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THE ACADIAN-NEWFOUNDLAND EARTHQUAKE.

—By D. S. McINTOSH, M.Sc., Department of Geology, Dalhousie University, Halifax, N. S.

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ABSTRACT.

The cable breaks on the ocean floor all occurred in the embayment of the North Atlantic between the New England-Nova Scotian fishing grounds and the Grand Banks of Newfoundland. The numerous breaks spread over a large area resulted from displacements of the sea bottom—vertical, and perhaps horizontal. The disturbed portion is in a line with the old submerged channel of the St. Lawrence river and it is probable that a settling of the sediments accumulated seaward from the river's mouth was the primary cause of the earthquake. The land region to the north has as a basement very old rock which must have a large degree of stability, but which through the past has at various times been subjected to earth movements. The loss of life and property at Burin, Newfoundland, the expense of repairing cables and the inconveniences to which the Cable Companies were put, and the minor effects that show the intensity of the shock are stated as a matter of record.

INTRODUCTION.

As a matter of scientific interest, it is desirable that the Nova Scotian Institute of Science should have placed upon its records an account of the recent earthquake which was felt through parts of the New England States, the Maritime Provinces and Southern Newfoundland. Nearness to the seat of disturbance makes it of especial interest to Nova Scotians and the disastrous effects in Newfoundland place it in the category of the lesser major earthquakes.

General Remarks.

The earthquake shock occurred at 4h. 32m. 8s. o'clock on the afternoon of November 18, 1929. It was felt within a radius of some hundreds of miles from the seat of disturbance on the ocean floor in the embayment of the North Atlantic between the New England-Nova Scotian fishing grounds and the Grand Banks of Newfoundland. The submarine area affected lies, in a rough way, between 52° and 58° West Longitude and 38° and 46° North Latitude, embracing an extent of territory approximating a hundred thousand square miles. Although this whole area suffered from the shock, there appears to have been greater intensity towards the north of the region for there the epicentre—the surface directly overlying the break— has been located by the scientists in charge of the seismographs at Dalhousie, Ottawa, Harvard, and Washington. The immediate effect of the shock was to put out of commission the telegraph cables crossing the area. A score or so of breaks in the cables were found by the repair ships that were dispatched at once to the disturbed area. The general report of the officers in charge of repair work is that the soundings where cable breaks occurred showed no appreciable difference from the charted depths. Any small disparity might be explained by original error in depth-taking. Nevertheless, the fact that a sea-wave was generated by the disturbance shows that there was vertical displacement on the ocean floor. The force that had to be exerted in lifting broken cables in certain places made it evident to those in charge of the work that the cables were buried under a mass of material that had apparently slid down a slope. The small number of depths marked on available charts of the locality make it impossible to know if any steep slopes are present on the sea bottom at this place. That such exist is not improbable. There may have been horizontal as well as vertical displacement. The depths in which cables were broken ranged from 44 to 2934 fathoms.

Effects of the Quake.

Phenomena accompanying disturbances on the sea bottom have often been described. The rock movements propagate

waves that travel through the overlying and adjacent waters. These vibrations are often felt by ships at sea. On this occasion the Captain of the S.S. Caledonia of the Cunard Line states that on November 18 at 3:30 p. m. Eastern Standard Time, the shock was felt on shipboard. A message sent from the ship at sea reads:—"44°26′ North Latitude, 57°4 West Longitude experienced earthquake shock causing ship violent vibrations for two minutes. No apparent damage." The ship's position at that time was quite close to the epicentre.

Sea waves whose dimensions vary with the intensity of the shock are an accompaniment of submarine earthquakes. In general, the disturbed waters are seen to recede from the land and then return often with destructive force. About two hours after the shock under consideration a sea-wave rolled from the ocean upon the Newfoundland and Cape Breton coast line. At Burin the usual recession of the water preceded the advance wave. Great destruction was wrought along the coast of southern Newfoundland in the Burin peninsula. About fifty miles of the south and eastern coastline from Lamaline on the south to Rock Harbour well up the peninsula on the east side was swept by a wave fifteen feet high. Waterside buildings—stores and dwellings,—fishing stands, boats, dories and skiffs were swept away with great loss of provisions, coal, etc. A small schooner was left stranded by the receding waters. One building swept seaward remained anchored in the sea. The worst feature of all was the loss of twenty-six lives. As a result, a pall of sadness hangs over the sparsely settled fishing communities along the Burin coast.

The wave struck the Nova Scotian shore also. At Canso a 28 ton schooner was swept from her moorings at a wharf at eight o'clock and later drifted ashore. The water at Sydney rose five feet above a maximum high tide; and at North Sydney about half-past eight o'clock over a foot of water covered the docks, and small boats floated near the business houses on Commercial Street, the water here having advanced on the land about two hundred yards.

All through the Province of Nova Scotia there was felt a distinct shock. It was accompanied by a peculiar noise that

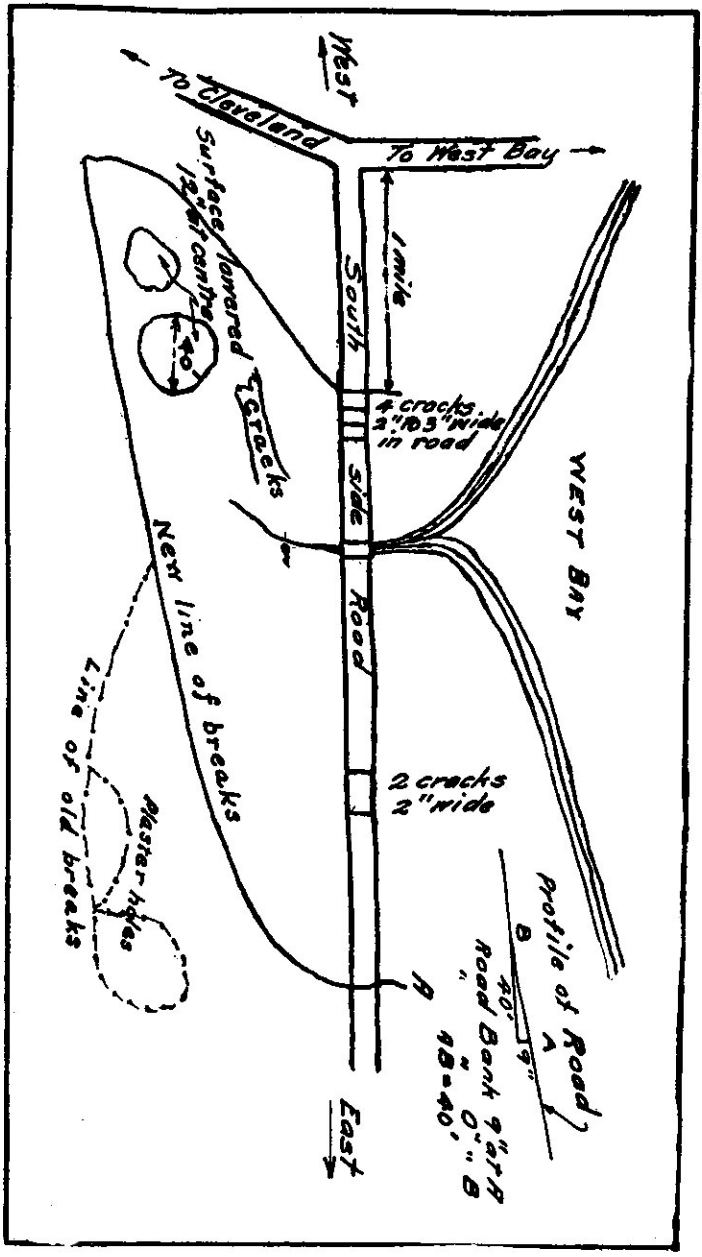
many people took to be furnace trouble in the basements of their dwellings. Added to this was the noise of moving objects. Doors and windows rattled, buildings shook and trembled, dishes rattled in the cupboards, and pictures swung out from the wall. From some localities are reported falling chimneys. Several cases are reported of objects stopping when just about to topple over. At Whitney Pier it is said the water of a well became roiled.

In two places in Cape Breton Island the road was damaged. Near Ross' Ferry at Boulardarie there was a landslide from the slope down upon the road. Here the underlying rock is gypsum which is often unstable and easily displaced by a movement such as an earthquake. At Dundee, Richmond County, which is also a gypsum district, several breaks occurred in the road and adjacent land where new plaster holes were made. On the main road in a distance of about two and a half miles there are seven breaks two to three inches wide extending only across the roadbed. The most easterly one had a vertical displacement of nine inches hinging at a distance of forty feet to the west. A similar explanation applied to this district as in the Ross' Ferry case. In general it would seem that gypsum districts suffered more than places underlain by more solid rock. Windsor fared worse than Halifax.

The Adjacent Land Mass.

It has been customary, and will continue to be so, to speak of Northeastern North America as a region of crustal stability. The reason is evident: the basement of the region, the Canadian Shield, Southeastern Quebec, and Cape Breton Island, is largely of Archaean rock, the oldest on the continent, and it is highly probable that the same rock prevails underneath the adjacent areas. Upon this has been built the less old, and much younger rocks. Such a condition gives stability to the whole territory.

While it is true that earth disturbances have not much affected the whole region since early geological time, the records of the rocks show that portions of the region have



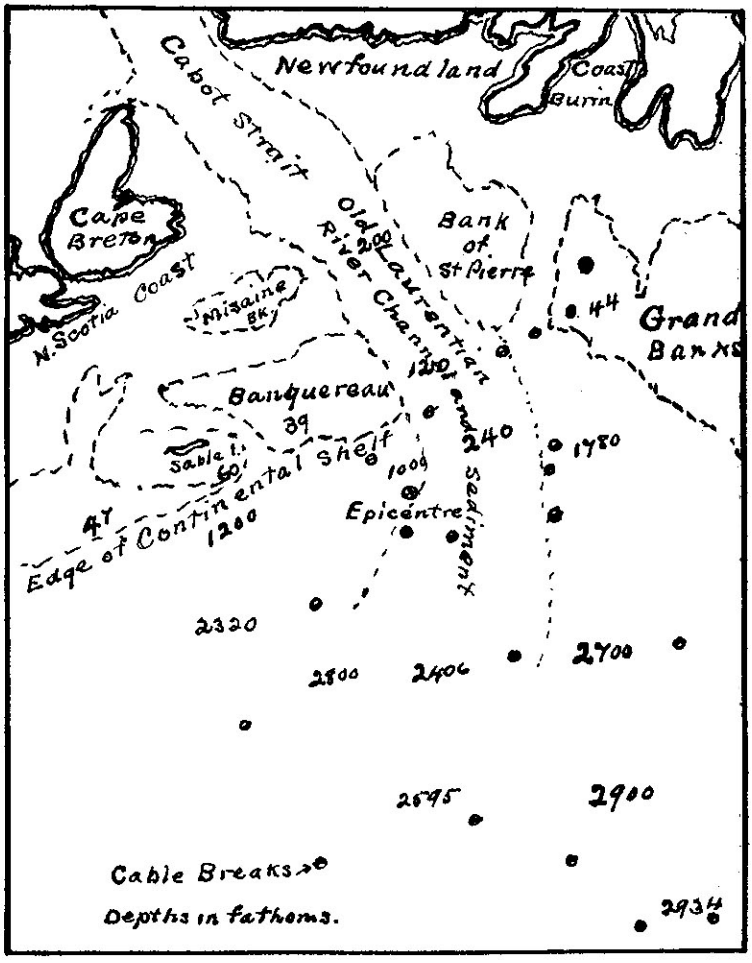
Map 1.—Breaks and depressions caused by the earthquake in the Dundee district. Sketched from a tracing furnished by the Nova Scotia Highway Board.

been subjected at various times in its long history to earth movements of great magnitude, and of long or short duration. The rock of the land mass that makes up the southeastern coastline of Nova Scotia and in all probability extends to the edge of the continental shelf is quartzite and slate surrounding granite areas. In Southeastern Newfoundland are rocks that in many respects resemble the Nova Scotian altered sedimentaries and may be of the same age. This Gold Measures Series of Nova Scotia has a thickness of over six miles which accumulated in a long trough-like depression extending from the western end of the Province to possibly the southeastern end of Newfoundland. Here was a zone of weakness. As the sediment grew in thickness the bottom kept sinking until the earliest formed sediment was miles below the surface and then the whole mass yielded to pressure from the ocean bottom and was folded into mountain ranges of Alpine height. This was some time later invaded by upwelling molten rock which solidified to make the Nova Scotia granite. These events were of revolutionary magnitude as earth movements.

Besides mountain building and intrusion of igneous material, there have been times in which stresses were relieved by rock fracture. There is in the St. Lawrence estuary the great Champlain fault; along the north shore of the Bay of Fundy is the Fundian, and associated faults; the Chedabucto fault is not far removed from the recently disturbed area; and there are numerous transverse faults that have cut across the Gold Measures Series and that have disturbed the rocks and the seams in various coal fields. There have been, also, regional uplifts and subsidences. The present coastline is a sunken one, the sea having invaded the lower courses of the rivers. The sinking was, however, followed by coastal stability, and it is highly probable that that condition continues, and has been such for some hundreds of years.

The Submarine Areas.

There is a fine development of the continental shelf around the coast. Off the Nova Scotia shore it extends seaward about



Map 2.—Map of the earthquake region and adjacent land and submarine areas.

125 miles, ending in 80 to 100 fathoms of water. From Burin to the south end of the St. Pierre bank is about 200 miles. The area of the Grand Banks is much more extensive. Over the continental shelf bottom are the Banks—shallower water averaging about 50 fathoms with depressions of greater depths. This continental shelf is, according to Dr. Goldthwait, the drowned portion of a peneplane, the landward part of which may be seen as a dissected inclined plane stretching over the New England States and the Maritime Provinces. The Banks are erosion remnants and the depressions are the result of stream action.

The continuity of the continental shelf is broken between the Nova Scotian banks and the St. Pierre banks where for a width of about sixty miles the water deepens to over 200 fathoms. This deeper-water belt beginning at the edge of the shelf extends through the Cabot Strait and with diminishing width and depth along the floor of the Gulf of St. Lawrence, and curving around the Gaspe′ peninsula it occupies the estuary of the St. Lawrence river. At the margin of the shelf, the water on either side has a depth of but 60 to 75 fathoms. This depression is undoubtedly the submerged channel of an old river whose head waters were somewhere in the Upper Great Lakes. Dr. Young describes this "hypothetical stream," the old Laurentian river, as cutting its course across from Georgian Bay to near Toronto—a pre-glacial stream.[1] If the direction of the course of this submerged channel be extended seaward, there is apparently found a flat "rise" that may be traced down towards the 40th parallel. For seventy miles from the mouth of the old river there is apparently very little drop in the slope. Recent soundings by the S. S. "Faraday" at 44°50′ north and 56°20′ west gave a depth of 240 fathoms. Beyond this point the slope becomes steeper; and about 60 miles to the east there is a depth of 2100 fathoms. The drainage basin of the old Laurentian river was extensive, probably as great or greater than that of the present St. Lawrence river; the volume of water was great enough to cut a course 60 miles

1. A larger map of the region is seen in Dr. Johnstone's paper, and may be consulted. These **Transactions, 17**, Pt. 4, 231, (1930).

wide at its mouth with banks at the side of 800 feet or so in height. The sediment carried and deposited by this great volume of water must be the ocean "rise" that extends southward from the old stream's mouth and is spread out in somewhat delta form. Settling of this mass of sediments would account for the breaks in the cables in the northern portion of the region, and the disturbance might also be communicated to points further south and all through the shattered area by fractured sub-strata.

Nowhere around the continental shelf from its edge to the ocean floor with depths of 2500 to 3000 fathoms is the slope steep, one in twelve to one in forty feet. There are apparently no declivities along the continental slope.

Another point of interest about the continental shelf is that there extends from Burin southwards to near the epicentre, as located by Dr. Keith, a depression about 25 miles wide with water about 30 fathoms deeper than that on either side. Apparently along this course the sea wave swept northward working such havoc on the Burin peninsula. Elsewhere its effect was lessened by the shallower water.

Several specimens of material from the sea bottom were obtained through the courtesy of officers of the "Faraday", "Cyrus Field," "Lord Kelvin" and "John W. Mackay." They ranged in locality from 42°30′ North to 44°50′, and from 54°58′ West to 56°20′. Most of the samples were clays with just sufficient calcareous material to produce effervescence with weak acid. Evidently the area is north of the foramenifera ooze belt. Dr. Keith, of the National Research Council at Washington, is having an analysis made of samples of these clays; and Dr. Kindle, of the Geological Survey at Ottawa, is having them examined for foramenifera. There was also recovered from a depth of 2100 fathoms pebbles of considerable size mixed with clay. From the depth of 240 fathoms previously referred to, large sized pebbles were obtained, chiefly igneous material, some of the pebbles showing glaciated surfaces.

The earthquake of the 18th of November is discussed from the seismological standpoint in a paper by Dr. J. H. L.

Johnstone who has charge of the seismograph at Dalhousie University.

Conclusions.

The old Laurentian river with its huge volume of water, its deeply trenched and broad course, the tremendous amount of rock waste carried from its bed and basin, and the evident presence of a great mass of debris seaward from its mouth appears to the present writer to furnish a case somewhat analogous to that of the Mississippi valley previous to 1811. Settling and fracturing of the thick mass of sediment concealed beneath the waters of the embayment is therefore put forward as a tentative cause of the recent earthquake. Besides the stream-borne material there is also the probability of much glacial drift lying upon the sea bottom. Cable breaks spread over such a large area point to several faults, not to one major fault. This would tend to make the recurrence of earthquakes of some magnitude less likely in this region; and, on account of the stable structural features of the country, freedom from major disturbances should continue to afford a large measure of satisfaction to the inhabitants along the seaboard as well as inland.

The above paper is the result of the application of well known geological principles, a probable cause for the recent earthquake being deduced from certain physical features shown on the maps and charts of the region studied. Among publications consulted should be mentioned—"The Gold Measures of Nova Scotia" by W. Malcolm; "Physiography of Nova Scotia" by J. W. Goldthwait, "The New England-Acadian Shoreline" by Douglas Johnson, and "Geology and Economic Minerals of Canada" by G. A. Young. The writer is under obligation to J. H. L. Johnstone who was indefatigable in collecting facts relating to the earthquake, and who generously passed them on to a colleague.