

SECTION 3.9 INTRODUCTION

3.9 Case Study

**The Alaska Earthquake of 1964:
Largest in North America**

▣ 1 class period*

Overview

This is an independent activity for the students to read more about a famous earthquake and apply some of the things they have learned in this *Learning Set*. This reading activity can be broken into sections for students to do as homework or to help with class multi-tasking during computer time (if needed).

*A class period is considered to be one 40 to 50 minute class.

Targeted Concepts, Skills, and Nature of Science	Performance Expectations
Scientific investigations and measurements are considered reliable if the results are repeatable by other scientists using the same procedures.	Students should use information from various sources to find trends and make claims.
Scientists make claims (conclusions) based on evidence obtained (trends in data) from reliable investigations.	Students should make claims about what happened in plate boundary regions and how these plates were interacting based on evidence.
Explanations are claims supported by evidence, accepted ideas, and facts.	Students should construct explanations about why the earthquakes are happening based on plate interactions.
Scientists measure and record earthquake activity using the Richter scale and the Mercalli Scale. The Richter scale is used for measuring the magnitude of an earthquake. The Mercalli Scale is used to measure the intensity.	Students use the Mercalli Scale to describe what they may have felt if they lived in various locations of an earthquake region.

Targeted Concepts, Skills, and Nature of Science	Performance Expectations
<p>Earthquake activity, volcanic activity, and topography are all evidence that Earth's crust is moving and changing.</p>	<p>Students should make claims of plates moving based on the earthquake evidence provided.</p>
<p>Interactions between Earth's crustal plates can result in mountain-building, rift valleys, and geologic activity such as earthquakes and volcanoes. Underwater volcanic activity may form underwater mountains, which can thrust above the ocean's surface to become islands.</p>	<p>Students should construct an explanation for an earthquake and how the plates are moving based on data provided.</p>

Homework Options

Reflection

- Science Content and Process:** Complete *Section 3.9* if students have not completed it in class. *(Students should describe the reasons for others agreeing or disagreeing with their plate boundary predictions.)*

Preparation for Back to the Big Question

- Science Content:** Based on what you know now, explain the changes happening in the region of your Earth structure. *(In the BBQ, students revisit the Unit's Big Question: How can you explain the changes happening in the region of your Earth structure?, and revise their explanations.)*

SECTION 3.9 IMPLEMENTATION

□ 1 class period*

3.9 Case Study

The Alaska Earthquake of 1964: Largest in North America

On March 27, 1964, at 5:36 in the evening local time, a 9.2 magnitude earthquake shook Prince William Sound, Alaska. This was the largest earthquake in Alaska's history and the largest ever recorded in North America. This great earthquake led to the loss of 125 lives and caused about \$311 million in property damage.

The largest city in the state, Anchorage, sustained the most severe damage to property. About 30 blocks of homes and businesses were destroyed in the downtown area. New multi-story buildings crumbled and collapsed. As seen in the picture, the Government Hill Grade School, was destroyed by a huge landslide that was caused by the earthquake.



The Government Hill Grade School was destroyed by a landslide during the 1964 Alaska earthquake.

The estimated duration of the initial shock was three to five minutes, but the vibrations were felt around the world. The earthquake was felt over a large area of Alaska, in parts of the western Yukon Territory, and British Columbia, Canada. In places as far away as Arkansas, Louisiana, and Texas there were reports of waters in rivers, lakes, and protected harbors sloshing back and forth and clouding up.

3.9 Case Study

The Alaska Earthquake of 1964: Largest in North America

This section was designed for students to complete independently. The answers to the questions in the Case Study are provided below. It is important to provide feedback to students. You may want to go over these answers as a class.

*A class period is considered to be one 40 to 50 minute class.

Modified Mercalli Scale	
I	Not felt except by a very few under especially favorable conditions.
II	Felt only by a few persons at rest, especially on upper floors of buildings.
III	Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated.
IV	Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.
V	Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.
VI	Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.
VII	Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.
VIII	Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.
IX	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
X	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.
XI	Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bent greatly.
XII	Damage total. Lines of sight and level are distorted. Objects thrown into the air.



This is an intensity map for the 1964 Alaska earthquake.

Stop and Think

(≈ 10 min.)

Stop and Think

1. Look at the intensity map and the Modified Mercalli Scale. Describe what you might have experienced if you live in the following locations in Alaska in 1964: Nome, Fairbanks, Kodiak, Anchorage, and Yakutat.
2. How long did the initial shock last?
3. After reading the following first-hand account, written 40 years after the earthquake by David Rice, determine what intensity zone he had lived in. Explain your reasoning.



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1. Nome, Alaska: Level III-IV. The earthquake would have been felt quite noticeably indoors, maybe outdoors. Cars would have rocked; dishes, windows, and doors would have been disturbed; walls would have made cracking sounds. It might have felt as though a large truck was passing or striking a building.

Fairbanks, Alaska: Level VI. Heavy furniture would move; some plaster might have fallen; there is only slight damage, but it was a frightening experience.

Kodiak Island, Alaska: Level VII. There would be negligible damage to buildings of good design and construction; slight to moderate damage in well-built ordinary structures; considerable damage in poorly built or badly designed structures; and some chimneys broken.



"In 1964 I was seven. I lived on Ash Place in Government Hill about two blocks from the elementary school, which I attended. I was sledding on our favorite hill on the other side of E. Loop Rd. and was walking up the hill when the first tremor hit. The first thing I remember was the water tower at the top of the hill making a lot of noise. My worst fear during the whole thing was that the tower would fall on me! After losing my footing and sliding to the bottom of the hill, I tried to stand up, but the earth was moving in waves. It was like being on the surface of the ocean, with waves of earth passing underneath me. The next thing I noticed was spruce trees hitting the ground on either side as these waves passed underneath them. Next were the cracks in the earth propagating around me. I remember seeing 2-3" cracks opening up and running for tens of feet. It is amazing how, after 40 years, the memories of that thirty minutes are still so vivid.

My oldest brother has even better stories. He was 17 and was moving furniture on the third (top) floor of the JC Penney building when the outside walls fell away. He remembers looking out of the building and seeing the destruction in the Fourth St. areas as it was happening."

What happened after the initial earthquake?

The great Alaska earthquake not only destroyed towns, it also changed the geology and topography of the region. The initial earthquake occurred about 14 miles (23 km) below the surface of Earth. This resulted in numerous landslides in the area. Some of these landslides cascaded into the sea and generated harbor waves as high as 100 feet above normal tide in some places. Other landslides occurred on land. In more populated areas, such as Anchorage, a landslide destroyed houses and broke water and gas mains, sewers, telephone lines, and electrical systems.

The ground lifted in some places and went down, or sank, in other places. In some places the ground lifted as much as 12 feet. At Montague Island the ground lifted 13-15 feet from where it was before. Places that were below sea level were now above sea level. On the next page you can see in the picture of the dock on Hinchinbrook Island how the land changed. The ground under the dock rose about eight feet. The dock is now unusable, except during extremely high tides.

All this movement also generated local and Pacific wide tsunamis that devastated many towns along the Gulf of Alaska. **Tsunamis** are large sea waves generated by seismic activity, particularly when underwater earthquakes occur. Reports of damage were recorded all across the Pacific.

tsunami: large sea waves generated by seismic activity.

Anchorage, Alaska: Level VIII-X, but probably closer to the level VIII zone. There would be fallen chimneys, factory stacks, columns, monuments, and walls. Heavy furniture would be overturned, and there would be substantial damage to buildings, with partial collapses.

Yakutat, Alaska: Level VI. Heavy furniture would move; some plaster might have fallen; there is only slight damage, but it was a frightening experience.

2. The initial shock lasted 3-5 minutes.
3. Student responses should be Level VIII or near that. Explanations will vary but should include evidence such as the wall collapsing at the building where his brother worked.

3.9 Case Study



The ground under this dock on Hinchinbrook Island, Prince William Sound, rose about 8 ft during the 1964 Alaska earthquake.

The largest wave height reported for this tsunami was 67 meters at Shoup Bay, Alaska. The Pacific-wide tsunami also hit the coasts of California, Washington, and Oregon. It resulted in the deaths of 17 people in those states and millions of dollars in damage. In Oregon, much of the damage was away from the coast where rivers overflowed. Waves and water levels rose in Hawaii. The coastal towns of British Columbia were also impacted by the tsunami. The tsunami raced across the Pacific Ocean at speeds over 400 miles per hour.

Below are clips of radio traffic that followed the earthquake. Since radio messages are full of shorthand, a translation is written above the real message in bold type. The initial earthquake started at 3:36 UTC. The first radio message here was heard about two hours after the initial earthquake. While you are reading, look for descriptions of the tsunamis, which are sometimes referred to as tidal waves. In the messages, "Z" is shorthand for UTC time or Greenwich Mean Time. A ham radio operator is an independent radio operator.

5:27Z a message came from the Honolulu Observatory in Hawaii. This was a severe tidal wave/seismic sea wave advisory. The message stated that an earthquake occurred in the vicinity of Seward, Alaska at 3:36Z. It was not known if a sea wave had been generated. If the wave had been generated, the estimated time of arrival at the Hawaiian Islands was March 28 at 9:00Z.



THIS IS BULLETIN NUMBER 001.

THIS IS A TIDAL WAVE/SEISMIC SEA WAVE ADVISORY.

A SEVERE EARTHQUAKE HAS OCCURRED LAT 61N LONG 147.5W VICINITY OF SEWARD, ALASKA AT 0336Z 28 MARCH. IT IS NOT KNOWN REPEAT NOT KNOWN AT THIS TIME THAT A SEA WAVE HAS BEEN GENERATED. YOU WILL BE KEPT INFORMED AS FURTHER INFORMATION BECOMES AVAILABLE. IF A WAVE HAS BEEN GENERATED, ITS ETA FOR THE HAWAIIAN ISLANDS/ HONOLULU IS 0900Z 28 MARCH.

5:28Z a message was heard on the Navy communications radio. The message stated that a coast guard boat had suffered severe damage at 3:35Z. Water was reported draining from the Lisianski Inlet at approximately 4:00Z. Water was also reported draining from Kodiak Bay. A marine operator reports that the town of Valdez was leveled and the dock disappeared. Bodies were being recovered. The waterfront at the town of Seward was set afire. A ham radio operator reports water covering the airstrips in Anchorage.

1. CGLORSTA SITKINAK SUFFERED SEVERE DAMAGE 280335Z.
2. WATER REPORTED DRAINING FROM LINIANSKI INLET APPROX 280400Z. WATER REPORTED DRAINING FROM KODIAK BY AT 282050Z.
3. MARINE OPERATOR REPORTS VALDEZ LEVELED, DOCK DISAPPEARED, BODIES BEING RECOVERED, WATERFRONT AT SEWARD SET AFIRE.
4. HAM OPERATOR REPORTS WATER COVERING AIRSTRIPS ANCHORAGE AREA.
5. FURTHER INFO AS OBTAINED.

5:28Z a message was heard on the Navy communications radio. The Alaska Communications System in Ketchikan received word from Seattle that a tidal wave was on the way to Kodiak Island.

ACS (ALASKA COMMUNICATIONS SYSTEM) KETCHIKAN RECEIVED WORD FROM SEATTLE TO ADVISE KODIAK THAT A TIDAL WAVE IS ON THE WAY TO KODIAK.

5:47Z this message came from a United States Coast Guard boat named the Sedge. The boat was aground in the middle of the

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NOTE: The radio messages in the student text are provided in the all capital lettering. An interpretation of the message is provided in bold type above the actual message.

Kodiak Channel. The tide was at minus 30 feet. The boat had communication with Cape Sarichef.

WE ARE AGROUND IN THE MIDDLE OF KODIAK CHANNEL AT POSIT 60-37.5n 145-41.4W.

WE HAVE A MINUS 30 FT TIDE. WE HAVE COMMUNICATIONS WITH CAPE SARICHEF.

6:36Z the message came from Kodiak, Alaska. The message stated that a seismic tidal wave (tsunami) had been generated and was spreading over the Pacific Ocean. The intensity could not be predicted and could cause severe damage.

A SEISMIC TIDAL WAVE HAS BEEN GENERATED AND SPREADING OVER THE PACIFIC.

INTENSITY CANNOT BE PREDICTED. COULD CAUSE SEVERE DAMAGE.

6:59Z this message came from a United States Coast Guard boat named the Sedge. The Sedge was now afloat and on its way to the town of Valdez. The boat had no apparent damage. The sea water was now at 15 feet below the mean low water level.

1. SEDGE AFLOAT AND UNDERWAY TO VALDEZ. NO APPARENT DAMAGE.

2. WATER IS NOW 15 FEET BELOW MEAN LOW WATER.

7:20Z this message was heard on the Navy communications radio. A ham radio operator reported that the villages on Kaiugnak Bay and Kodiak Island were wiped out. The water levels in the town of Yakutat were reported as rising fast.

1. HAM OPERATOR REPORTS VILLAGE ON KAIUGNAK BAY, KODIAK ISLAND WIPED OUT.

2. WATER REPORTED RISING FAST AT YAKUTAT.

7:28Z this message was sent from Kodiak, Alaska to Honolulu Observatory in Hawaii. This radio message stated that a tsunami was generated. The message described the water levels at Kodiak as follows: 4:35Z the water was at about 15 feet above mean sea level. At 5:40Z high water levels at about 18 feet above mean sea level. At 6:30Z the high water levels are at 15 feet above sea level. At 6:44Z, six feet above mean sea level. The message also



reported that wave heights were decreasing rapidly. At 7:15Z wave action was reported as only slight.

TSUNAMI. HIGH WATER LEVELS REACHED 280435Z ABOUT 15 FEET ABOVE MEAN SEA LEVEL. 280540Z HIGH WATER ABOUT 18 FEET ABOVE MSL. 280630Z ABOUT 15 FEET ABOVE MSL. 280644Z HIGH WATER ABOUT 6 FEET ABOVE MSL. AMPLITUDE RAPIDLY DECREASING. TIDE GAUGE INOPERATIVE SINCE 280332Z. FURTHER COMMUNICATIONS PENDING RESTORATION MAJOR COMMUNICATION LINKS. 280715Z WAVE ACTION ONLY SLIGHT. APPEARS TO BE DAMPENED OUT COMPLETELY.

11:00Z the Honolulu Observatory sent a message summarizing the tsunami activity across the Pacific. The message stated that the larger waves had apparently passed Hawaii and issued an all clear status for Hawaii at 11:00Z. The message also reported wave heights for a variety of locations across the Pacific Ocean.

Oahu, Hawaii – 8 feet Hawaii, Hawaii – 6 feet Miewas – 1.5 feet
Kauai, Hawaii – 3 feet Kodiak, Hawaii – 30 feet
Cordova, California – 30 feet Tofino, British Columbia – 8 feet
Crescent City, California – 12 feet

THIS IS BULLETIN NUMBER 004.

THIS IS A TIDAL WAVE/SEISMIC SEA WAVE INFORMATION BULLETIN. THE LARGER WAVES HAVE APPARENTLY PASSED HAWAII. AN ALL CLEAR STATUS FOR HAWAII CAN BE ASSUMED AT 1100Z. ALL PARTICIPANTS IN THE SSAWS SHOULD ASSUME THE ALL CLEAR STATUS TWO HOURS AFTER THEIR PARTICULAR ETA UNLESS LOCAL CONDITIONS WARRANT THE CONTINUANCE OF THE ALERT STATUS. MAXIMUM WAVE HEIGHTS REPORTED BY VARIOUS MEDIA ARE:

OAHU – 8 FEET HAWAII – 6 FEET MIEWAS – 1.5 FEET
KAUAI – 3 FEET KODIAK – 30 FEET CORDOVA – 30 FEET
TOFINO – 8 FEET CRESCENT CITY – 12 FEET

HONOLULU OBSERVATORY

15:55Z this message was heard. At the north end of the town of Kodiak, the lower areas, houses are floating. One appears to be floating in the lake area.

NORTH END OF TOWN (KODIAK), LOWER AREA, HOUSES ARE FLOATING, ONE APPEARS LAKE AREA.

23:14Z this message was heard on the Navy command radio. Slight tremors were reported from Hinchinbrook. Tremors are felt every five to ten minutes with a hard jolt every twenty to thirty minutes. These jolts rock buildings severely. Tremors are continuing.

CGLTSTA CAPE HINCHINBROOK REPORTS SLIGHT TREMORS ARE FELT EVERY FIVE TO TEN MINUTES WITH HARD JOLT EVERY TWENTY TO THIRTY MINUTES, WHICH ROCKS BUILDING SEVERELY. TREMORS CONTINUING.

Stop and Think

(≈ 15 min.)

Stop and Think



1. The initial earthquake happened at 3:36Z. The Honolulu Observatory sent out a message indicating that they were unsure if a tsunami wave was generated, but estimated an arrival time to Hawaii. About how many hours after the initial earthquake did the Observatory expect the tsunami wave to hit Hawaii?
2. At 5:27Z, Honolulu was not sure if a tsunami was generated, but the people in and around the epicenter of the earthquake had observed warning signs that a tsunami was generated as early as 4:00Z and again at 5:47Z. What did these two radio operators observe and report that indicated a tsunami wave was generated?
3. A message was sent from Seattle that a tidal wave (tsunami) was on its way to Kodiak Island. What time was this warning sent?
4. At 7:28Z a message was sent from Kodiak, Alaska to the Honolulu Observatory describing the wave and water levels during the past several hours. About what time did the tsunami wave hit Kodiak, Alaska?
5. About how long did the tsunami waves last at Kodiak Island?
6. At 6:36Z a message came from Kodiak, Alaska warning that a Pacific-wide tsunami had been generated. How many hours after the initial earthquake was this warning sent? Was this warning sent out before or after Kodiak was hit with tsunami waves?
7. From the radio messages, describe what happened to Kodiak Island after the tsunami.

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EARTH STRUCTURES AND PROCESSES

1. The Observatory expected the tsunami waves at 9:00Z, 5.5 hours after the initial earthquake.
2. At 4:00Z the radio handler reported that water was draining from the Lisianski Inlet, and at 5:47Z there were reports of the tide in the Kodiak Channel being at minus 30 ft. These are sure signs that a tsunami is being generated.
3. The warning was sent at 5:28Z.
4. The tsunami hit Kodiak, Alaska around 4:35Z.
5. The waves lasted from 4:35Z until 7:15Z, approximately 2 hours and 40 minutes.



8. The Honolulu Observatory reported 30 foot waves at Kodiak, Alaska. What other town was hit with 30 foot waves?
9. The New Madrid, Missouri earthquake was destructive and devastating to people and the geology of the area because of the sedimentary nature of the ground. What made this Alaskan earthquake so destructive and impact such a large area?
10. The last radio message in the list describes the tremors that followed the earthquake. How many hours after the initial earthquake were these tremors and jolts being felt?
11. According to the United States Geological Survey, in the first day there were eleven aftershocks with magnitude greater than 6.0 on the Richter Scale. During the next three weeks there were nine more. Smaller aftershocks continued for more than a year. How would you describe this experience? What was happening in this region for a year? Remember: Earthquake magnitudes 4 to 6 are always felt and result in minor damage. Earthquakes with magnitudes larger than 6 are felt by everyone, and there is much damage and devastation.
12. Which plate did this great earthquake occur on? What plate is interacting with this plate to have caused this earthquake?
13. How would you explain this earthquake? What do you think is happening where these two plates meet?



6. The warning was sent exactly three hours after the initial earthquake. The warning was sent after Kodiak was hit with tsunami waves.
7. The radio messages indicate that after the tsunami, there had been so much damage that houses were floating in the water.
8. The town of Cordova, California was hit with 30-ft waves.
9. The large tsunami that was generated is what made the earthquake so destructive; the waves affected an area much larger than the immediate zone where the earthquake hit.
10. The earthquake began at 3:6Z, and the tremors were being reported at 23:14Z—that's almost 20 hours (approximately 19 hours and 40 minutes) after the initial earthquake.

11. The region had been shaking for more than a year. The first day there was a series of smaller quakes that were felt and minor damage broken up by larger quakes that everyone would feel. There was a large amount of damage and devastation. Just when the people thought that it was calming down, another devastating quake would be felt.
12. The earthquake in Prince William Sound, Alaska happened on the North American Plate. The North American Plate is interacting with the Pacific Plate.
13. The two plates are bumping into each other.

Teacher Reflection Questions

- What difficulties did students have with interpreting and applying the Mercalli Scale?
- What pros and cons occurred during this independent activity?
- What management issues arose with this independent activity and what ideas do you have on how to address these next time?