Maine Geological Survey
DEPARTMENT OF CONSERVATION
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Title: The Possibility of Pleistocene - Holocene Movement Along the Oak Bay Fault on the Maine - New Brunswick Border.

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Contents: 7 page report

Introduction

The purpose of this investigation was to determine if the Oak Bay Fault Zone was active during late Wisconsinan and Holocene time. The accessible portion of the fault zone was to be examined for evidence of fault movement as indicated by offsets of late Wisconsinan and Holocene erosional and depositional features. The types of structures that were sought included vertical and horizontal displacements of glacial striae and grooves, deformational features in till and stratified drift at the bedrock-overburden interface, and offsets in recent strandlines. Topographic maps and aerial photographs were to be examined for offsets in the trend of bedrock structures and glacial landforms.

The Oak Bay Fault Zone

According to Ruitenberg (1968) the Oak Bay Fault Zone trends northwestward across Campobello Island, through Western Passage (see map), and thence along a course that takes it up the St. Croix River channel and into Oak Bay. It passes through the eastern edge of Cookson Island before striking inland at the mouth of the Gallop Stream and disappearing beneath glacial drift and recent alluvium. The Oak Bay fault extends a minimum distance of 55 km (33 mi) of which all but 5.8 km (3.5 mi) is submerged beneath the waters of Passamaquoddy Bay, the St. Croix River, and Oak Bay.

On Campobello Island, Ruitenberg (1968) projected the Oak Bay Fault trace through the gentle saddle between Herring Cove and Friars Bay (see map) a distance of approximately 2.6 km (1.6 mi). Bedrock is not exposed along this section of the projected fault trace. It may well be that differential erosion lowered the bedrock surface in the vicinity of the fault zone to or below sea level. The bedrock exposed at Con Robinsons Point and Deer Point (see map) is sheared and shattered and probably represents a fault-line scarp that has retreated some distance from the actual fault trace. Between Friars Bay and Herring Cove the bedrock is blanketed by a mantle of hummocky, well-sorted, and interbedded sand and gravel ranging in thickness from 3m (10 ft) to 18m (60 ft). Gravel pits excavated into this material have failed to encounter bedrock.

In Oak Bay, Ruitenberg (1968) interpreted the fault trace to just graze the eastern edge of Cookson Island and then trend northwestward along the eastern shore of the upper bay (map). Both the exposed bedrock of the eastern shore of upper Oak Bay and the eastern shore of Cookson Island exhibit extensive shearing and shattering and appear to be fault-line scarps that are being eroded back. In some instances the bedrock has been reduced to a rubble with average clasts measuring less than 5 cm in diameter. The rubble appears to have resulted from the disaggregation of thinly sheared siliceous volcanic rhyolite(?). In some localities small secondary thrust faults strike nearly normal to and intersect the fault trace.

At the mouth of the Gallop Stream, the stream follows the fault trace for a short distance. Here the stream has cut down into the fault zone, producing steep walls on the fault-line scarps on either side of the stream channel. As in the previously mentioned localities, the bedrock is extensively shattered and

intensively sheared. To the northwest the fault trace quickly disappears under a mantle of stream debris and glacial drift.

Late Wisconsinan History

There is no reported evidence to support the existence of an early Wisconsinan or pre-Wisconsinan glacial deposit in the Passamaquoddy Bay area. The surficial materials of the Passamaquoddy Bay area are assumed to be of late Wisconsinan or Holocene age.

The late Wisconsinan ice sheet reached its maximum extent on the continental shelf off Maine and New Brunswick some 20,000 years ago and was receding by 17,000 years ago (King, 1969; Schafer and Hartshorn, 1965; Sirkin and others, 1970).

Southeast trending drumlins, streamlined features, and striations suggest a southeast ice-flow generally paralleling the Oak Bay fault trace during the Wisconsinan maximum.

The distribution of striae in the Passamaquoddy Bay area (see map) suggests that the ice margin during deglaciation formed a "bulbous" lobe with its margin extending southwestward through Black Harbor and onto the continental shelf south of Campobello Island. Gadd (1973) dates this ice position at about 16,500$\pm$ 370 C^{14} yrs B.P. (GSC-1063) based on an analysis of freshwater lake organic sediment from the bottom of Little Lake, located to the east of the study area.

Recession of the Passamaquoddy Bay lobe is visualized as shrinking from a position seaward of Campobello Island to a narrow tongue confined to the St. Croix River estuary (map). Ice-contact deposits on the west side of Oak Bay near Benson Corner and the kame terrace deposits at Sand Point on the east side of the river(map) define this ice position (Gadd, 1973). Superposition of fossiliferous marine offshore sediments on kame deposits at Benson Corner and Sand Point attest to the Passamaquoddy Bay area being open to the sea, and therefore free of ice, by 12,300 C^{14} years B.P. (GSC-886; GSC-795).

Radiocarbon dated organic material from a bog located approximately 12 km (7 mi) northwest of the head of Oak Bay suggests the minimum age of deglaciation for the study area to be 12,600$\pm$ 270 C^{14} yrs B.P. (Gadd, 1973; GSC-1067). This recession was accompanied by or was followed by a marine transgression that extended well into the upper reaches of Oak Bay.

Seismic History

The recent seismic history of the Oak Bay fault zone is not clearly understood. The epicenters for instrumentally recorded events may be inaccurate by as much as 5-15 km (3-10 mi). Locations for non-instrumentally recorded events may be inaccurate by as much as 10-25 km (6-15 mi) (Rand, 1977).

Given the possible inaccuracies of individual epicenter locations, one must view all plotted epicenters in and around Passamaquoddy Bay and the St. Croix River as possibly being associated with seismic activity along the Oak Bay Fault although there is no evidence that displacement in the fault zone correlates with a local earthquake (Rand, 1977).

Since 1873 there have been 27 earthquakes recorded in and around the Passamaquoddy Bay area (Table 1). Of these quakes, eleven were recorded with an intensity of IV (Modified Mercalli Scale) or greater, and one quake had a recorded intensity of VI.

Discussion and Conclusions

I observed no evidence of Pleistocene-Holocene movement along the Oak Bay Fault Zone. The bedrock adjacent to the fault was extensively shattered during faulting, thus permitting extensive differential weathering and erosion along the fault zone. Regional ice-flow indicators (Gadd, 1973) suggest that during the late Wisconsinan deglaciation the ice-flow direction generally paralleled the fault trace.

Ice flowing in the fault zone probably scoured out much of the shattered rubble. Thus the fault zone was deepened and the opposing walls trimmed back. The brecciated bedrock along the fault zone was probably unable to resist the shear of the basal-ice load, and hence grooves and striae might not have formed.

Deformation structures in till and stratified drift at the bedrock-overburden interface were not observed. A thick, continuous sediment cover was observed only along the shorelines of Campobello Island. The sediments appeared to be glacial outwash that was subsequently reworked by wave action during marine submergence and offlap episodes. No evidence of faulted sediment or deformed sediment layers were observed other than those created during recent slope failures.

Although the presence of a major fault is suggested by the remarkably linear nature of the Oak Bay-St. Croix Estuary-Western Passage Channel and to some extent their terrestrial extensions on topographic maps and aerial photographs, there is no evidence to suggest that movement occurred along the Oak Bay Fault in late Wisconsinan or Holocene time. Evidence for recent movement along the fault would have been rapidly obliterated by rapid coastal erosion of the shattered bedrock and by mass wasting and tree throw on the loose, unconsolidated sediment mantle.

Suggestions for further research

1. The submerged portion of the Oak Bay Fault along with its tributary fault system should be mapped in detail using a high resolution sub-bottom profiler (EG&G, 1977). This device would not only provide exact information as to the disposition of the Oak Bay Fault but would establish the relationships of the tributary faults to the main fault and permit mapping their extensions on shore.

Table 1

EARTHQUAKES RECORDED IN THE VICINITY OF THE
OAK BAY FAULT ZONE

Date	Time (EST)	Latitude	Longitude	Intensity	
Feb. 22, 1873	12:30	44.9°	67.0°	III*	
Feb. 28, 1874	03:35	45.2	67.3	IV	
Nov. 20, 1876	-	44.9	67.0	II	
Jan. 1, 1883	02:55	45.0	67.0	V	
Mar. 23, 1896	00:56	45.2	67.2	V	
Jan. 26, 1897	A.M.	44.9	66.9	III	
Mar. 21, 1904	06:04	45.0	67.2	VI	
Mar. 20, 1912	12:00	45.1	67.4	III	
Dec. 11, 1912	10:15	45.0	68.0	IV	
Jan. 13, 1914	08:00	45.2	67.3	IV	
Jan. 14, 1918	07:20	45.0	67.3	IV	
Nov. 9, 1920	00:40	45.0	67.3	IV	
Oct. 10, 1921	13:00	44.8	67.0	IV	
Sept. 9, 1922	06:00	45.0	67.1	III	
Nov. 20, 1928	02:30	45.0	67.2	IV	
Mar. 29, 1929	00:00	45.2	67.3	II	
Apr. 9, 1931	A.M.	45.0	67.0	III	
Aug. 26, 1934	11:36	44.9	67.0	III	
Mar. 4, 1935	02:40	44.9	67.0	III	
Jul. 15, 1945	10:44	44.9	67.0	IV	
Aug. 28, 1945	01:37	44.9	67.0	II	
Nov. 21, 1948	15:41	44.9	67.0	III	
Mar. 23, 1958	22:04	45.6	67.1		3.4**
Mar. 11, 1967	23:39	45.2	67.3		2.1
Dec. 22, 1974	05:25	45.4	67.1		2.9
Jan. 17, 1975	00:10	44.9	66.9		3.1
Dec. 26, 1977	16:19	45.0	66.9		2.1

*Modified Mercalli Scale
**Magnitude

Source: Chiburis (in press)

2. If the submerged portion of the Oak Bay Fault is overlain by faulted late Wisconsinan and Holocene sediments then the age of the youngest of the faulted layers should be determined and that would provide a minimum date for fault movement. The dating of the fault sediment would be accomplished by utilizing a high resolution subbottom profiler (EG&G, 1977) to map the stratigraphic section and determine exactly which layers have been faulted. Depending on the sediment thickness a coring device of some sort would be used to retrieve relatively undisturbed sediment layers for radiocarbon dating of specific horizons.

3. Control points (bench marks) should be established at selected sites across the fault zone. The selection of these sites would not be very difficult as the fault zone is crossed by numerous roads, a power line, and an abandoned railroad line. Measurements of the relative displacements between these control points should be done on a regular basis, perhaps once every five years. In the event of a local earthquake displacement measurements should be made immediately.

4. Submerged archaeological control points such as Coast and Geodetic Survey markers, moorings, foundations, ring bolts, etc... must be sought out in the literature, then located under water. These artifacts can be dated and their original position determined. The present submerged position of these artifacts once the eustatic sea level rise correction has been subtracted will be a measure of the crustal subsidence in the area.

Acknowledgments

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References

Chiburis, L.F., Seismicity, recurrence rates, and regionalization of the northeast U.S. and adjacent areas: (in press).

EG&G, 1977, Fundamentals of high resolution seismic profiling TR76-035: 31p.

Gadd, N.R., 1973, Quaternary geology of southwest New Brunswick with particular reference to Fredericton area: Canada Geol. Survey Paper 71-34, 31p.

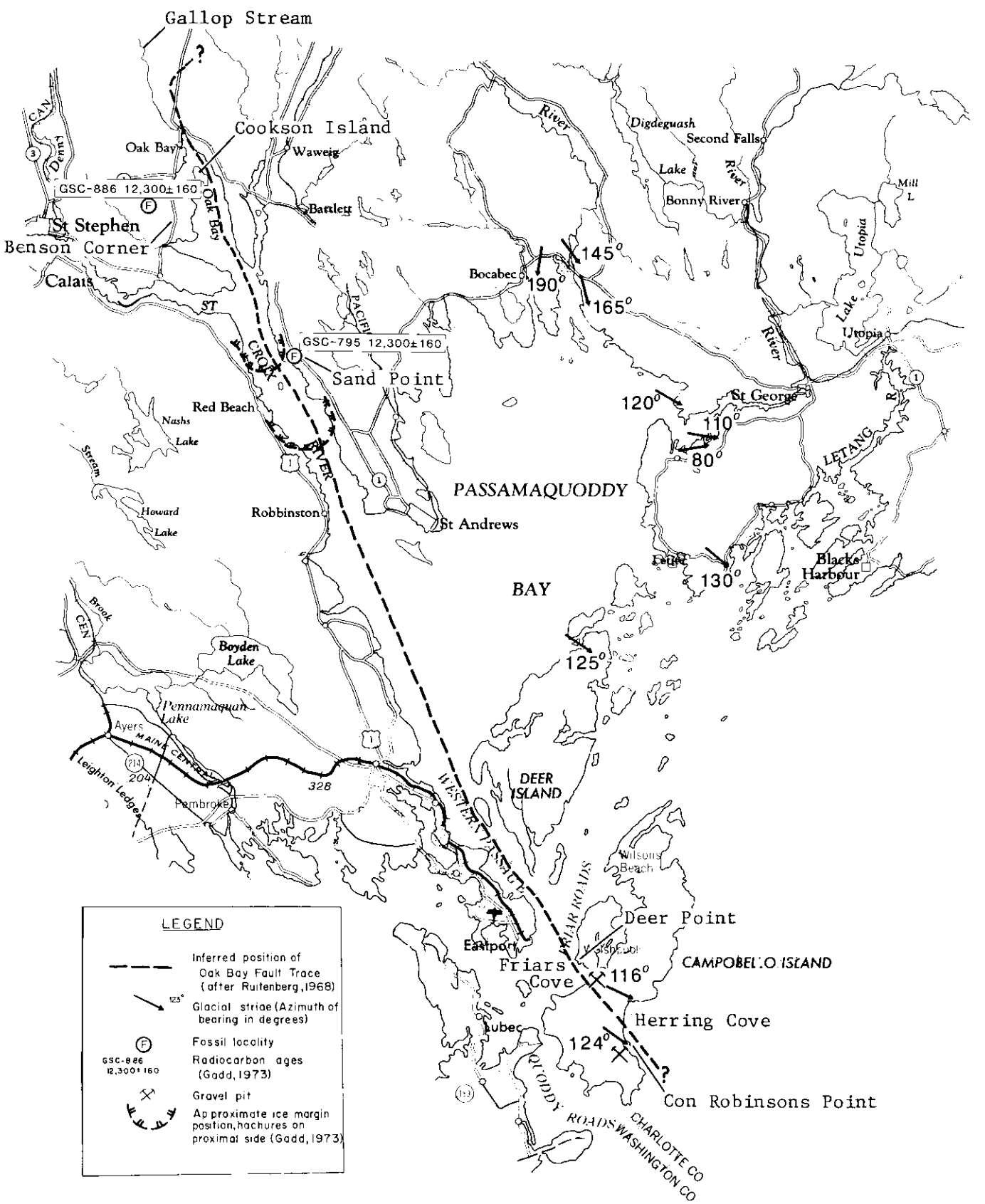
King, L.H., 1969, Submarine end moraines and associated deposits on the Scotian Shelf: Geol. Soc. America Bull., v. 80, p. 83-96.

Rand, J.R., 1977, Historical earthquakes in Maine: The Maine Geologist, v. 3, n. 3, p.3-6.

Ruitenberg, A.A., 1968, Geology and mineral deposits, Passamaquoddy Bay area: Mineral Resources Branch, Dept. of Natural Resources, New Brunswick, Report of Investigations no. 7.

Schafer, J.P. and Hartshorn, J.H., 1965, The Quaternary of New England, in Wright, H.E., Jr. and Frey, D.G., eds., The Quaternary of the United States: Princeton, N.J., Princeton Univ. Press, p. 113-127.

Sirkin, L.A., Owens, J.P., Minard, J.P., and Rubin, M., 1970, Palynology of some Pleistocene peat samples from the coastal plain of New Jersey: U.S. Geol. Survey Prof. Paper 700-D, P. D77-D87.



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THE OAK BAY FAULT TRACE
WASHINGTON COUNTY, MAINE AND CHARLOTTE COUNTY, N.B.

SCALE 1:250,000