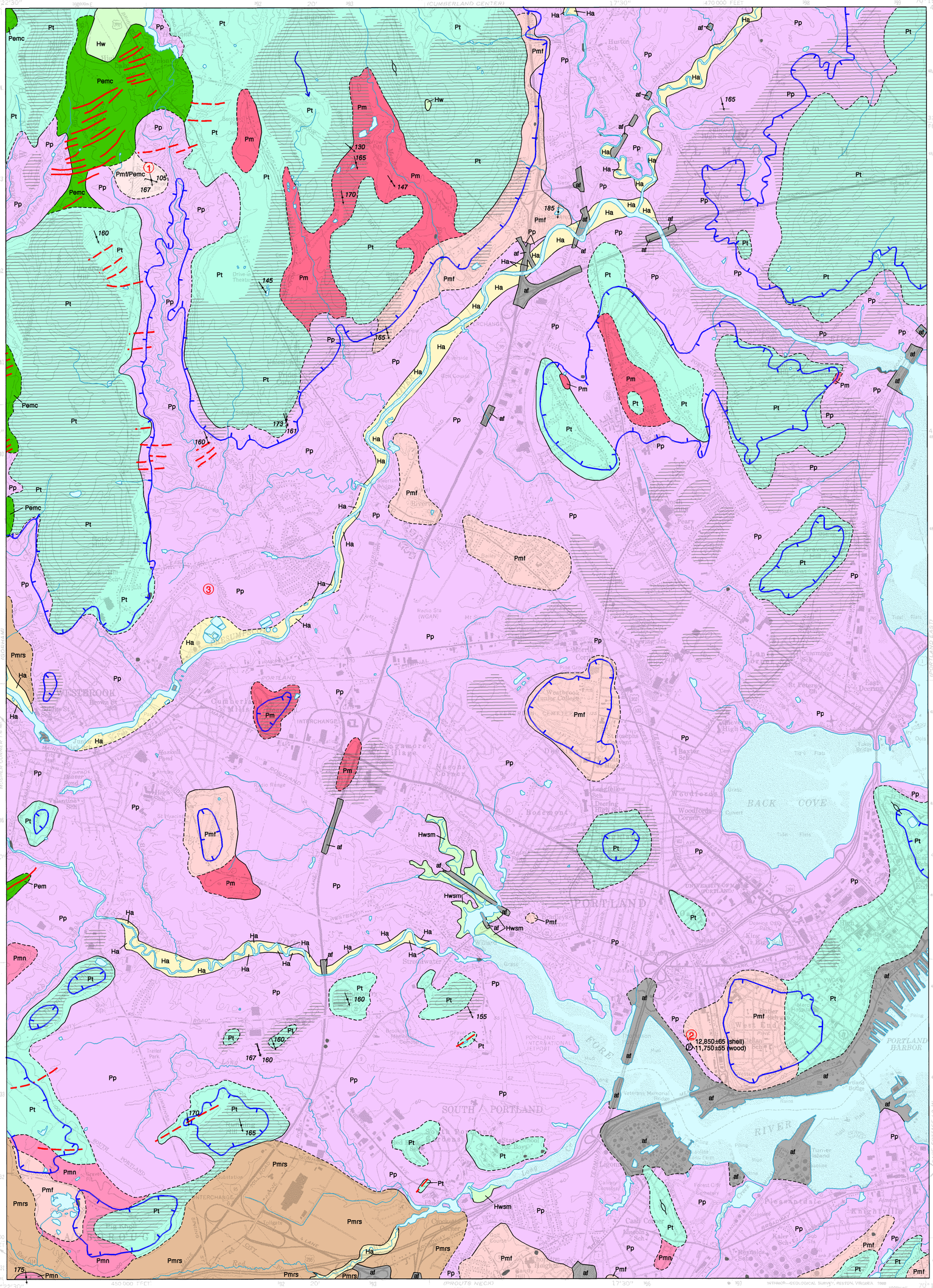
Surficial Geology



SOURCES OF INFORMATION

Surficial geologic and materials mapping by Woodrow B. Thompson completed during the 1976 and 1994 field seasons; funding for this work provided by the Maine Geological Survey. J. Michael Clinch conducted additional surficial materials field work during the 1988 field season, funded by the U.S. Geological Survey COGEOMAP program. Modified in 2008 based on 2007 field work by Woodrow B. Thompson.

Quadrangle Location

SCALE 1 : 24,000

CONTOUR INTERVAL 20 FEET

TRUE NORTH

Topographic base from U.S. Geological Survey Portland West quadrangle, scale 1:24,000 using standard U.S. Geological Survey topographic map symbols.

The use of industry, firm, or local government names on this map is for location purposes only and does not imply responsibility for any present or potential effects on the natural resources.

Note: The first letter of each map unit indicates the general age of the unit:
H = Holocene (postglacial deposit; formed during the last 10,000 years).
Q = Quaternary (deposit of uncertain age, but usually late-glacial and/or postglacial).
P = Pleistocene (deposit formed during glacial to late-glacial time, prior to 10,000 yr B. P. [years before present]).

Ha — **Stream alluvium** - Sand, silt, gravel, and organic material. Deposited on flood plains of modern streams.

Hwsm — **Salt marsh deposits** - Salt-marsh peat, muck, and fine-grained sediments deposited along tidal inlets.

Hw — **Wetland deposits** - Peat, muck, and/or fine-grained sediments deposited in poorly drained (wetland) areas. Variable tree cover may be present.

Pmrs — **Marine regressive sand deposits** - Sand, silt, and minor gravel deposited in shallow marine waters during late-glacial regression of the sea. May include a variety of nearshore and fluvial sediments. Commonly occurs as flat sandy areas and is likely to be underlain by marine clay-silt of the Presumpscot Formation.

Pmn — **Marine nearshore deposits** - Sand, gravel, and minor silt. Formed by wave and current action in shoreline and shallow nearshore environments, usually during regressive phase of late-glacial marine submergence in Maine's coastal lowland.

Pm — **Marine deposits, undifferentiated** - Poorly exposed sand and gravel of uncertain origin, thought to have been deposited in the sea during late-glacial time. May include deltaic, submarine fan, shoreline, and/or nearshore deposits.

Pmf — **Marine fan deposit** - Sand and gravel deposited on the sea floor at the glacier margin during the late-glacial marine submergence.

Pp — **Presumpscot Formation** - Silt, clay, and minor sand deposited on the sea floor during the late-glacial marine submergence.

Pem — **End moraine** - Ridge of till and/or sand and gravel deposited at the glacier margin during recession of the last ice sheet.

Pemc — **End moraine complex** - Cluster of closely spaced end moraines deposited at the receding margin of the last glacial ice sheet. Composed of till and/or sand and gravel. Locally includes ice-marginal submarine fan deposits.

Pt — **Till** - Loose to very compact, poorly sorted, mostly nonstratified mixture of sand, silt, and gravel-size rock debris deposited directly from glacial ice. Locally contains lenses of water-laid sediment.

Bedrock - Gray areas are individual outcrops. Ruled pattern indicates areas where outcrops are common and/or surficial sediments are generally less than 10 ft thick.

af — **Artificial fill** - Variable mixtures of surficial sediments, rock fragments, and artificial materials, transported and dumped to build up roads, waterfronts, etc.

Contact - Boundary between map units. Dashed where very approximate.

End moraine - Line shows axis of end-moraine ridge. Dashed where inferred or approximately located, especially in areas where moraines are overlain by younger sediments.

Glacially streamlined hill - Symbol shows trend of long axis of hill, which parallels former ice-flow direction.

135 **Glacial striation locality** - Arrows show ice-flow directions (with azimuths in degrees) inferred from striations (scratches on bedrock caused by glacial abrasion). Dot marks point of observation. Flagged trend is older.

Meltwater channel - Channel eroded by glacial meltwater. Arrow shows inferred direction of former stream flow.

12,850±65 (shell) 11,750±55 (wood) Ⓟ **Fossil locality** - Fossil locality in marine sediments at Mercy Hospital site, with examples of contrasting radiocarbon ages of closely associated spruce wood and marine shells. Ages are in years before present as reported by the National Ocean Sciences Accelerator Mass Spectrometry Facility, Woods Hole, Massachusetts. The discrepancy between marine and terrestrial ages resulted from the shells incorporating older carbon from seawater (marine reservoir effect).

④ **Photo locality** - Location of photographed site shown and described in map legend.

Approximate ocean shoreline when spruce logs were deposited on the sea floor in Portland. Hachures point toward higher ground. This sea level (+120 ft) is estimated from the radiocarbon ages of marine shells associated with the logs (Thompson and others, 2008), and the relative sea-level curve derived from shell ages in the Portland-Lewiston region (Retelle and Weddle, 2001). The highest sea level in Portland (about 270 ft) occurred immediately after deglaciation. The land rose when the weight of the ice sheet was removed, causing the shoreline to recede.

USES OF SURFICIAL GEOLOGY MAPS

A surficial geology map shows all the loose materials such as till (commonly called hardpan), sand and gravel, or clay, which overlie solid ledge (bedrock). Bedrock outcrops and areas of abundant bedrock outcrops are shown on the map, but varieties of the bedrock are not distinguished (refer to bedrock geology map). Most of the surficial materials are deposits formed by glacial and deglacial processes during the last stage of continental glaciation, which began about 30,000 years ago. The remainder of the surficial deposits are the products of postglacial geologic processes, such as river floodplains, or are attributed to human activity, such as fill or other land-modifying features.

The map shows the areal distribution of the different types of glacial features, deposits, and landforms as described in the map explanation. Features such as striations and moraines can be used to reconstruct the movement and position of the glacier and its margin, especially as the ice sheet melted. Other ancient features include shorelines and deposits of glacial lakes or the glacial sea, now long gone from the state. This glacial geologic history of the quadrangle is useful to the larger understanding of past earth climate, and how our region of the world underwent recent geologically significant climatic and environmental changes. We may then be able to use this knowledge in anticipation of future similar changes for long-term planning efforts, such as coastal development or waste disposal.

Surficial geology maps are often best used in conjunction with related maps such as surficial materials maps or significant sand and gravel aquifer maps for anyone wanting to know what lies beneath the land surface. For example, these maps may aid in the search for water supplies, or economically important deposits such as sand and gravel for aggregate or clay for bricks or pottery. Environmental issues such as the location of a suitable landfill site or the possible spread of contaminants are directly related to surficial geology. Construction projects such as locating new roads, excavating foundations, or siting new homes may be better planned with a good knowledge of the surficial geology of the site. Refer to the list of related publications below.

OTHER SOURCES OF INFORMATION

1. Thompson, W. B., 1997, Surficial geology of the Portland West 7.5-minute quadrangle, Cumberland County, Maine: Maine Geological Survey, Open-File Report 97-66, 10 p.
2. Thompson, W. B., 1999, Surficial materials of the Portland West quadrangle, Maine: Maine Geological Survey, Open-File Map 99-38.
3. Neil, C. D., 1999, Significant sand and gravel aquifers of the Portland West quadrangle, Maine: Maine Geological Survey, Open-File Map 99-11.
4. Retelle, M. J., and Weddle, T. K., 2001, Deglaciation and relative sea-level chronology, Casco Bay Lowland and lower Androscoggin River valley, Maine, *in* Weddle, T. K., and Retelle, M. J. (editors), Deglacial history and relative sea-level changes, northern New England and adjacent Canada: Geological Society of America, Special Paper 351, p. 191-214.
5. Thompson, W. B., Griggs, C. B., Miller, N. G., and Weddle, T. K., 2008, Associated terrestrial and marine fossils in the late-glacial Presumpscot Formation, southern coastal Maine, and the marine reservoir effect on radiocarbon ages: Geological Society of America, Abstracts with Programs, v. 40, no. 2.

Portland West Quadrangle, Maine

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For additional information, see Open-File Report 97-66.
This map supersedes Open-File Map 97-51.

SURFICIAL GEOLOGY OF MAINE

Continental glaciers like the ice sheet now covering Antarctica probably extended across Maine several times during the Pleistocene Epoch, between about 1.5 million and 10,000 years ago. The slow-moving ice superficially changed the landscape as it scraped over mountains and valleys, eroding and transporting boulders and other rock debris for miles. The sediments that cover much of Maine are largely the product of glaciation. Glacial ice deposited some of these materials, while others washed into the sea or accumulated in meltwater streams and lakes as the ice receded. Earlier stream patterns were disrupted creating hundreds of ponds and lakes across the state. The map at left shows the pattern of glacial sediments in the Portland West quadrangle.

The most recent "Ice Age" in Maine began about 30,000 years ago, when an ice sheet spread southward over New England (Stone and Borns, 1986). During its peak, the ice was several thousand feet thick and covered the highest mountains in the state. The weight of this huge glacier actually caused the land surface to sink hundreds of feet. Rock debris frozen into the base of the glacier abraded the bedrock surface over which the ice flowed. The grooves and fine scratches (striations) resulting from this scraping process are often seen on freshly exposed bedrock (**Figure 1**), and they are important indicators of the direction of ice movement. Erosion and sediment deposition by the ice sheet combined to give a streamlined shape to many hills, with their long dimension parallel to the direction of ice flow. Some of these hills (drumlins) are composed of dense glacial sediment (till) plastered under great pressure beneath the ice.

A warming climate forced the ice sheet to start receding as early as 21,000 calendar years ago, soon after it reached its southernmost position on Long Island (Ridge, 2004). The edge of the glacier withdrew from the continental shelf east of Long Island and reached the present position of the Maine coast by about 16,000 years ago (Borns and others, 2004). Even though the weight of the ice was removed from the land surface, the Earth's crust did not immediately spring back to its normal level. As a result, the sea flooded much of southern Maine as the glacier retreated to the northwest. Ocean waters extended far up the Kennebec and Penobscot valleys, reaching present elevations of up to 470-490 feet in the central part of the state.

Great quantities of sediment washed out of the melting ice and into the sea, which was in contact with the receding glacier margin. Sand and gravel accumulated as deltas and submarine fans where streams discharged along the ice front, while the finer silt and clay dispersed across the ocean floor (**Figures 2, 3**). The shells of clams, mussels, and other invertebrates are found in the glacial-marine clay that blankets lowland areas of southern Maine. Fossil plant material has been found in a few places in the clay (**Figures 5-7**). Ages of these fossils tell us that ocean waters covered parts of Maine until about 13,000 years ago. The land surface rebounded as the weight of the ice sheet was removed, forcing the sea to retreat.

Meltwater streams deposited sand and gravel in tunnels within the ice. These deposits remained as ridges (eskers) when the surrounding ice disappeared. Maine's esker systems can be traced for up to 100 miles, and are among the longest in the country.

Other sand and gravel deposits formed as mounds (kames) and terraces adjacent to melting ice, or as outwash in valleys in front of the glacier. Many of these water-laid deposits are well layered, in contrast to the chaotic mixture of boulders and sediment of all sizes (till) that was released from dirty ice without subsequent reworking. Ridges consisting of till or washed sediments (moraines; **Figure 4**) were constructed along the ice margin in places where the glacier was still actively flowing and conveying rock debris to its terminus. Moraine ridges are abundant in the zone of former marine submergence, where they are useful indicators of the pattern of ice retreat.

The last remnants of glacial ice probably were gone from Maine by 12,000 years ago. Large sand dunes accumulated in late-glacial time as winds picked up outwash sand and blew it onto the east sides of river valleys, such as the Androscoggin and Saco valleys. The modern stream network became established soon after deglaciation, and organic deposits began to form in peat bogs, marshes, and swamps. Tundra vegetation bordering the ice sheet was replaced by changing forest communities as the climate warmed (Davis and Jacobson, 1985). Geologic processes are by no means dormant today. Rivers continue to erode the land, worldwide sea level is gradually rising against Maine's coast, and landslides occur where slopes are unstable (**Figure 8**).

References Cited

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Devin, S. C., and Sandford, T. C., 1990, Stability of natural slopes in the Presumpscot Formation: Maine Geological Survey, Open-File 90-24, 75 p.

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Stone, B. D., and Borns, H. W., Jr., 1986, Pleistocene glacial and interglacial stratigraphy of New England, Long Island, and adjacent Georges Bank and Gulf of Maine, *in* Sibrava, V., Bowen, D. Q., and Richmond, G. M. (editors), Quaternary glaciations in the northern hemisphere: Quaternary Science Reviews, v. 5, p. 39-52.

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Figure 1: Glacial grooves on granite ledge at the Toppi pit, Westbrook (**Locality 1**). Direction of ice flow was from right to left (south-southeast). White area is snow cover. The large boulders were deposited as part of a moraine that has been removed by excavation in the area shown here.

Figure 2: Glaciomarine clay (Presumpscot Formation) overlying deformed sand and gravel (marine fan), Toppi pit, Westbrook (**Locality 1**). Two episodes of clay deposition are represented here. Older clay layers (left center) were deformed along with the underlying sand and gravel, while the younger clay beds (top) are horizontal.

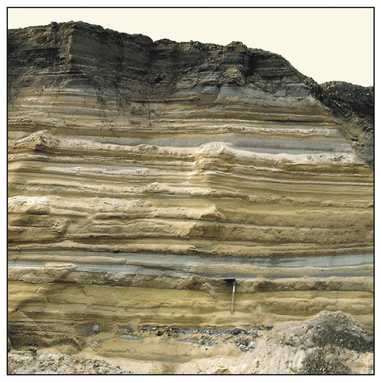

Figure 3: Marine fan deposit at the Toppi pit in Westbrook (**Locality 1**), showing progressively finer-grained sediments that washed into the ocean during retreat of glacial ice. The materials seen here grade from sand and gravel at the base of the section to silt and sand at the top.

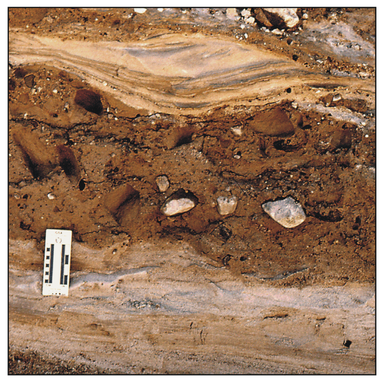

Figure 4: Sand with interbedded flowtill (center) in end moraine at Toppi pit in Westbrook (**Locality 1**). The sand beds were deposited by glacial meltwater currents, but the stony flowtill was emplaced as a debris flow off the glacier margin. Scale card graduated in centimeters and inches.

Figure 5: Scientists collecting fossil plant remains from marine clay in pit north of the Fore River (**Locality 2**). This gravel pit was the first place in Maine where abundant remains of trees and other terrestrial plants were found in the Presumpscot Formation. Additional plant material was found nearby in 2007, when this site became part of the new Mercy Hospital complex (Thompson and others, 2008).

Figure 6: Spruce log embedded in clay at pit shown in Figure 5 (**Locality 2**). The age of this log in calendar years is between 13,500 and 14,000 years, but it has the fresh appearance of modern spruce wood. A count of its growth rings showed that the tree lived for at least 180 years. See locality description in Thompson (1997).

Figure 7 : Imprints of spruce twigs in clay from pit shown in Figure 5 (**Locality 2**). Spruce cones were also found at this site, and some of the needles were so well preserved in the clay that they are still green. See locality description in Thompson (1997).

Figure 8: The landslide of November, 1868, in glaciomarine clay at Westbrook (**Locality 3**). This massive slide caused an estimated 20 acres of land to collapse and flow into the Presumpscot River, raising the upstream water level at least 15 feet and causing serious flooding. Photo from Devin and Sandford (1990), courtesy of P. Spiller.