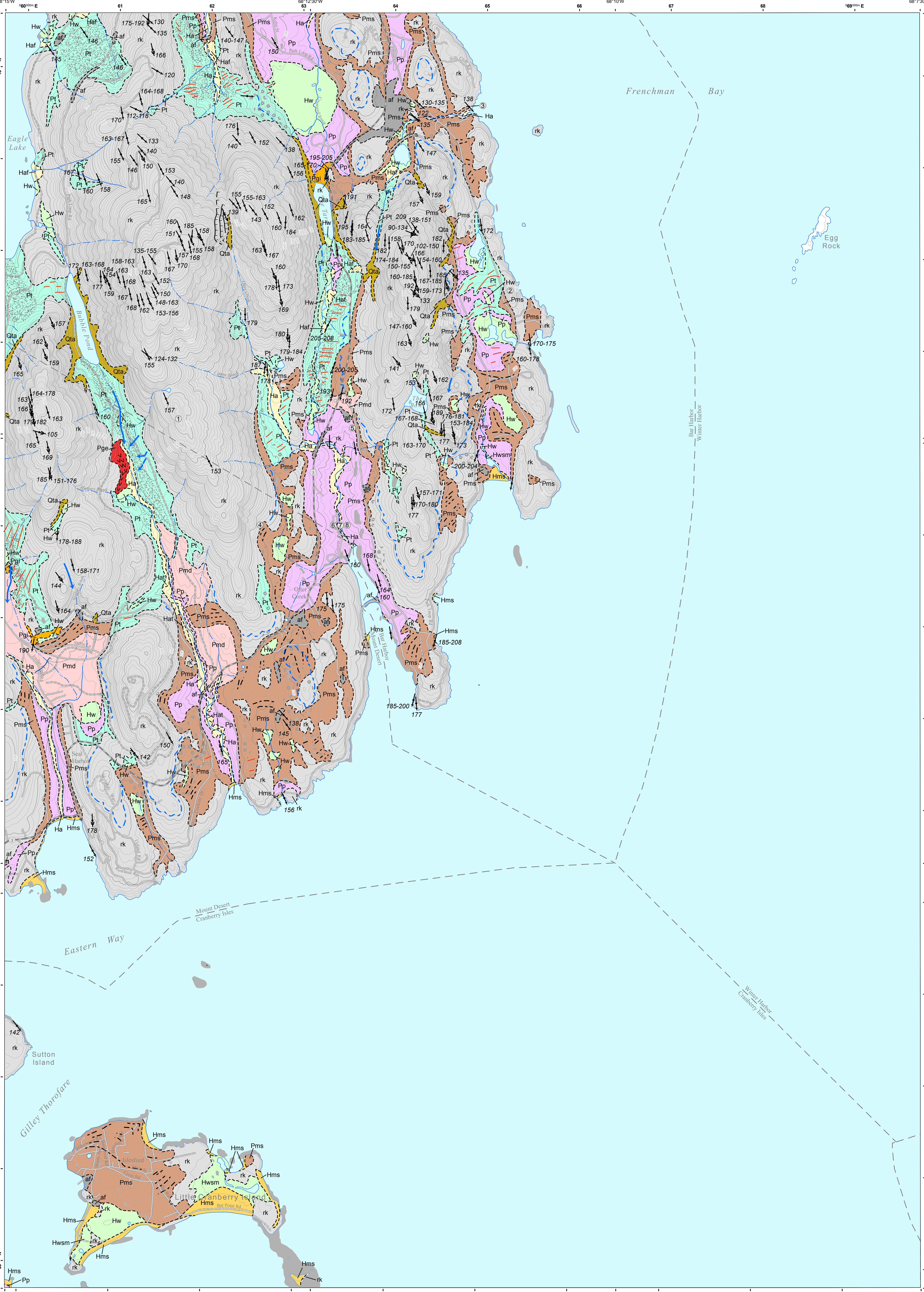
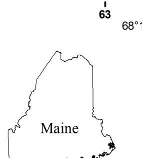
Surficial Geology



SOURCES OF MAP INFORMATION

Surficial geologic mapping of the Seal Harbor quadrangle was conducted by Duane D. Braun during the 2013 field season.



Salsbury Cove	Bar Harbor	Winter Harbor
Southwest Harbor	Seal Harbor	Schoodic Head
Bass Harbor	Baker Island	

SCALE 1:24,000

CONTOUR INTERVAL 20 FEET

Approximate Mean Declination, 2015 16.5° W (not to scale)

Base map features from Maine Office of GIS - 1:24,000 USGS contour lines, E911 roads, 1:24,000 National Hydrography Dataset, USGS GNIS placenames and 1:24,000 political boundaries. Map projection Universal Transverse Mercator, North American Datum, 1927.

Note: The first letter of each map unit indicates the general age of the unit:
H = Holocene (postglacial deposit; formed during the last 11,700 years).
Q = Quaternary (deposit of uncertain age usually late-glacial and/or postglacial).
P = Pleistocene (deposit formed during glacial to late-glacial time, prior to 11,700 yr B.P. [years before present]).

af — **Artificial fill** - This unit occurs along roadways and at building sites.

Ha — **Stream alluvium** - Stratified sand and gravel with minor amounts of silt deposited on flood plains of present day streams; typically 1–2 m (3-6 ft) thick.

Haf — **Alluvial fan** - Stratified gravel and sand deposited in a fan-shaped landform where steep stream channels enter more gently sloped and wider areas; typically 2 m (6 ft) or more thick.

Hat — **Alluvial terrace** - Stratified sand and gravel forming benches running parallel to and 1-3 m (3-10 ft) above the present floodplain; usually 1-2 m (3-6 ft) thick.

Hms — **Marine shoreline deposit** - Beach ridges composed of cobble to boulder-size material 2-5 m (6-15 ft) thick. The most extensive beaches occur on Little Cranberry Island.

Hw — **Freshwater wetland** - Muck, peat, silt, and sand, typically 0.3-2 m (1-6 ft) thick. Poorly drained areas, often with standing water. The most extensive wetland is Great Meadow.

Hwsm — **Salt marsh** - Grass, reed, and sedge wetland, inundated at high tide, that is underlain by fine grained sediment having a variable thickness of 0.3-2 m (1-6 ft). Salt marsh is only present on Little Cranberry Island.

Qta — **Talus** - Angular to subangular rock blocks deposited at the base of bedrock cliffs. Individual blocks are typically around 0.6-1 m (2-3 ft) and range in size from 0.3-10 m (1-33 ft). Deposit thickness is typically 1-5 m (3-15 ft), with some deposits more than 10 m (33 ft) thick. Much of material was deposited during late Pleistocene periglacial climate conditions with lesser amounts of material deposited during the Holocene. The most extensive talus deposits are around The Tarn.

Pge — **Esker** - A ridge of stratified boulder to pebble gravel and sand deposited in a subglacial tunnel. The bedding is often chaotic with abrupt bedding and grain size changes. The only esker is in the headwaters of Hunters Brook.

Pgi — **Ice-contact gravel** - Stratified boulder to pebble gravel and sand deposited in contact with the melting glacial ice. Stratification in places may be horizontal or dipping consistently while in other places stratification may be chaotic with abrupt bedding and grain size changes. A 10-15 m (30-50 ft) thick deposit of such material marks an ice margin position separating The Tarn from Great Meadow.

Pmd — **Marine delta** - Stratified sand and gravel with nearly horizontal top strata (topsets) underlain by seaward dipping strata (foresets). Top surface graded to sea level at time of deposition. Deposit thickness is generally 5-15 m (15-50 ft). A large delta is present in the headwaters of Stanley Brook on the north side of the village of Seal Harbor.

Pms — **Marine shoreline deposit** - Stratified pebble to boulder gravel and sand that has layering dipping downslope. This deposit was mapped where abandoned gravel and sand pits show the material to be 2-5 m (6-15 ft) thick or where there are distinct strandline features. Deposited during the postglacial marine submergence of the coast. The most extensive areas of such deposits are north of Sand Beach, between Otter Cove village and Hunters Brook valley, and on Little Cranberry Island.

Pp — **Presumpscot Formation** - Fine-grained marine mud (silt and clay with sandy lenses) commonly containing gravel dropstones and, more rarely, marine shell fossils. The mud was deposited in deeper, quieter water during the postglacial marine submergence of the coast. The most extensive such deposits are around Great Meadow, in the lower part of Otter Creek north of Otter Cove, and in the lower part of Hunters Brook.

Pt — **Till** - Poorly sorted mixture of gravel, sand, silt and clay (diamict) deposited directly by glacial ice; typically 1-5 m (3-15 ft) thick. Land surface is often more bouldery than the underlying till due to removal of smaller-size surface material by running water or waves. The most extensive deposits of till, often forming a series of moraine ridges, are in the headwaters of Kebo Brook, Otter Creek, and Hunters Brook.

Pt — **Thick Till** - Poorly sorted mixture of gravel, sand, silt and clay (diamict) deposited directly by glacial ice and having a thickness of 3-10 m (10-33 ft). Land surface is often more bouldery than the underlying till due to removal of smaller surface material by running water or waves.

rk — **Bedrock** - Areas shown as solid gray are where 25% or more of the land surface is knobs of bare or vegetation-covered bedrock ledge. Thin (.3-1 m [1-3 ft]) glacial, colluvial, and/or residual materials overlie the bedrock between knobs. On higher, more steeply sloped areas 75-100% of the surface is bare or vegetation-covered ledge. Where gray spots lie within other colored areas of glacial deposits, the gray spots are bedrock ledges projecting through the glacial deposits.

Boulder surface mantle - Area of boulders covering the ground surface on top of other material such as till or bedrock. Boulders typically cover 50 to 100 percent of the ground surface. Average boulder size is 0.6 to 1 m (2-3 ft) and ranges from 0.3 to 5 m (1 to 15 ft).

Contact - Indicates approximate boundary between adjacent map units. Expectable line location error is 3-6 m (10-20 ft) to locally as much as 10-15 m (30-50 ft) where the materials are obscured by dense surface vegetation and lack diagnostic landforms.

Upper limit of marine submergence - Shows highest elevation of sea level immediately following recession of the glacier from the area. This elevation is approximate, based on glacial-marine delta elevations in the region (~67-73 m [~220-240 ft] above sea level; Thompson and others, 1989, figure 2 contours). Everywhere below this elevation wave erosion has cut into the glacial deposits. Where such deposits were thin, only lags of large boulders have been left on bedrock ledges. Where such deposits were thicker, a thin 0.3-1 m (1-3 ft) deposit of gravel and sand, often with a boulder surface, overlies other glacial deposits. This thin "wave wash veneer" is not shown on the map, only the underlying material.

Small moraine ridge - Ridge of till and/or sand and gravel deposited and/or deformed by glacial ice; about 1-5 m (3-15 ft) high and 5-30 m (15-100 ft) wide. Such ridges probably represent annual "push moraines".

Marine beach ridge or strandline - Subtle ridge or bench feature with an abrupt steepening of slope in the downslope direction in an area of Pleistocene marine shoreline deposits. A strandline marks a temporary pause in sea-level lowering or an especially stormy period as the sea receded.

Marine scarp - Marks the top edge of a marine wave-cut scarp; hachures point downslope.

Rock slide scarp - Marks top edge of down dropped rock slide mass. Hachure marks point down the slip direction.

Meltwater channel - Arrow shows trace of former meltwater channel; arrowhead shows direction of water flow.

>>>>>> **Esker ridge crest** - Chevrons show direction of glacial metlwater flow.

Glacial striation locality - Arrow shows ice-flow direction(s) inferred from striations on bedrock. Dot marks point of observation. Number is azimuth (in degrees) of flow direction. Where relative ages are known, flagged arrow shows older flow direction.

Crescentic mark - Arrow shows direction of ice-flow. Dot indicates point of observation. Number is azimuth (in degrees) of flow direction.

② **Photo locality**

SOURCES OF RELATED INFORMATION

Braun, Duane D., Foley, Michael E. and Prescott, Glenn C., Jr., 2015, Surficial materials of the Seal Harbor quadrangle, Maine: Maine Geological Survey, Open-File Map 15-15, map, scale 1:24,000.

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Seal Harbor Quadrangle, Maine

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This map supersedes Open-File Map 15-30.

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 2.5 million and 11,700 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 this 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, 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 420 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. The shells of clams, mussels, and other invertebrates are found in the glacial-marine clay that blankets lowland areas of southern Maine. Ages of these fossils tell us that ocean waters covered parts of Maine until about 13,000 years ago. The land 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) 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, however, since rivers and wave action modify the land and worldwide sea level is gradually rising against Maine's coast.

References

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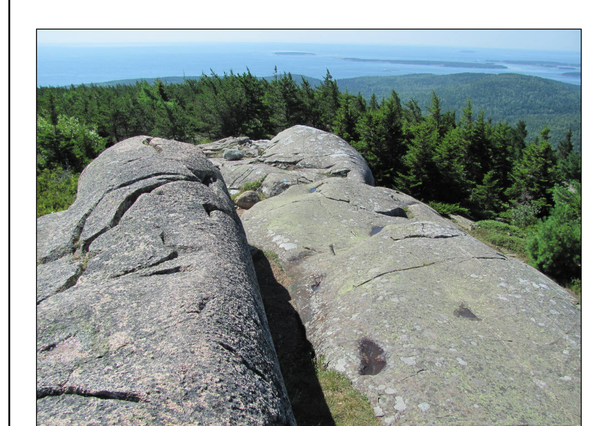

Figure 1: Glacial sculpting of "whale back" knobs on a basalt dike on the Cadillac Mountain south ridge. View to the south along the gentle "up-ice" scoured parts of the knobs with the steep "down-ice" plucked parts hidden from view.

Figure 2: Cliff on the east side of Champlain Mountain steepened by glacial plucking. Postglacial frost splitting of joint blocks from the cliff has deposited a pile of blocks (talus) at the base of the cliff. View westward from Cranberry Hill.

Figure 3: Glacially polished and striated ledge surface that cuts through and highlights the edges of Shatter Zone fragments in the

Figure 4: Boulder beach berm at an elevation of 67 m (220 ft) at the east base of Eagles Crag on the Cadillac Mountain south ridge. View to north along the crest of the berm marking the highest level of immediate postglacial marine submergence of the area.

Figure 5: Beach deposit at an elevation of 47 m (155 ft) consisting of pebbly sand containing a flat angular clast of clayey silt marine mud (Presumpscot Formation). The mud had been deposited when sea level was up to a maximum of 20 m (65 ft) above that elevation,. As the land rebounded out of the ocean from the removal of the weight of the glacial ice, the falling sea level formed a beach at this site. The waves ripped up the semi-consolidated mud on the sea floor and the clast was incorporated in the gravelly sand.

Figure 6: South to north view of Otter Creek cutting into glacial deposits. Exposure is 45-50 m (150-165 ft) long and 6-10 m (20-30 ft) high. Gray glaciomarine clayey silt with dropstones (Presumpscot Formation), interbedded with thin gravelly sand layers and diamict lenses, overlie (cap) yellowish to reddish-yellow glaciofluvial sandy gravel that in turn overlies greenish-gray glacial till (in lower right part of stream bank).

Figure 7: Closer view of a 7 m (23 ft) high by 10 m (30 ft) wide area in the middle the exposure shown in Figure 6. At the upper right an orange notebook marks a cobbly diamict lens in the marine mud. Near the center a rectangular scale bar marks the contact of stratified clayey silt with underlying yellowish oxidized sandy gravel.

Figure 8: Close-up of the northern or distal part of the exposure in Figure 6. Interbedded layers of gray clayey silt and yellowish to reddish sand are steeply tilted down to the northeast. The tilting is probably due to postglacial slumping of the area as Otter Creek cut down into the deposits. The landscape behind the exposure shows arcuate slump headwalls.