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Surficial materials of the Purgatory quadrangle, Open-File 03-59

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

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INTRODUCTION

This report describes the surficial geology and Quaternary history of the Purgatory 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 fieldwork 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, 2003b) 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 Purgatory 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 80 km (50 mi) north-northeast of Portland (Figure 1). It includes parts of the towns of Monmouth, Wales, West Gardiner, Litchfield, and Richmond. Altitudes range from about 135 feet (41 meters) above sea level (asl), where Cobbosseecontee Stream and Pleasant Pond flow eastward in the southeast part the quadrangle, to 166 m (553 ft) at Springer Hill near the southwest central part of the quadrangle. Thus, maximum relief is 125 m (418 feet).

Many hills in the Purgatory quadrangle were shaped by glacial ice flowing south-southeast to southeast and have been elongated in that direction. The major features of the topography in the study area, however, especially stream valleys, are controlled by structures in the underlying bedrock. The bedrock consists primarily of north-northeast-trending, folded, steeply dipping, metasedimentary rocks of varying resistance to weathering and erosion, resulting in alternating ridges and valleys with that orientation.

Jock Stream flows northeast from the central west edge of the quadrangle, on the north side of Oak Hill, into the headwaters of Cobbosseecontee Lake, which is dammed to the north, in the southeast part of the Winthrop quadrangle. Cobbosseecontee Stream thence flows south to the central east edge of the Purgatory quadrangle and flows into Pleasant Pond less than a mile east of the quadrangle border. The Tacoma Lakes drain northeast on the south side of Oak Hill, controlled by a dam near Purgatory village, from which the outlet stream meanders northeast less than a mile to the south-flowing Cobbosseecontee Stream. Jug Stream on the northwestern edge of the map drains Annabessacook Lake, which lies just north of the quadrangle, southward into Cobbosseecontee Lake. The south and east parts of the Purgatory quadrangle drain southeast into Pleasant Lake via Potters Brook and its tributaries. Magotty Meadow Brook drains the south-central part of the quadrangle southward and thence eastward into the swampy northward-flowing headwaters of Pleasant Pond in the Bowdoinham quadrangle. Pleasant Pond drains to the Kennebec River in the Gardiner quadrangle.

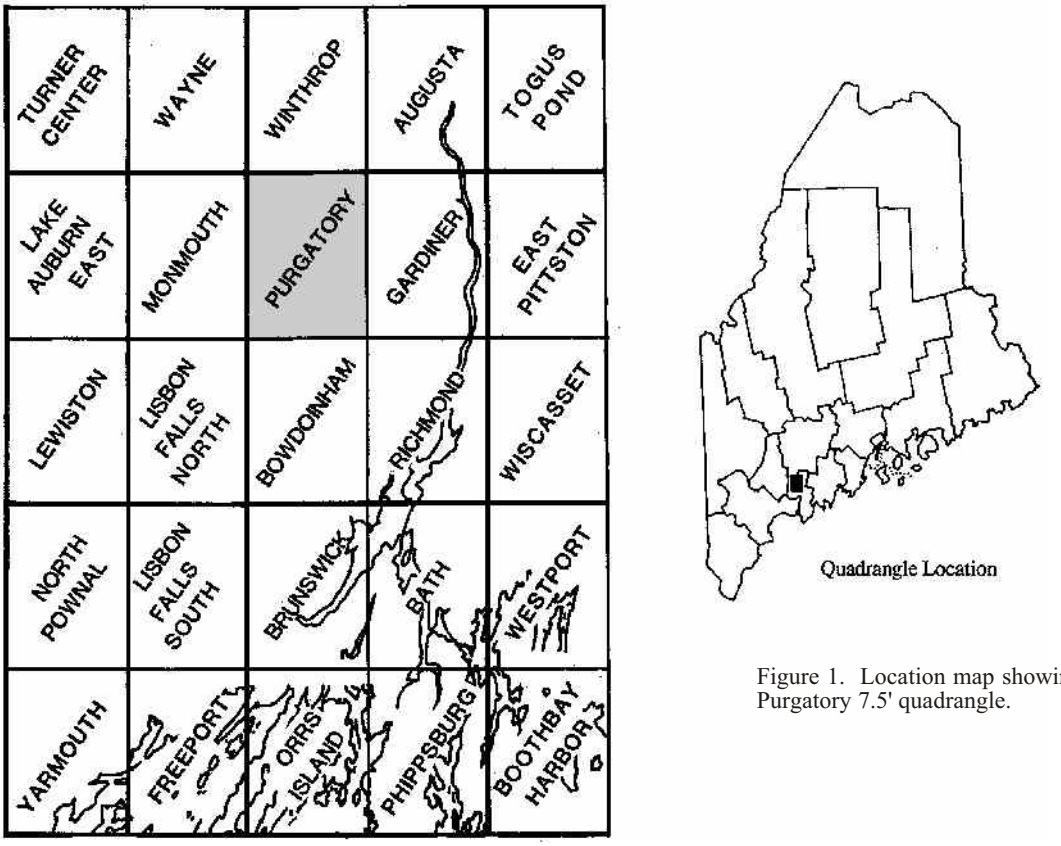

Figure 1. Location map showing the Purgatory 7.5' quadrangle.

Bedrock geology

The northwest part of the quadrangle is underlain by steeply dipping, north-northeast-trending, metasedimentary rocks of the Silurian Sangerville and Waterville Formations. Many of the lakes occupy depressions developed along weak limestone units in the Waterville Formation. The southeast part of the quadrangle is mostly underlain by folded, north-northeast-trending, high-grade metasedimentary rocks of the Silurian-Ordovician Vassalboro Formation. In the southeast corner of the quadrangle, Pleasant Pond is underlain by the weakly resistant rocks of the western edge of the NNE-trending Norumbega fault zone. The late Precambrian-early Paleozoic Cushing Formation lies within the fault zone and occupies the southeastern-most part of the quadrangle (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 has been completed in the Bowdoinham quadrangle (Hildreth, 2003a).

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 Purgatory 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 Purgatory area there are few, if any, true drumlins. However, several glacially streamlined hills that have bedrock

cores are elongated in a southeast- to south-trending direction. Examples are scattered throughout the map area. In addition, in the southeastern part of the quadrangle, there are a number of narrow, low, parallel ridges that trend southeast, which are herein inferred to be grooved till surfaces that were carved by the flow of glacial ice parallel to their long axes (and they may be related to structures in the underlying bedrock as they are apparent only in the area underlain by the Cushing Formation; further detailed investigations of these landforms may clarify their origin).

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 Purgatory) have a radiocarbon age of 14,045 yr B.P. (Weddle and others, 1993). The ice sheet terminus is inferred to have reached the Purgatory area by about that 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 Purgatory 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 80+ km (50+ mi) southwest of the Purgatory 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 (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 intertidal 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 Purgatory 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 Jock, Cobbosseecontee, and other 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 deposits (Pe) in the area, most of which are too thin to map.

GLACIAL AND POSTGLACIAL DEPOSITS

As the ice sheet melted in the Purgatory 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 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 Purgatory area and sea level dropped well below the surfaces it had covered here. They include materials 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 Purgatory area is given in the correlation chart (Figure 2), showing the relative ages of the map units.

Till (unit Pt)

Till occurs throughout the Purgatory 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 bed-

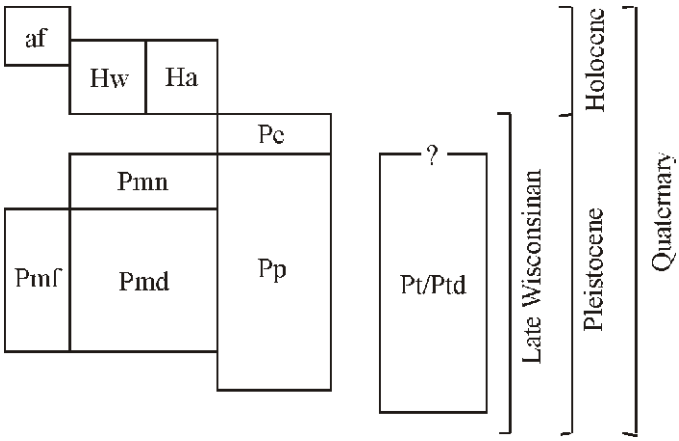

Figure 2. Correlation of map units, Purgatory quadrangle, Maine.

rock; 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.

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 map area penetrated at least 18 meters (60 feet) of probable till, and one in the southeast part of the map penetrated 110 feet of inferred till. Some of the areas mapped as thin glacial drift (Ptd), where generally less than 3 meters (10 feet) of materials overly bedrock, are composed of till, especially on hill slopes and ridge crests within the area. In places, very low ridges cored by till are inferred to be moraines that were deposited and/or deformed by active glacial ice; they are mapped as moraine ridges, whose long axes are inferred to be perpendicular to the direction of ice movement; the ridges are commonly mantled by Presumpscot Formation (Pp). Another till landform in the southeast part of the area is mapped as grooved till surface; the SSE long axes of the grooves and ridges are inferred to have been carved into the till surface by the ice as it flowed over the area.

Marine delta deposits (unit Pmd)

Unit Pmd consists of sorted and stratified sand and gravel deposited by glacial meltwater in contact with, or downstream from, adjacent ice, and graded to the late-glacial sea. They are distinguished primarily by their composition, flat tops, and foreset and topset beds (often seen in gravel pits). The topset beds were deposited by streams flowing across the delta tops. They generally form a horizontal gravelly layer on top of the inclined foreset beds, which were deposited as sediments cascaded down the advancing delta front. The contact between topset and foreset beds in each delta closely approximates the position of sea level when the delta was built.

Two delta deposits in the Purgatory quadrangle have been assigned unique geographic names. The Litchfield Plains delta (Pmdlp) has a topset-foreset contact elevation of 308 feet (Thompson and others, 1989). The Grant Cemetery delta (Pmdgc) lies just to the northeast of Pmdlp and is inferred to be contemporaneous as indicated by the ice-margin position on the map (Hildreth, 2003b).

Glaciomarine fan deposits (unit Pmf)

Unit Pmf is composed of stratified sand and gravel deposited as submarine fans at the glacier margin. Pmf deposits occur in the Jimmy Pond and Cobbossecontee Stream valleys, as well as the northwest corner of the quadrangle. In some places the upper portions of the fans have been reworked by marine nearshore processes during regression of the sea.

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 sea-floor 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, Pmd 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 or equal to 15 ft (5 m) thick in one dug well in the northwestern part of the quadrangle (Locke, 1999) and is probably 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. They formed as relative sea level fell during uplift of the land in late-glacial time. Pmn deposits are thin (commonly less than 10 feet [3 m] thick) and generally overlie till or high-level marine bottom deposits.

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, dune deposits consisting of eolian (windblown) sand were formed. Only one Pe deposit is shown on the map (adjacent to the Litchfield Plains delta), 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 Purgatory 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 de-

posits (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 does not exceed 20 ft (6 m).

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