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Title: *Surficial Geology of the Bowdoinham 7.5-minute Quadrangle, Sagadahoc and Kennebec Counties, Maine*

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Surficial materials of the Bowdoinham quadrangle, Open-File 03-53

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Surficial Geology of the Bowdoinham 7.5-Minute Quadrangle, Sagadahoc and Kennebec Counties, Maine

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INTRODUCTION

This report describes the surficial geology and Quaternary history of the Bowdoinham 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 (Thompson, 2001).

The field work for this study was carried out in 2002 for the STATEMAP cooperative between the Maine Geological Survey and the U.S. Geological Survey (USGS). Two maps are associated with this report. The *geologic map* (Hildreth, 2003a) 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* (Locke and Hildreth, 2003) shows specific data used to help construct the 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 Bowdoinham 7.5-minute quadrangle has an area of about 133 km^2 (52 mi^2). It is located in southwestern Maine, on the inland edge of the Seaboard Lowland physiographic province, about 48 km (30 mi) north-northeast of Portland (Figure 1). It includes parts of the towns of Bowdoin, Bowdoinham, Litchfield, and Richmond. Altitudes range from sea level, where tidewater parts of the Cathance River flow southward at the southeast corner of the quadrangle, to 177 m (581 ft) near the northwest corner of the quadrangle. Thus, maximum relief is 177 m (581 feet).

Many ridges in the Bowdoinham quadrangle were shaped by glacial ice flowing south-southeast to southeast and have been elongated in that direction. The topography in the study area, especially that of stream valleys, is also controlled by structures in the underlying bedrock.

The central part of the quadrangle is drained southward by East and West Cathance Streams and their tributaries. The tidewater Cathance River flows southeastward from the southeast corner of the quadrangle to enter Merrymeeting Bay less than a mile south of the quadrangle border. The eastern part of the quadrangle drains southward via Sedgely Brook and Denham Stream into the West Branch, thence into the Cathance River at tidewater at the southeast corner of the map area. The western edge of the map area drains west via Gillespie Brook and an unnamed brook near the southwest edge of the map into the south-flowing Little River, which joins the Androscoggin River in the Lisbon Falls South quadrangle southwest of the Bowdoinham quadrangle. The northwestern part of the map area drains northward into the headwaters of the Tacoma Lakes in the Purgatory quadrangle. The northeastern part of the area drains northward into the headwaters of Pleasant Pond in the Purgatory quadrangle.

Bedrock geology

The quadrangle is nearly bisected, from southwest to northeast, by the western edge of the Norumbega fault zone, which trends northeast in the quadrangle. The large northerly

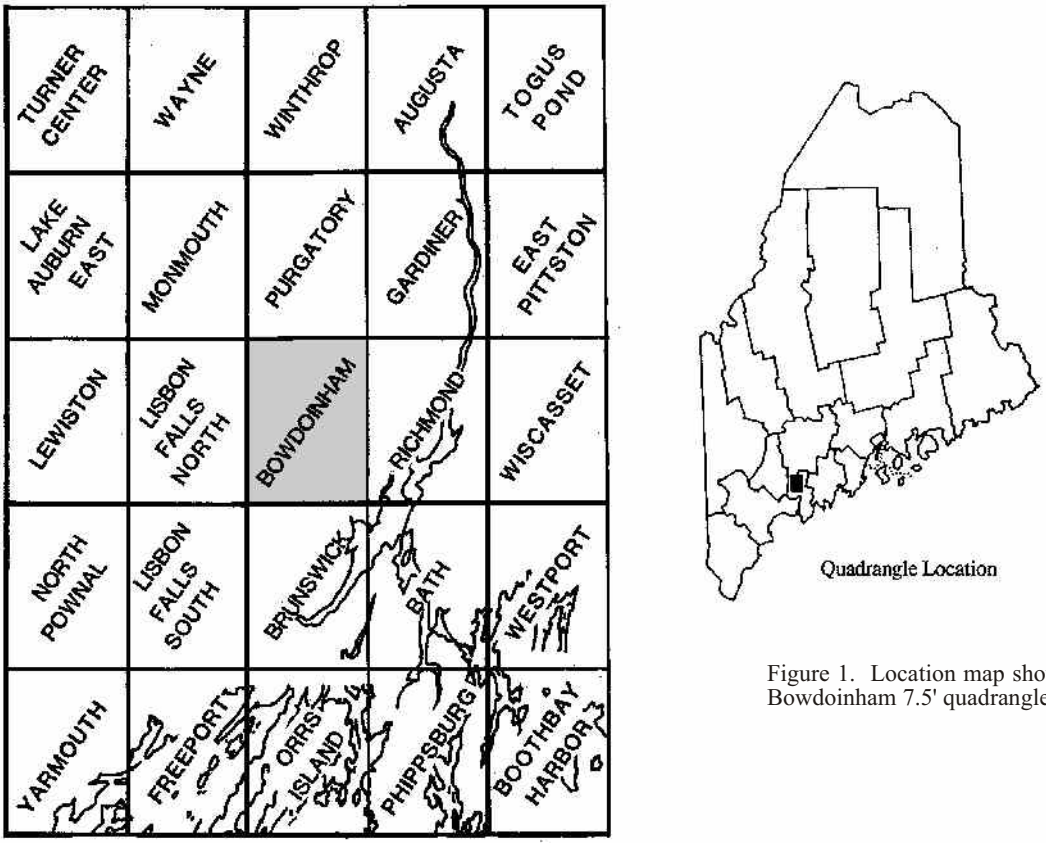

Figure 1. Location map showing the Bowdoinham 7.5' quadrangle.

elongated swamp in the northeastern part of the map is underlain by the weakly resistant rocks of the western edge of the Norumbega fault zone, as are the valleys of the West and East Cathance Streams in the southwest part of the map area. The late Precambrian-early Paleozoic Cushing Formation lies within the fault zone and occupies nearly all the southeast part of the quadrangle; here, it contains several thin members, including a relatively easily weathered limestone member that underlies Denham Stream, the West Branch, and the main stem of the Cathance River southeast of their juncture. Northwest of the Norumbega fault zone, the map area is underlain by folded, north-northeast-trending, high-grade metasedimentary rocks of the Silurian-Ordovician Vassalboro Formation (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 and Smith, 1977; Thompson and Borns, 1985). The soil surveys of Androscoggin and Sagadahoc Counties (McEwen, 1970) and Kennebec County (Faust and LaFlamme, 1978), and the recent surficial materials map (Locke, 1999), all facilitated fieldwork. Surficial geologic mapping has been completed at the 1:24,000 scale in several adjoining quadrangles, including Lisbon Falls North (Weddle and others, 1999), Lisbon Falls South (Weddle, 1997a), Brunswick (Weddle, 2001), and Monmouth (Foley, 2002). In addition, mapping at this scale is underway in the Purgatory quadrangle (Hildreth, 2003b).

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 Bowdoinham 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. Two locations contained more than one set of striations; the southeast set was the older and the south-southeast set the younger. 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 Bowdoinham area there are few, if any, true drumlins. However, several streamlined hills that have bedrock cores are elongated in a southeast- to south-trending direction. Examples are in the northwest and east parts of the map area. In addition, in the northeast and east-central part of the quadrangle, there are a number of narrow, shallow, parallel ridges that trend southeast, which are herein inferred to be grooved till surfaces that were carved by flow of glacial ice.

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 (southwest of Bowdoinham) have a radiocarbon age of 14,045 yr B.P. (Weddle and others, 1993). The ice sheet terminus is inferred to have reached the Bowdoinham area about the same time or 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 Bowdoinham quadrangle lying below a current elevation of approximately 350 ft above sea level, which is at the limit of maximum marine submergence for this part of Maine. 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 84+ km (40+ mi) southwest of the Bowdoinham quadrangle.

In his report on the Lisbon Falls South quadrangle, Weddle (1997b, p. 8) states: "An uncorrected 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 adjacent 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, just south of Bowdoinham, 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 *Portlandia arctica* shells found in Presumpscot Formation mud approximately one meter below the nearshore deposits containing the interidal fauna supports the older offlap dates."

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

GLACIAL AND POSTGLACIAL DEPOSITS

As the ice sheet melted in the Bowdoinham area, it dropped much of the debris incorporated within it in the form of till. At the same time and somewhat later, 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, Quaternary, and Holocene) are characterized on that basis. A few deposits are distinguished by the agent of deposition, such as till (Pt), for which glacial ice is the agent of deposition, and eolian deposits (Pe) for which wind is the agent. Postglacial deposits include materials laid down since the glacier melted north of the Bowdoinham area and sea level dropped well below the surfaces it had covered here. They include materials mapped as Quaternary in age: that may have been continuously deposited since the recession of the sea; that may have been deposited during a time that spanned the Pleistocene and Holocene; or that may have been deposited in either Pleistocene or Holocene time. Holocene deposits are commonly referred to as recent or modern deposits; they were laid down within the last 10,000 years and most are still in the process of deposition.

The succession of Pleistocene and Holocene surficial deposits in the Bowdoinham area is given in the correlation chart (Figure 2), showing the relative ages of the map units.

Till (unit Pt)

Till occurs throughout the Bowdoinham 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

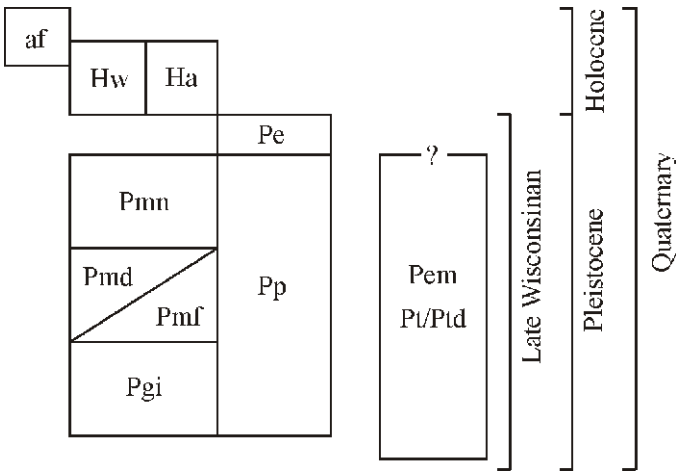

Figure 2. Correlation of map units, Bowdoinham quadrangle, Maine.

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.

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. Though most till is less than 6 meters (20 ft) thick in the area, several wells in the southern part of the map area penetrated at least 18 meters (60 feet) of probable till.

End moraines (unit Pem)

End moraines are ridges consisting of stratified sand and gravel, which may be interbedded with, or overlain by, Presumpscot Formation silty clay. These ridges were deposited along the margin of the last glacial ice sheet during its northward retreat from the map area. In some places the sand and gravel in the ice-proximal sides of the moraines is interlayered with till. One group of moraines has been assigned a unique geographic name, the Ridge Road moraines (1-2).

Undifferentiated ice-contact deposits (unit Pgi)

Small isolated areas of thin glacial outwash and ice-contact deposits consisting of sand, gravel, and silt were identified in the west part of the quadrangle. These may include esker or glaciomarine fan deposits. These deposits are useful as a source of sand and gravel.

Marine delta deposits (unit Pmd)

Unit Pmd consists of sand and gravel deposited into the sea at the glacier margin and built up to the ocean surface. The resulting deltas have flat tops whose elevations approximate the level of the sea when they were formed. One small area in the west-central part of the quadrangle is inferred to be a delta, based on the presence of glacial sand and gravel whose flat upper surface is graded to an elevation of 300-310 ft.

Glaciomarine fan deposits (unit Pmf)

Unit Pmf is composed of sand and gravel deposited as a submarine fan at the glacier margin. A single Pmf deposit was mapped in the southwestern part of the quadrangle. Unit Pmf locally is overlain by sediments reworked by marine nearshore processes during regression of the sea. These nearshore deposits have been distinguished as a separate map unit (Pmn) in several areas of the Bowdoinham quadrangle, and it is likely that they conceal additional Pmf sediments at depth.

Glaciomarine bottom deposits (Presumpscot Formation) (unit Pp)

Materials consisting of predominantly silt and clay with locally sandy beds and intercalations 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 310-foot contour - and may underlie units Ha, Hw, Pe, and Pmn in the quadrangle. Subsurface data and exposures indicate that Pp overlies Pt, bedrock, fans and end moraines and can be interbedded with subaqueous outwash materials. It is more than 70 ft (21 m) thick in one test hole in downtown Bowdoinham (Locke,1999), but is generally much thinner. In places throughout the map area, Pp is overlain by thin unmapped dune deposits.

Marine nearshore deposits (unit Pmn)

Unit Pmn consists of waterlaid sediments that range from clay to gravel and 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 various glaciomarine deposits such as units Pp and Pmf.

Eolian deposits (unit Pe)

When sea level fell and exposed the glacial outwash and marine regressive deposits, wind erosion was extensive before vegetation was able to take root and anchor the sediments. As a result, deposits of eolian (windblown) sand dunes were formed. Only one Pe deposit is shown on the map, but eolian sand probably is more extensive than indicated here. Many dune deposits in southern Maine are thin and patchy and thus not easily recognized unless they happen to be exposed in excavations. Further detailed investigation of these dune deposits is needed to decipher their complex distribution and history.

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 Bowdoinham 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 are 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).

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