although it is almost certain that Maine was affected by more than one glaciation (Weddle and others, 1989; Thompson and Borns, 1985b), the deposits in the Mousam Lake quadrangle reflect only the most recent (late Wisconsinan) glacial episode. Interglacial erosion and weathering are probably responsible for the lack of evidence of earlier glaciation. The regional ice flow in late Wisconsinan time is interpreted to have ranged between southeast and south-southeast, as indicated by striations on bedrock (134-170^{o}) and the orientations of glacially streamlined hills. One bedrock outcrop showed a younger set of striations trending 187^{o}, which may indicate the southward shift in late-glacial ice flow recorded elsewhere in southwestern Maine.

Regional studies indicate that ice entirely covered the Gulf of Maine during the last glacial advance. Ice retreat began approximately 17,000 yr B.P., and although radiocarbon dates on the time of deglaciation are not available for the Mousam Lake quadrangle, dates obtained elsewhere in southwestern Maine show that the map area was ice-free by 13,000 yr B.P. (Smith, 1985; Thompson and Borns, 1985a) and perhaps as early as 14,000 yr B.P. (Weddle and others, 1993).

Stagnation occurred in the marginal zone of the retreating glacier, resulting in the formation of debris-covered ice remnants and great outpourings of sediment-laden meltwater. The Square Pond outwash fans, the glacial Lake Mousam delta complex, and other ice-contact sand and gravel deposits formed as the ice withdrew. Glacial Lake Mousam was initiated when meltwater was ponded between the ice margin and a topographic threshold at about 505 ft elevation in the northwestern part of the Sanford quadrangle. Unit $Plmd_1$ was deposited into this first stage of the lake.

When the ice margin stood in the Spicer Pond area (northwest part of quadrangle), a thick deposit of fan-delta sediments (unit $Plmd_2$) built into glacial Lake Mousam, reaching elevations of 560-580 ft. At this time, the lake may have been dammed by the earlier $Pgfsp_1$ and $Plmd_1$ sediments in the Square Pond-Goose Pond area. Water draining southward out of the lake cut a broad channel across these earlier deposits. The spillway channel has an elevation of about 525 ft and can be seen today where it crosses Route 11 east of Goose Pond.

The third stage of glacial Lake Mousam developed when further ice retreat allowed the lake to expand across the lowlands in the northern and northeastern parts of the quadrangle and drain though a spillway at about 440 ft in the vicinity of Middle Branch Pond. Unit $Plmd_3$ is a large fan-delta complex that built into the lake at this time. Meltwater streams filled the lake with sediments derived from both the Little Ossipee River valley to the west (Great East Lake quadrangle) and an ice-margin position north of Silver Lake in the adjacent Limerick quadrangle.

The segmented esker ridges are thought to have formed sequentially from south to north as the ice margin retreated. Subglacial streams flowed through tunnels in the glacier and carried sediments to the margin of the ice sheet, where they were deposited to form the deltas and other meltwater deposits described above. The ice tunnels progressively became filled with sand and gravel, forming the esker ridges that now remain.

Following deglaciation, wind action blew sand up onto the sides of some of the valleys in the Mousam Lake quadrangle. Gradual downcutting of stream valleys has occurred in postglacial time, with erosion of the older glacial sediments and deposition of alluvium on flood plains. Wetlands have formed in areas that are poorly drained and have a high water table. Modification of the landscape by human activity is very localized, mainly in the form of gravel pit excavations and areas where fill has been dumped.

ACKNOWLEDGMENTS

Support for field work was provided by the Maine Geological Survey and U. S. Geological Survey through the COGEOMAP cooperative mapping program. Field discussions with Tom Weddle (Maine Geological Survey), Carl Koteff (U. S. Geological Survey), and Jon Boothroyd (University of Rhode Island) were most beneficial and greatly helped in the interpretation of the surficial geology of the study area.

REFERENCES CITED

Boothroyd, J. C., 1997a, Surficial geology of the Great East Lake quadrangle, Maine: Maine Geological Survey, Open-File Map 97-46.

Boothroyd, J. C., 1997b, Surficial geology of the Great East Lake 7.5-minute quadrangle, York County, Maine: Maine Geological Survey, Open-File Report 97-61, 9 p.

Flewelling, L. R., and Lisante, R. H., 1982, Soil survey of York County, Maine: U. S. Dept. of Agriculture - Soil Conservation Service report, 143 p. and maps.

Gilman, R. A., 1972, Mesozoic plutonic-volcanic rocks of the Newfield quadrangle, Maine: Maine Geological Survey, Open-File Report 72-1, 16 p.

Gilman, R. A., 1991, Bedrock geology of the Newfield 15' quadrangle, Maine-New Hampshire: Maine Geological Survey, Open-File No. 91-2, 10 p. and map.

Hussey, A. M, 1968, Stratigraphy and structure of southwestern Maine, *in* Zen, E-an, White, W. S., Hadley, J. B., and Thompson, J. B., Jr. (editors), Studies of Appalachian geology: northern and maritime: Interscience Publishers, New York, p. 291-301.

Hussey, A. M., II., 1985, The bedrock geology of the Bath and Portland 2-degree map sheets, Maine: Maine Geological Survey, Open-File Report 85-87, 82 p.

Lanctot, E. M., and Tolman, A. L., 1985, Hydrogeologic data for significant sand and gravel aquifers in part of York County, Maine - Map 3: Maine Geological Survey, 1:50,000-scale map.

Meglioli, A., 1999a, Surficial geology of the Waterboro quadrangle, Maine: Maine Geological Survey, Open-File Map 99-103.

Meglioli, A., 1999b, Surficial geology of the Waterboro 7.5-minute quadrangle, York County, Maine: Maine Geological Survey, Open-File Report 99-134, 7 p.

Meglioli, A., and Thompson, W. B., 1997, Surficial geology of the Mousam Lake quadrangle, Maine: Maine Geological Survey, Open-File Map 97-59.

Meglioli, A., and Thompson, W. B., 1998, Surficial materials of the Mousam Lake quadrangle, Maine: Maine Geological Survey, Open-File Map 98-172.

Neil, C. D., 1997a, Surficial geology of the Sanford quadrangle, Maine: Maine Geological Survey, Open-File Map 97-55.

Neil, C. D., 1997b, Surficial geology of the Sanford 7.5-minute quadrangle, York County, Maine: Maine Geological Survey, Open-File Report 97-70, 9 p.

Smith, G. W., 1977, Reconnaissance surficial geologic map of the Newfield quadrangle, Maine: Maine Geological Survey, Open-File Map 77-15.

Smith, G. W., 1982, End moraines and the pattern of the last ice retreat from central and southern Maine, *in* Larson, G. J., and Stone, B. D. (editors), Late Wisconsinan glaciation of New England: Kendall Hunt, Dubuque, Iowa, p. 195-210.

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 of America, Special Paper 197, p. 29-44.

Thompson, W. B., and Borns, H. W., Jr., 1985a, Surficial geological map of Maine: Maine Geological Survey, 1:500,000-scale map.

Thompson, W. B., and Borns, H. W., Jr., 1985b, Till stratigraphy and Late Wisconsinan deglaciation of southern Maine: a review: Geographie Physique et Quaternaire, v. 39, no. 2, p. 199-214.

U. S. Dept. of the Interior - Fish and Wildlife Service, 1992, National wetlands inventory map - Mousam Lake quadrangle, 1:24,000-scale map.

Weddle, T. K., Stone, B. D., Thompson, W. B., Retelle, M. J., Caldwell, D. W., and Clinch, J. M., 1989, Illinoian and late Wisconsinan tills in eastern New England: A transect from northeastern Massachusetts to west-central Maine, *in* Berry, A. W., Jr. (editor), Guidebook for field trips in southern and west-central Maine: New England Intercollegiate Geological Conference, 81st annual meeting, University of Maine at Farmington, Farmington, Maine, p. 25-85.

Weddle T. K., Koteff, C., Thompson, W. B., Retelle, M. J., and Marvinney, C. L., 1993, The late-glacial marine invasions of coastal central New England (northeastern Massachusetts-southwestern Maine): its ups and downs: Field Trip I, *in* Cheney, J. T., and Hepburn J. C. (editors), Field trip guidebook for the Northeastern United States: Geological Society of America, 1993 Annual Meeting, Boston, Massachusetts, p. I-1 to I-31.

Wilch, T., 1999a, Surficial geology of the Limerick quadrangle, Maine: Maine Geological Survey, Open-File Map 99-89.

Wilch, T., 1999b, Surficial geology of the Limerick 7.5-minute quadrangle, York County, Maine: Maine Geological Survey, Open-File Report 99-120, 7 p.