Mega - Tsunamis

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Mega-tsunamis are defined as waves of over 100-meter height in the deep ocean. The primary source of mega-tsunamis are asteroid impacts with the ocean, volcanic explosions, and landslides. A mega-tsunami did occur in 1958 in Lituya Bay, Alaska; however the mechanism of its formation is uncertain. Various models for the event are described in [1].

Lituya Bay, Alaska is on the northeast shore of the Gulf of Alaska. It is an ice-scoured tidal inlet with a maximum depth of 220 meters and a narrow entrance with a depth of only 10 meters. It is a T-shaped bay, 7-miles long and up to 2-miles wide. The two arms at the head of the bay, Gilbert and Crillon Inlets, are part of a trench along the the Fairweather Fault. On July 8, 1958, a 7.5-magnitude earthquake occurred along the Fairweather fault with an epicenter near Lituya Bay.

A mega-tsunami wave was generated that washed out trees to a maximum altitude of 520 meters at the entrance of Gilbert Inlet.

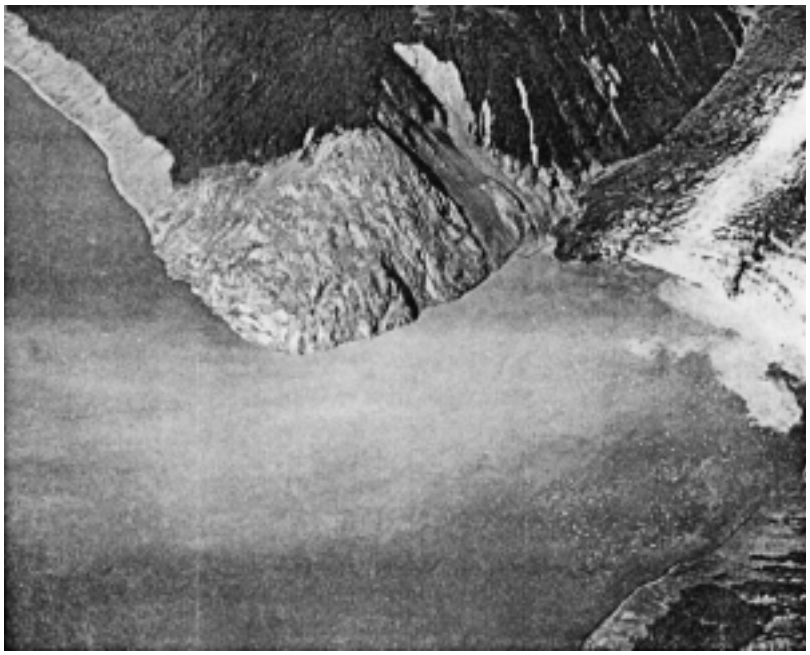

Figure 1: Photograph of where mega-tsunami reached 520 meters in Lituya Bay, Alaska on July 9, 1958.

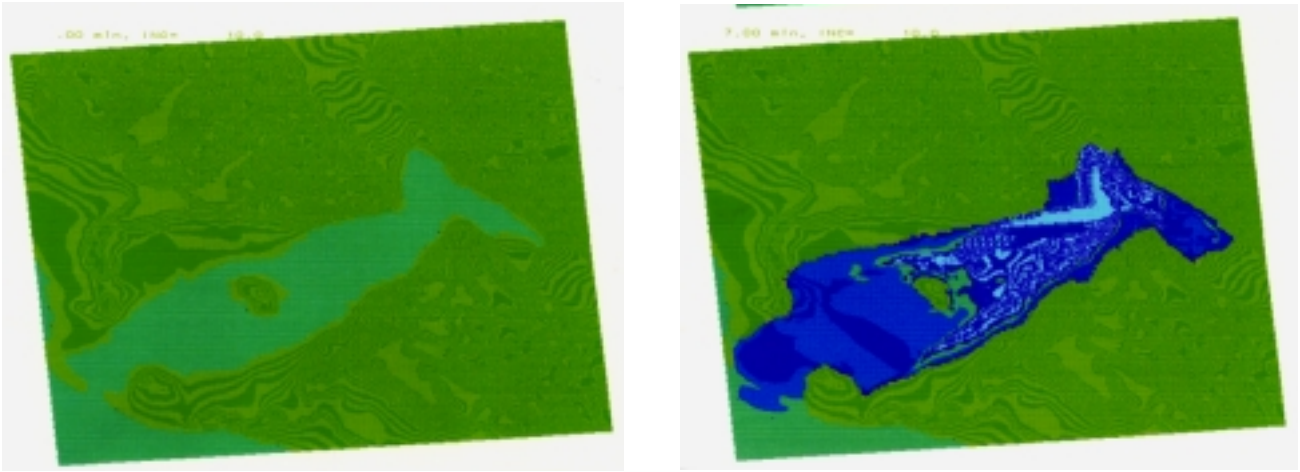

Figure 2: The Lituya Bay numerical model initial condition and the calculated level of maximum flooding in the bay. The contour interval is 10 meters. The 520-meter-high tsunami inundation area is the triangular dark blue region in the upper right of the figure.

A photograph of the region is shown in Figure 1. Much of the rest of the shoreline of the Bay was denuded by the tsunami from 30 to 200 meters altitude.

During the last 150 years, five giant waves have occurred in Lituya Bay. The previous event occurred on October 27, 1936, it washed out trees to a maximum altitude of 150 meters and was not associated with an earthquake.

The July 9, 1958 earthquake occured at about 10:15 p.m. which is still daylight at Lituya Bay. The weather was clear and the tide was ebbing at about plus 1.5 meters. Bill and Vivian Swanson were on their boat anchored in Anchorage Cove near the western side of the entrance of Lituya Bay. Their astounding observation was as follows:

> *"With the first jolt, I tumbled out of the bunk and looked toward the head of the bay where all the noise was coming from. The mountains were shaking something awful, with slide of rock and snow, but what I noticed mostly was the glacier, the north glacier, the one they call Lituya Glacier.*
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> *I know you can't ordinarily see that glacier from where I was anchored. People shake their heads when I tell them I saw it that night. I can't help it if they don't believe me. I know the glacier is hidden by the point when you're in Anchorage Cove, but I know what I saw that night, too.*
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> *The glacier had risen in the air and moved forward so it was in sight. It must have risen several hundred feet. I don't mean it was just hanging in the air. It seems to be solid, but it was jumping and shaking like crazy. Big chunks of ice were falling off the face of it and down into the water. That was six miles away and they still looked like big chunks. They came off the glacier like a big load of rocks spilling out of a dump truck. That went on for a little while—its hard to tell just how long—and then suddenly the glacier dropped back out of sight and there was a big wall of water going over the point. The wave started for us right after that and I was too busy to tell what else was happening up there."*

The front of Lituya Glacier on July 10 was a nearly straight, vertical wall almost normal to the trend of the valley. Comparisions with photographs of the glacier taken July 7 indicate that 400 meters of ice had been sheared off of the glacier front.

After the earthquake there was a fresh scar on the northeast wall of Gilbert Inlet, marking the recent position of a large mass of rock that had plunged down the steep slope into the water. The volume of the rockfall was approximately 30 million cubic meters (40 million cubic yards). The Swanson observations and numerical modeling studies (1) indicate that a lot more than a simple landslide had to occur to produce a 520-meter-high wave. The Swanson observations suggest a water wave lifted the front of the glacier up and moved it out from its initial position and generated the 520-meter-high-wave run-up.

George Pararas-Caryannis (2) suggested that the wave was formed by a landslide impact similar to an asteroid impact, making a cavity in the inlet ocean to the depth of the inlet floor (120 meters) near the landslide. The water in the inlet with the width of the landslide and between the landslide and the 520-meter-high run-up is sufficient to cover the run-up region to 100 meter height. Using the shallow water code SWAN described in reference 3, it was determined that this water layer is sufficient to form a wave that will reproduce the observed flooding of the bay beyond the inlet. The results of the model are shown in Figure 2. It is not known how a landslide impact could result in the observed movement of the water and glacier.

The Tlingit natives believe that a powerful spirit, Kah Lituya, lives in deep ocean caverns near the entrance to the bay. He resents being disturbed and rises up to shake the mountains and wash away intruders with giant waves.

[1] Charles L. Mader, "Modeling the 1958 Lituya Bay Mega-Tsunami," *Science of Tsunami Hazards* **17,** pages 57-67 (1999).

[2] George Pararas-Carayannis, "Analysis of Mechanism of Tsunami Generation in Lituya Bay," S*cience of Tsunami Hazards* **17**, pages 193-206 (1999).

[3] Charles L. Mader, **Numerical Modeling of Water Waves**, UC Press (1988).

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