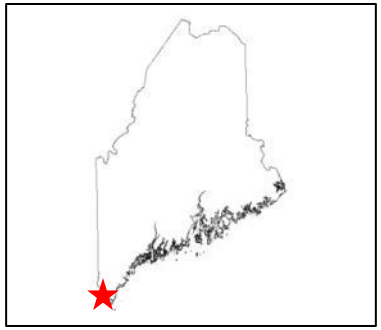
Maine Geologic Facts and Localities

February, 2000

A Natural Beach Bonfire in Kittery, Maine



43° 5‘ 0.32“ N, 70° 42‘ 28.19“ W

Text by
Stephen M. Dickson

Introduction

We will now visit Kittery Point on the coast of southern Maine (see Figure 1). Kittery Point is a semi-protected peninsula along the Maine-New Hampshire border, about two miles east of the US Route 1 bridge (see Figure 2). The shoreline of the point is a combination of bedrock ledges, mud flats, salt marshes, and low-energy sand and gravel beaches -- a very typical arrangement of estuarine environments along the Maine coast. The pocket beaches along the south shore of Kittery Point in Pepperrell Cove are very unusual, however, because natural beach fires occurred there on two occasions in the fall of 1905.

Kittery Point

Kittery Point is at the confluence of Spruce Creek and the Piscataqua River (Figure 1). The point lies between Seavey Island, home to the Portsmouth Naval Shipyard, and Gerrish Island that fronts the Gulf of Maine along the eastern coast of York County. Kittery Point, strategically located along the entrance to the Piscataqua River, is the site of Fort McClary State Historic Site. Fort McClary was part of Maine's coastal defenses beginning with the American Revolution.

Figure 1. Portion of the 1893 U.S. Geological survey topographic map of York SW (15' quadrangle) showing the buildings on Pepperrell Cove a few years prior to the beach fire.

Coastal Geology

Pepperrell Cove is south and east of Kittery Point and has shallow subtidal mud flats (Figure 2). The intertidal zone has mud flats as well as sand and gravel pocket beaches. The beaches are between small bedrock headlands and generally face south into the Piscataqua River and out to sea. This limited exposure to waves from the south has sorted sediment along the shoreline into the beaches and mud flats. Mixed sand and gravel beach ridges occur along the high-tide line as a result of the waves rolling up the river from the south.

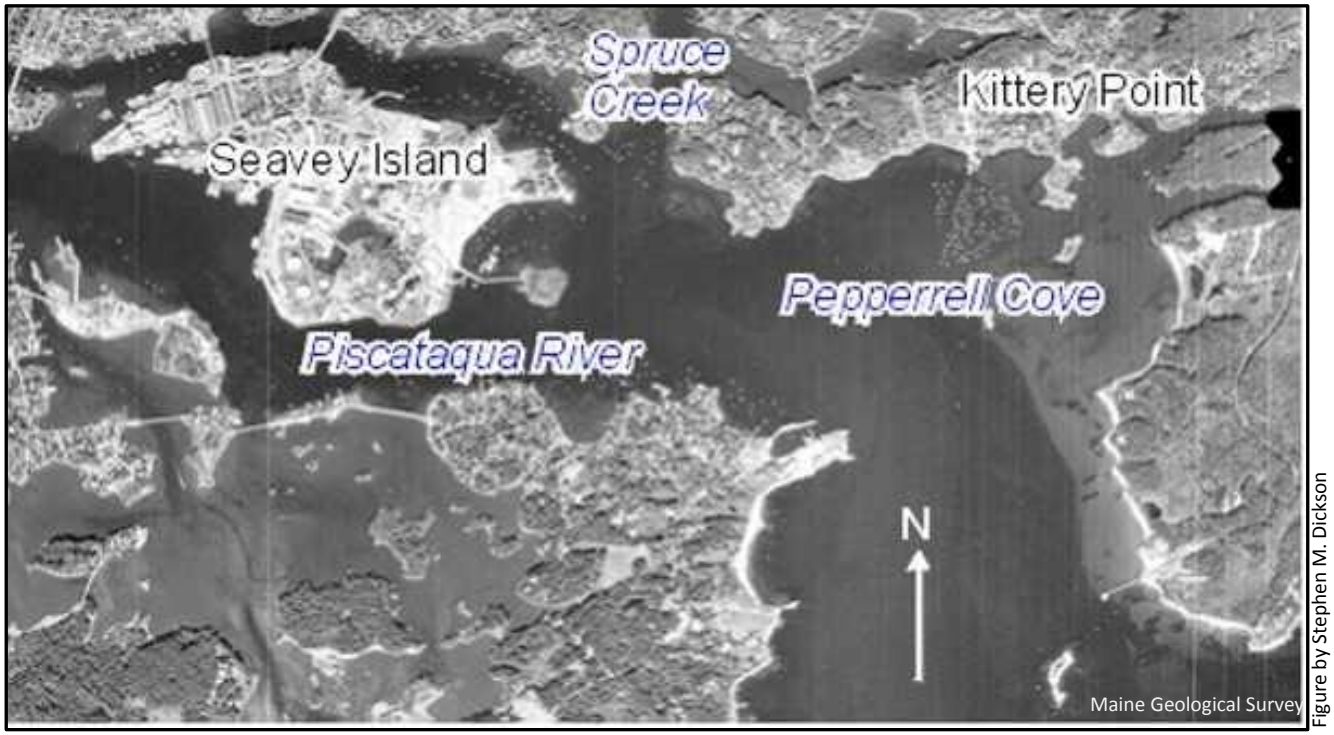


Figure by Stephen M. Dickson

Figure 2. Air photo of the lower Piscataqua river showing Kittery Point and Pepperrell Cove in 1980.

The "Blazing Beach"

Two accounts of the beach burning at Kittery Point were published in the scientific literature by botany professor David P. Penhallow of McGill University, Montreal, Canada. The first reference was a short note in the journal Science in December 1905 (Penhallow, 1905). A second and longer paper was published in Popular Science Monthly in 1907 (Penhallow, 1907) after he revisited the site in the summer of 1906. Penhallow provided a very thorough description of the beach that burned. It can be matched to the coastal geology of Pepperrell Cove shown on the current Coastal Marine Geologic Environments Maps (Figure 3).

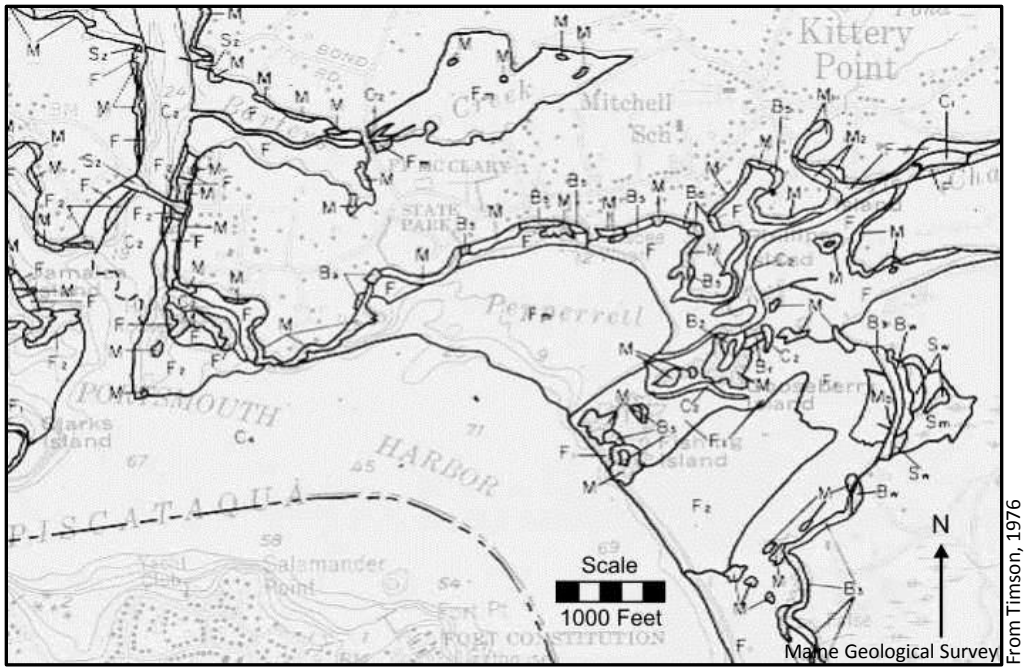


Figure 3. Detailed coastal environments in the vicinity of Kittery Point. Low-energy beaches are shown by B symbols, ledge by M, and flats by F. For more detail, see the original MGS map and legend (Timson, 1976).

The "Blazing Beach"

He describes a "barrier ridge" and "...beach [that] extends laterally for a distance of one hundred and seventy-five to two hundred feet ... in a pocket..." (Penhallow, 1907, p. 557).

By Penhallow's account,

[o]n the evening of Friday, September 1, the guests at the Hotel Parkfield were startled by the appearance of flames rising from the beach and from the surface of the water, an event of so remarkable and unusual a character as to excite great curiosity and some alarm. The conflagration occurred between seven and eight o'clock in the evening and lasted for upwards of forty-five minutes. The flames were about one foot in height. They were accompanied by a loud and continuous crackling noise which could be distinctly heard one hundred yards away, while at the same time there was a very strong liberation of sulphurous acid fumes which penetrated the hotel ... When some of the sand was taken into the hotel and stirred in water, bubbles of gas were liberated and produced flame as they broke the surface in contact with the air." (Penhallow, 1905, p. 795).

"On the evening of Wednesday, October 4, 1905, as reported by a reliable observer, the phenomenon was repeated with identical features except that instead of occupying the entire area ... it was restricted to ... probably less than one fourth the area of the first conflagration. ... [I]n general, the flames were not more than three or four inches in height..." (Penhallow, 1907, p. 558).

The "Blazing Beach"

Even one hundred years ago it was understood that sea level was rising relative to the land and resulted in the burial of organic matter from salt marsh plants and eel grass in Pepperrill Cove. Microbial decay of organic matter to produce methane and hydrogen sulfide at shallow depth in the beach sediments was correctly identified by Professor Penhallow as the most probable source of the combustible gas. By digging into the beach, Penhallow examined the layers, or strata, of the cove and determined that buried organics, rather than a salt marsh submerged by sea-level rise, were the most likely source of carbon.

"[S]torage of gas would be quite possible in a deposit of coarse gravel, pebbles and coarse sand, overlaid by a layer of fine, wet and compact sand acting as a retaining layer. It is possible, also, that the accumulation of gas may have been brought about under slight pressure, so that the earthquake of the day before may have furnished just that shaking which was necessary to disturb the conditions of equilibrium and liberate the gas at a critical moment. The occurrence of a smaller conflagration one month later may or may not harmonize with this idea, but it does seem to emphasize the suggestion of storage of large volumes of gas which were not wholly set free on the first occasion." (Penhallow, 1907, p. 559).

A Modified Mercalli seismic intensity scale V earthquake occurred in coastal New Hampshire at 5:40 a.m. local time on August 30, 1905. This intensity would be strong enough to be felt outdoors, awake sleeping people, and disturb liquids (Richter, 1958). The New England earthquake catalog officially lists the earthquake as occurring two days before the beach first burned.

Biogenic Methane in Coastal Maine Sediment

Methane gas is a common product of microbial decay of organic matter in both marine and terrestrial environments. Large accumulations of methane produced by microbial decay of organics are known in Maine estuaries and in muddy sediments offshore. Known offshore methane deposits are shown on maps of the Surficial Geology of the Maine Inner Continental Shelf (Barnhardt et al., 1996), published by the Maine Geological Survey. The geologic history of sea-level rise and how it affect the physiographic environments of the Maine coast is described in The Seafloor Revealed (Kelley et al., 1998). In large muddy bays of the Maine coast large craters in the seafloor are produced by the release of methane and other biogenic gas from the seafloor (Kelley et al., 1994).

Bubbles rising from the seafloor have been observed indirectly in geophysical records. Gas bubbles have been directly observed in the water column by scuba divers and bubbling on the sea surface in Penobscot Bay has been seen from the shoreline. It seems from the accounts by Penhallow (1905, 1907) that occasionally these natural gas emissions are in such concentrations as to be flammable.

References and Additional Information

Barnhardt, Walter A., Belknap, Daniel F., Kelley, Alice R., Kelley, Joseph T., and Dickson, Stephen M., 1996, Surficial geology of the Maine inner continental shelf: Maine Geological Survey (Department of Conservation), Geologic Maps 96-7 through 96-10, map, scale 1:100,000.

Kelley, Joseph T., Dickson, Stephen M., Belknap, Daniel F., Barnhardt, Walter A., and Henderson, Mark, 1994, Giant sea-bed pockmarks; evidence for gas escape from Belfast Bay, Maine: Geology, v. 22, no. 1, p. 59-62.

Kelley, J. T., Barnhardt, W. A., Belknap, D. F., Dickson, S. M., and Kelley, A. R., 1998, The Seafloor Revealed: Maine Geological Survey, Open-File Report 96-6, 55 p.

Penhallow, David Pearce, 1905, A blazing beach [Kittery Point, Me.]: Science, new series, v. 22, p. 794-796.

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Timson, Barry S., 1976, Coastal marine geologic environments of the Kittery quadrangle, Maine: Maine Geological Survey (Department of Conservation), Open-File Map 76-101 (scale 1:24,000).

Related Links

- Pockmarks Record Seafloor Gas Escape
- Coastal Marine Geologic Environments Maps
- Inner Continental Shelf Maps
- The Seafloor Revealed
- Sea Level on the Maine Coast
- Earthquakes in Maine
- UNH Dimond Library Map Archives
- NOAA Historical Map and Chart Collection
- Fort McClary State Historic Site