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The 1929 Tsunami – A Look Inside

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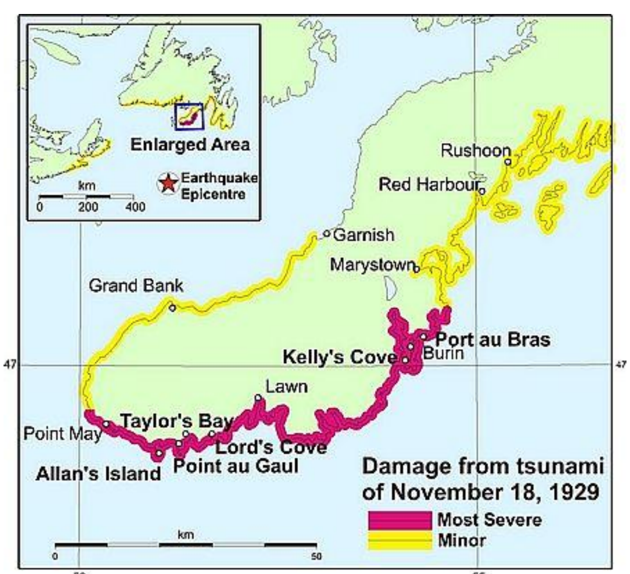
ABSTRACT

Lawn is a small fishing community located on the tip of the Burin Peninsula along the south coast of Newfoundland. In 1929, a Tsunami brought considerable damage to property and loss of life to the Burin Peninsula. As a resident of Lawn for 18 years, I grew up hearing stories about my grandparents experience during the Tsunami of 1929. As a result I have always been very interested in this topic.

The Tsunami was caused by an underground earthquake that measured 7.2 on the Richter scale. The quake forced waves across the ocean at speeds more than eight hundred kilometers an hour. It created the great tsunami on the Burin Peninsula that struck the shores with waves at a speed of over 104 kilometers an hour.

Tsunamis can arrive in less than a minute after natural warning signs such as an earthquake, the receding of shore water or a loud roaring sound. The people on the Burin Peninsula had only natural warning signs to alert them. They were not prepared for what these signs were or what they meant and therefore had little time to react before the Tsunami hit the shorelines.

As a part of this case study, I plan to research the earthquake that occurred in the Grand Banks about 265 kilometers south of the Burin Peninsula. I will also review the tsunami and the waves that spread across the water surface, how the quake intensified and the breakage of the transatlantic cables caused by the underwater slump and the engineering lessons learned from the disaster.



1 INTRODUCTION

On Monday November 18th, 1929 at 5:02pm (Newfoundland Standard time) an earthquake occurred in 2000 metres of water just south of the Burin Peninsula, Newfoundland. Its epicentre was about 265 km from the coastline and was located 18 kilometres beneath the Laurentian Continental Slope. A submarine landslide transformed into turbidity currents at speeds of 93 to 130 km/s and flowed as far as 1,700 km. It ruptured 12 trans-Atlantic cables in 28 places [1]. The Laurentian Slope was shaken loose and underwater landslides continued for over 20 hours and travelled from the epicentre out to 5,000 meters into the southeast corner of the map shown in Figure 1. The landslides continued another 1,100 kilometres out into the Sohm Abyssal Plain [2]. The map in Figure 1 is a Bathymetric map of the Laurentian Slope and the Sohm Abyssal Plain. It shows the epicentre, the distribution of gravel, instantaneous cable breaks, and the time delayed cable breaks in hours and minutes after the earthquake occurred.

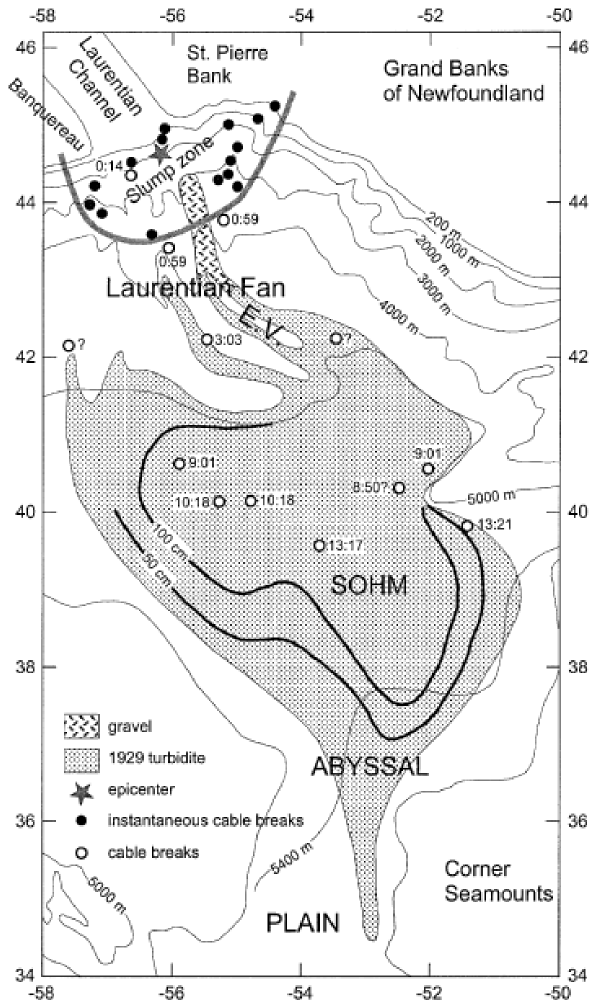


Figure 1: Epicenter Location [2]

The earthquake caused the tsunami that struck the shores of the small fishing communities on the Burin Peninsula. Tsunamis' are characterized as a shallow wave with long periods and wave lengths. A tsunami's wave becomes a shallow water wave when the ratio between the water depth and its wave length gets very small. Tsunamis propagate at high speeds and can travel great distances as a result of the wave energy lose being inversely related to its wave length. The 1929 tsunami travelled east and southward at 600 kilometres per hour as deep ocean waves. It also travelled as a shallow ocean wave to the north and west with an average speed of 105 kilometres per hour.

2 THE EARTHQUAKE & LANDSLIDE

The massive underwater earthquake measuring 7.2 on the Richter Scale occurred between the ridge of the St. Pierre Valley and the Eastern Valley with a focal depth of 16.8 km. The initial shock at approximately 20:30 GMT was followed by two aftershocks at around 23:00 and 02:00 (Nov. 19^{th}) GMT that produced earthquake-induced ground accelerations that triggered widespread surficial failure [3]. This tsunami sparked scientific interest as it had an uncommon generation mechanism; it was induced not directly by a seismic source but by a resultant submarine slope failure [4]. It was also one of the only slide-generated teletsunami that was recorded on the opposite side of the ocean far from the source area [4].

As identified by McCall, original studies thought that failure was instantaneous within 100km of the epicenter as a result of the deep-sea cable breaks [3]. The cable breaks continued downslope on the Laurentian Fan for a period of 13 hours after the earthquake. The breaks were a result of turbidity current that developed from failed sediments that swept down the upper slope to the Sohm Abyssal Plain. Therefore it was thought that this event was the result of a single slumping event. However, through interpretation of sidescan sonar data and high resolution seismic refection data it was shown that this was not the case [3]. It was then apparent that sediment failures were numerous and widespread in the form of slides and debris flows. The failure seemed to occur both instantaneously during the earthquake shocks and after the initial shocks [3].

It was concluded by McCall that there were four types of surficial mass transport deposits (MTDs); mass flows, slumps, glides and creep deformation. McCall also found that the total volume of sediment involved in initial failure was 93.5km^3, 47.1km^3 of which were remaining on the slope as MTDs, and the remaining 46.4 km^3 was evacuated from the slope and contributed to the turbidite. The turbidity eroded and displaced an estimate of 225 km^3 of sediments during the event.

More recent studies have been completed of the Laurentian Fan presenting results from data collected in September 2006. One of such articles by Mosher and Piper have identified results of data collected during this time [5]. During September 2006 multibeam bathymetric data was acquired for an area of 32,150km^2 of the upper Laurentian Fan by GeoSurveys Inc. on the Kommandor Jack. Some general aspects of the continental margin are presented using the bathymetric data in Figure 3 [5].

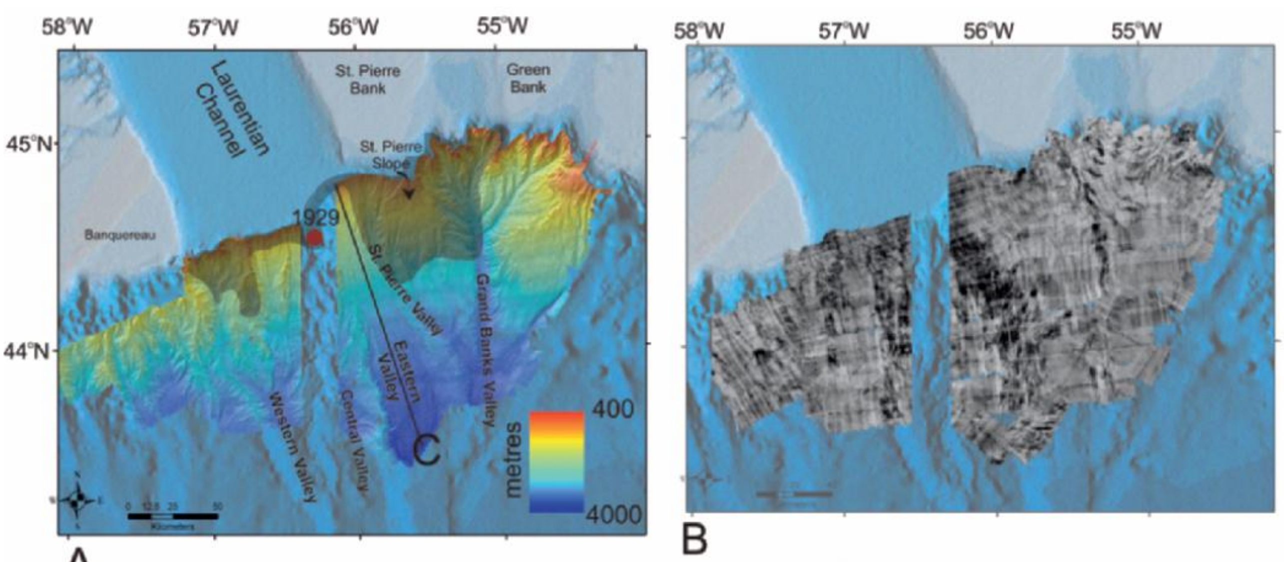


Figure 2: Bathymetric Data [5]

The shaded polygon in image A represents the zone where 100% of the seafloor failed in 1929. While image B is the EM120 backscatter reflectivity data.

The aspects identified in this image are [5]:

- An overall slope angle on the Laurentian Fan is two degrees, being steepest (six degrees) near the shelf break.
- Prominent features are the numerous canyons and valleys with complex upslope tributary systems.
- Erosional systems include the eastern, western and central valleys

The results of the recent studies demonstrate that the greatest amount of sediment failure occurred on the Eastern St. Pierre Slope, a broad flat area with relatively low gradients that are seaward of the eastern part of the St. Pierre Bank. The landslide was relatively thin-skinned with an average of about 20m and dispersed over a relatively large area. The studies show no evidence of a single large sediment mass failure, no single major headwall scarp, subsequent slump and debris lobe [5].

As identified through research most, tsunamis are generated by various submarine processes such as earthquakes, volcanoes or landslides. However, there is a distinction between each event that causes the generation of a tsunami. Landslide-generated waves are approximated as deep water waves and studied in four different categories: viscous fluid model, rigid body, initial static water surface profile and moving kinematic water surface profile [6]. The earthquake-generated tsunamis follow the shallow-water approximation, even though the actual ocean depth is deep. The tsunamis are different because of the source length and water depth is usually similar [6]. As noted previously the 1929 Tsunami had an uncommon generation; the combination of an earthquake and landslide generated the tsunami. It was not until understanding of undersea geologic processes had vastly improved before it was realized that an earthquake-generated submarine landslide precipitated these events [5].

3 THE WAVES

Different types of submarine activities will create a different type of tsunami wave. A shallow-water wave or a long wave is identified when the wavelength is much larger than the water depth. The vertical acceleration of water is negligible compared to the gravity. Therefore the horizontal motion of water mass is almost uniform from the bottom to the surface. As a result of this concept, earthquake-generated tsunamis are approximated as shallow-water waves as illustrated in Figure 2 below [6]. A landslide-generated tsunami occurs when the velocity depends on the wavelength. A deep-ocean wave has a longer wavelength component so waves propagate faster than the shorter wavelength component as show in Figure 2 below. Therefore the wave shows dispersion and cannot reach a long distance with the initial profile [6]. “Shallow” or “deep” water does not refer to the actual water depth in this case. It refers to the relative depth compared with the horizontal scale of the source [6].

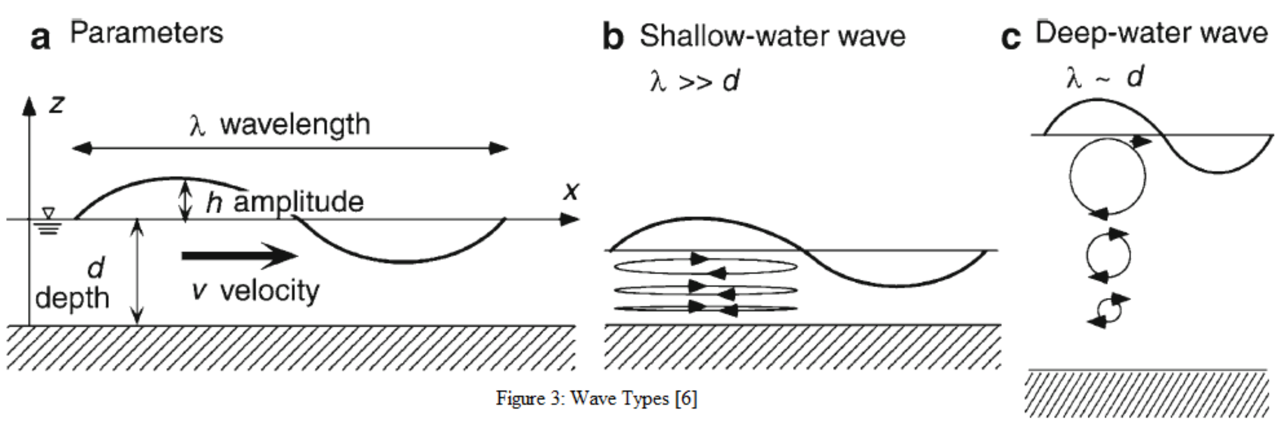


Figure 3: Wave Types [6]

The landslide was transformed into a turbidity current carrying mud and sand that flowed eastward up to 1000km along the Atlantic floor onto the Sohm Abyssal Plain at speeds ranging from 60-100km/hr [4]. The turbidity current had an estimated flow thickness of several hundred meters and flowed for at least 4 hours [4]. The slide movement was mainly directed southward and southeastward, spreading cylindrical surface waves ahead of it. Local topography near the source area and the general orientation of the east coast of North America determined the specific sector-like form of the propagating frontal wave. Due to wave reflection from the shelf of Newfoundland and Nova Scotia, the tsunami waves formed a complicated structure of standing oscillations near the source area. The catastrophic tsunami runup observed during the event can be explained by strong resonant effects as a result of some straits in inlets along the coast [4].

Some observations made by Fine et al. concerning the propagation of tsunami waves have been identified as [4]:

- The waves propagate rapidly northwestward through the deeper Laurentian Channel toward Anticosti Island.
- There is an observable interaction between the tsunami wave and the New England Sea mounts, a lineation of features extending south-eastwards from approximately Cape Cod.
- Tsunami waves become ‘trapped’ by Bermuda as they refract around the islands.

Thrust-like effects and nonpiston-like interactions are two mechanisms that generated the tsunami. Seismically related thrust-like effects have shorter time scales than the typical time scales of wave propagation, which is why the initial sea level elevation can usually be taken as equal to the residual sea-floor displacement. Another effect of importance during the 1929 tsunami is the nonpiston-like interaction between the water and the slide. With an increase in slide velocity, the slide is transformed into a turbidity current with high mass and momentum exchange with the surrounding seawater [4]. The tsunami heights ranged from 9 m to 15 m along the coast of the Burin Peninsula.

4 WARNING SIGNS

4.1 Natural Signs

The people of the Burin Peninsula had only natural warning signs on the day of the event. Most people felt the shake but did not further regard this event. They took the shaking lightly and continued their daily activities. Several quotes from Maura Hanrahan’s book ‘Tsunami: The Newfoundland Tidal Wave Disaster’ are presented below:

“The three waves that slammed into Lord’s Cove were between sixteen to fifty feet high. They hit the harbor at almost 130 kilometers an hour, clearing the little cove of everything it had held. The tsunami did untold damage in Lord’s Cove, affecting virtually every family.” [7]

“At seven-thirty the water drained out of Lawn Harbour, revealing a mass of seaweed over endless grey and blue beach rocks. There was no loss of life in Lawn, due largely to the efforts of Pat Tarrant. But the property damage was considerable, especially for those families who lived near the beach.”[7]

The people of the Burin Peninsula had only natural warning signs. The earthquake that they experienced was the very first sign that a tsunami would occur. The people of the Burin Peninsula felt what they called “The Big Thump” but almost no one anticipated the approach of a tsunami. Pat Tarrant, as mentioned above, was one of the very few people on the peninsula that anticipated what might happen after the initial shake. He was a member of the Royal Navy and had witnessed similar events in the Indian Ocean. He was a trusted man in the town of Lawn and warned the residents to get to high ground after the initial quake. It was a result of his efforts that no lives were lost in Lawn during the tsunami [7]. There were 28 lives lost during the tsunami and extensive damage to all communities hit by the waves. There was a total of $208,199.68 of distributed relief to the various communities affected on the 9th of May 1931 [8]. During this time Newfoundland did not have a seismograph or a tide gauge that could warn the people of the approaching tsunami to allow any early preparation for the oncoming waves.

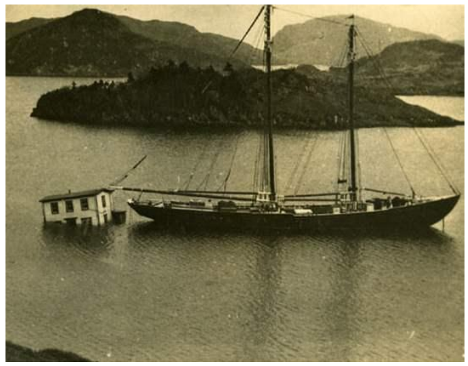


Figure 4: Famous Picture from the Tsunami [7]

4.2 New Technologies

Any type of advanced technology would have been very beneficial to the people of the Burin Peninsula during the 1929 event. However, since these types of events have rarely ever happened in this part of the world there was no type of early detection device that would have aided the communities during this time. Such instruments like Tide Gauges or seismographs would have been very beneficial to the Burin Peninsula to allow for better preparation for the event. Another technology that is continually being advanced is the DART (Deep Ocean Assessment and Reporting of Tsunamis). It is a warning system to prepare people living near the coast of the possible striking of a tsunami. Each DART system consists of a seafloor Bottom Pressure Recording package that detects pressure changes caused by tsunamis. It consists of a surface bouy that receives information from the bottom pressure recording package and the information is then sent to a satellite and back to NOAA's (National Oceanic and Atmospheric Administration) Tsunami warning centers [9]. If Newfoundland had any technology available to them during this time like we have today, lives and property could have been saved during the 1929 Grand Banks Tsunami.

5 INFRASTRUCTURE PREPARATION

During a tsunami any building that stands in the way of the waves will be subject to wave forces from the rising and falling of the tsunami wave. The buildings will block the water and cause pressure to increase on the face of the building with seaward exposure as the tsunamis travels inland. The pressure will also build as the wave recedes out to sea. The pressure of this water on the building can cause an overload resulting in total building failure. As buildings fail during tsunamis the debris from these buildings become weapons of destruction for other buildings or any person floating in the water [10].

One main method to prepare buildings against the wave forces is to build buildings at high elevations away from the shore line. It also helps if buildings are not square on to the wave front, a diagonal facing the wave will all for diversion of waves once the hit the pointed corner. As well buildings should be spread apart from each other to allow waves to pass through easier. The columns of buildings will be the most heavily loaded members during a tsunami. If the building is designed in such a way as to withstand the possible forces of the waves with stronger or more resistant materials then some buildings can be used as a shelter or post disaster building as it will withstand the wave forces and survive the tsunami [10]. It is now common for cities to have designated post-disaster buildings. These buildings are built to withstand such disasters.

6 CONCLUSIONS

There has been much research and development made in the study of the 1929 Grand Banks Tsunami. However, one of the major difficulties that I have noted in the study of this tsunami was the lack of observation data of the wave. With no tide gauges or seismographs there was a lack of data to be studied for this tsunami. In September 2006 multibeam data was produced which greatly aided researchers in the study of the submarine events that generated the 1929 tsunami. Research is still being refined with the hope of better results based on the ongoing geological, geophysical and geotechnical studies.

The largest number of earthquakes occur around the rim of the Pacific Ocean associated with a series of volcanoes and deep-ocean trenches known as "The Ring of Fire". Therefore, the largest source region for tsunamis is in the Pacific Ocean with 71% of all occurrences. As a result the 1929 Grand Banks Tsunami was a very rare event and a shock to the people of the Burin Peninsula.

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