

Department of Education
National Capital Region

**SCHOOLS DIVISION OFFICE
MARIKINA CITY**

Disaster Readiness and Risk Reduction

First Quarter-Module 10

Earthquake and Tsunami Hazards

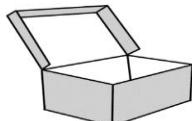


Maybele L. Roa



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What I Need to Know

This module was designed and written with you in mind. It is here to help you master earthquake and tsunami hazards. The scope of this module permits it to be used in many different learning situations. The language used recognizes the diverse vocabulary level of students.

The module is divided into two lessons, namely:

- Lesson 1 – Earthquake Hazard
- Lesson 2 – Tsunami Hazard

After going through this module, you are expected to **develop a family emergency preparedness plan to guide them on what to do before, during, and after an earthquake.**

Specifically, students should be able to

1. identify various potential earthquake hazards; (DRR11/12-If-g-17); and
2. recognize the natural signs of an impending tsunami (DRR11/12-If-g-18).



What I Know

Read each question carefully and encircle the letter of the correct answer.

1. Which of the following is **NOT** the cause of earthquake in the Philippines?
 - A. Our country lies between two tectonic plates.
 - B. Philippines is within the subduction zones called the ring of fire.
 - C. Our country is an archipelago consisting of almost 7100 islands and islets.
 - D. The areas surrounding the Philippine Sea plate are very active, producing numerous geological processes.
2. The seismic activity of an area exposed to earthquake over a period of time is dependent on the following factors **EXCEPT** for what?

A. Size of earthquake	C. Location of earthquake
B. Type of earthquake	D. Frequency of earthquake
3. Which of the following is **NOT TRUE** about earthquake's intensity?
 - A. It is written in Roman Numerals (ex: I, IV, or X).
 - B. It is the energy released by an earthquake at the focus.
 - C. It refers to the strength of earthquake as felt by people in certain area.
 - D. It is a rating based on the effects of earthquake to people and properties.



4. Which kind of earthquake is likely to happen if a certain house is located near an area where construction is always ongoing?
- A. Tectonic earthquake
 - B. Volcanic earthquake
 - C. Human-induced earthquake
 - D. Earthquake-induced landslide
5. Which of the following is **NOT** an indication of an incoming earthquake?
- A. Change in the color of the soil
 - B. Sudden uplifting of earth surface
 - C. Presence of large oil flow from oil wells
 - D. Rise in water level at any bodies of water
6. After an earthquake, you found your floor moist, and there were some water coming out of the cement cracks. What resulted to this event?
- A. Your house is actually too old.
 - B. There was water overflow nearby.
 - C. Liquefaction occurred beneath your house.
 - D. The cement used in your house was of low quality.

For numbers 7-9, use the following pictures inside the box.



7. Which of the following pictures show an example of ground shaking?
8. Which of the following pictures show an example of ground rupture?
9. Which of the following pictures show an example of liquefaction?
10. Which of the following statements is **NOT TRUE** about a tsunami?
- A. It can cause flooding to lowlands.
 - B. It can lead to greater earthquakes.
 - C. It can result to erosion in coastal areas.
 - D. It can be the reason of loss of lives due to drowning.



11. Which of the following is **NOT** the cause of tsunami?
- A. Icefalls
 - B. Landslide
 - C. Ground rupture
 - D. Volcanic eruption
12. Which of the following kinds of tsunami is relatively close within a hundred kilometers from the source of tsunami?
- A. Local tsunami
 - B. Distant tsunami
 - C. Regional tsunami
 - D. Far Field tsunami
13. Which of the following statements **DOES NOT** describe distant tsunami?
- A. It can travel wide across a wide path.
 - B. It is also known as ocean-wide tsunami.
 - C. It is an extremely powerful kind of tsunami.
 - D. It can reach the coast so fast that there will be no enough time to evacuate.
14. Which of the following is **NOT** a factor used by scientists to estimate the time of arrival of tsunami?
- A. Depth of water
 - B. Height of tsunami
 - C. Distance from the coastline
 - D. When the tsunami happened
15. Which of the following is **NOT** an indicator of an incoming tsunami?
- A. Rapidly rising tide
 - B. Presence of water turbulence
 - C. Some heavy objects being thrown
 - D. Sudden change in air temperature



Lesson 1

Earthquake Hazards

The Philippines is an archipelago consisting of almost 7100 islands and islets. It is located in Southeast Asia in the Western Pacific Ocean near the equator. Our country lies between two tectonic plates. The Pacific plate at the east is beneath the Philippine Sea plate, and into our west side lies the Eurasian plate. The areas surrounding the *Philippine Sea plate* are very active, producing numerous local earthquakes, volcanic activities, mass movement, and other related geological processes. Our country is also part of the so called circum-Pacific Seismic Belt, and is within the subduction zones called the *ring of fire*. Geologic hazards such as earthquakes, the landslides they induce, and volcanic eruptions are concentrated in this ring of fire, and the seismic sea waves called *tsunamis* most commonly originate from earthquake shocks there as well.



What's In

You may have heard, read on the news, or discussed in our class about different disasters such as earthquake and tsunami. Many of us, like you, might have experienced such disasters.

Activity 1.1. What I See

In a separate sheet, draw a scenario where it shows that an earthquake occurred in a certain place. It might be something you have read, seen, or even experienced. Include 2-3 sentences to describe your illustration.

A large, empty rectangular box with a thin black border, intended for students to draw their illustration of an earthquake scenario.

What's New

Activity 1.2. Match with the Pictures

An earthquake is such a disastrous event that it sometimes leads to other kinds of disaster. Can you name the following events that usually come before, during or after earthquake? Choose your answers from the words found inside the box below. Write your answers on a separate sheet of paper.

Ground rupture
Liquefaction

Ground shaking
Subsidence

Landslide
Tsunami



1. _____

2. _____



3. _____

4. _____



5. _____

6. _____





What Is It

Earthquake

An **earthquake** refers to weak to violent shaking of the underground due to the sudden movement of rock materials found below the earth's surface. The earthquakes originate in tectonic plate boundary. Earthquakes occur along the fault lines that exist throughout the globe. **Seismic waves** resulted from the sudden release of energy in the earth's crust. The seismic activity of an area depends on the frequency, type, and size of earthquakes experienced over a period of time. **Earthquake fault zones** are areas of surface or underground fracturing that can experience earthquakes. The **hypocenter or focus** is a point inside the earth where the earthquake originates, while **epicenter** is the point on the surface of the earth directly above the focus.

There are two ways by which we can measure how powerful an earthquake is, it is through magnitude and intensity. Magnitude is equal to the energy released by an earthquake at the hypocenter or focus. It is measured by using an instrument called seismograph. Arabic Numbers such as 4.8, 9.0 are used to tell the magnitude of an earthquake. On the other hand, Intensity refers to the strength of an earthquake as perceived and felt by people in a certain area. It is a numerical rating based on the effects of earthquake to people, objects, environment, and surrounding structures. The intensity is usually higher near the epicenter. It is represented by Roman Numerals (e.g. II, IV, IX). In the Philippines, the intensity of an earthquake is measured using the PHIVOLCS* Earthquake Intensity Scale (PEIS).

*PHIVOLCS – Philippine Institute of Volcanology and Seismology

An earthquake can be explained simply as this: If you throw stone in a pond of still water, series of waves then appear on the surface of water. These waves spread out in all directions from the place where the stone strikes directly at the water. Likewise, any sudden movement in the earth's crust may produce vibration in the crust which will travel in all direction from the point of disturbances.

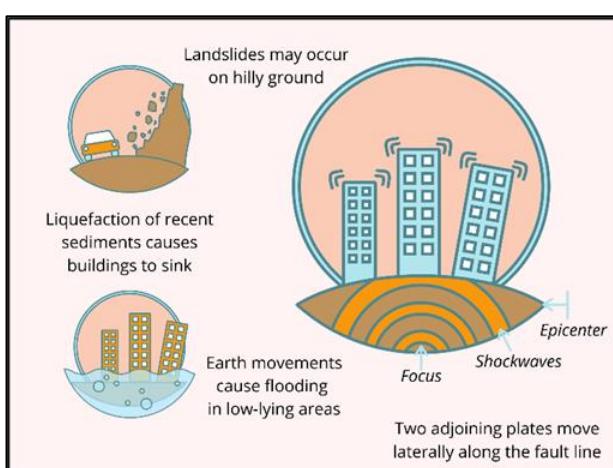


Figure 1.1. The illustration above shows the focus and epicenter of an earthquake



Table 1.1. PHIVOLCS Earthquake Intensity Scale (PEIS)

Intensity Scale	Shaking	Description
I	Scarcely Perceptible	Perceptible to people under favorable circumstances. Delicately balanced objects are disturbed slightly. Still Water in containers oscillates slowly.
II	Slightly Felt	Felt by few individuals at rest indoors. Hanging objects swing slightly. Still Water in containers oscillates noticeably.
III	Weak	Felt by many people indoors especially in upper floors of buildings. Vibration is felt like one passing of a light truck. Dizziness and nausea are experienced by some people. Hanging objects swing moderately. Still water in containers oscillates moderately.
IV	Moderately Strong	Felt generally by people indoors and by some people outdoors. Light sleepers are awakened. Vibration is felt like a passing of heavy truck. Hanging objects swing considerably. Dinner, plates, glasses, windows and doors rattle. Floors and walls of wood framed buildings creak. Standing motor cars may rock slightly. Liquids in containers are slightly disturbed. Water in containers oscillate strongly. Rumbling sound may sometimes be heard.
V	Strong	Generally felt by most people indoors and outdoors. Many sleeping people are awakened. Some are frightened, some run outdoors. Strong shaking and rocking felt throughout building. Hanging objects swing violently. Dining utensils clatter and clink; some are broken. Small, light and unstable objects may fall or overturn. Liquids spill from filled open containers. Standing vehicles rock noticeably. Shaking of leaves and twigs of trees are noticeable.
VI	Very Strong	Many people are frightened; many run outdoors. Some people lose their balance, motorists feel like driving in flat tires. Heavy objects or furniture move or may be shifted. Small church bells may ring. Wall plaster may crack. Very old or poorly built houses and man-made structures are slightly damaged though well-built structures are not affected. Limited rockfalls and rolling boulders occur in hilly to mountainous areas and escarpments. Trees are noticeably shaken.
VII	Destructive	Most people are frightened and run outdoors. People find it difficult to stand in upper floors. Heavy objects and furniture overturn or topple. Big church bells may ring. Old or poorly-built structures suffer considerably damage. Some well-built structures are slightly damaged. Some cracks may appear on dikes, fish ponds, road surface, or concrete hollow block walls. Limited liquefaction, lateral spreading and landslides are observed. Trees are shaken strongly. (Liquefaction is a process by which loose saturated sand lose strength during an earthquake and behave like liquid).
VIII	Very Destructive	People are panicky. People find it difficult to stand even outdoors. Many well-built buildings are considerably damaged. Concrete dikes and foundation of bridges are destroyed by ground settling or toppling. Railway tracks are bent or broken. Tombstones may be displaced, twisted or overturned. Utility posts, towers and monuments may tilt or topple. Water and sewer pipes may be bent, twisted or broken. Liquefaction and lateral spreading cause man-made structure to sink, tilt or topple. Numerous landslides and rockfalls occur in mountainous and hilly areas. Boulders are thrown out from their positions particularly near the epicenter. Fissures and faults rupture may be observed. Trees are violently shaken. Water splash or stop over dikes or banks of rivers.
IX	Devastating	People are forcibly thrown to ground. Many cry and shake with fear. Most buildings are totally damaged, bridges and elevated concrete structures are toppled or destroyed. Numerous utility posts, towers and monument are tilted, toppled or broken. Water sewer pipes are bent, twisted or broken. Landslides and liquefaction with lateral spreadings and sandboils are widespread, the ground is distorted into undulations. Trees are shaken very violently with some toppled or broken. Boulders are commonly thrown out. River water splashes violently on slopes over dikes and banks.
X	Completely Devastating	Practically all man-made structures are destroyed. Massive landslides and liquefaction, large scale subsidence and uplifting of land forms and many ground fissures are observed. Changes in river courses and destructive seiches in large lakes occur. Many trees are toppled, broken and uprooted.

Source: <http://www.phivolcs.dost.gov.ph/index.php/earthquake/earthquake-intensity-scale>



Causes of Earthquake

As mentioned, Philippines is prone to earthquakes due to our location at the Ring of Fire, also known as Circum-Pacific Belt. It is a path along the Pacific Ocean characterized by active volcanoes and frequent earthquakes.

Being situated at the Typhoon Belt with large bodies surrounding our country, Philippine weather is greatly affected, and this results to change in temperature of the surroundings, leading to possibility of earthquakes. Lastly, the effect of climate change in the temperature of the whole planet that can lead also to geological hazards.

In general, there are different types of earthquake, depending on its origin or causes.

1. **TECTONIC EARTHQUAKES** are caused by plate tectonics, or where tectonic plates meet (boundary). These type of earthquakes account for most earthquakes worldwide.

Types:

- a. Divergent boundary (due to compression) formed from *Normal Fault*.
Mid-ocean ridges can be formed here.
- b. Convergent boundary (due to tension) formed from *Reverse Fault*.
This can create mountain or subduction zones.
- c. Strike-slip Fault (due to shearing) formed from *Transform Fault*. The movement creates deformation.

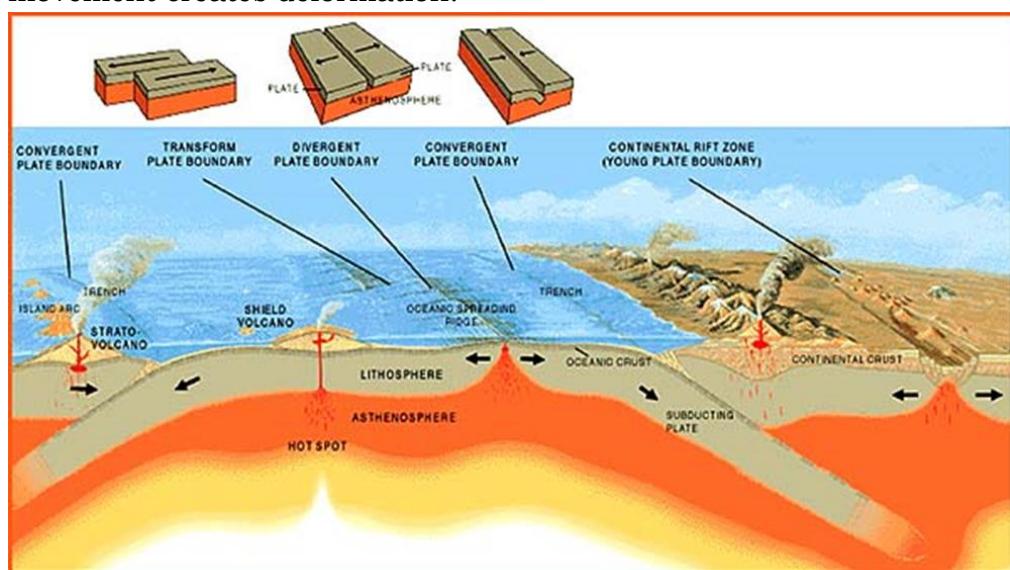


Figure 1.2. Different types of tectonic earthquakes

Source: Tectonic plates. Wikimedia Commons. Accessed September 6, 2020.
https://commons.wikimedia.org/wiki/File:Tectonicplates.jpg?fbclid=IwAR2uC6xhaQ9C6nj7qFUOnEwpLytrLIWiSY7ai2_GMgJzwhzuwVWswGk87V8blowing-up-baukran-underground-construction-work-work



2. **VOLCANIC EARTHQUAKES** are associated with active volcanism, or induced by rising lava or magma beneath active volcanoes. These type of earthquakes are not as powerful as tectonic quakes because they often occur relatively near the surface. These are usually felt only in the vicinity of the hypocenter (focus).

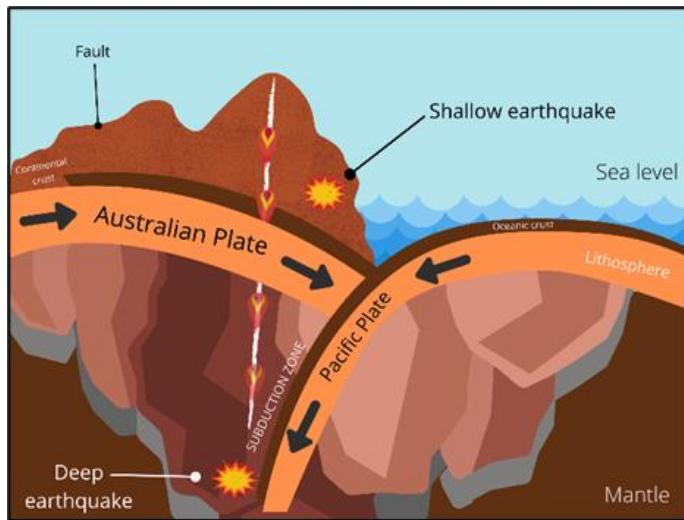


Figure 1.3. Example of volcanic earthquake

3. **HUMAN-INDUCED EARTHQUAKES** are earthquakes due to human activities like constructions of tunnel, filling of reservoirs, carrying out geothermal projects.



Figure 1.4. Examples of induced earthquake: tunnel construction, and filling water reservoirs

Source: Tunnel Blow Up. Needpix. Accessed September 6, 2020.

<https://www.needpix.com/photo/941153/tunnel-blow-up-site-construction-workers-blowing-up-baukran-underground-construction-work-work>

Earthquake Prediction

Prior to an earthquake, there are some evidences that may show before it happens. These can be helpful for Seismologists (scientists who study earthquakes) in predicting the earthquake's epicenter, magnitude, intensity, and time of the event.

1. Unusual animal behavior – Though it has been debunked the long accepted theories that animals can sense earthquakes before it happens, it is actually more of secondary effects, like release of gases from the underground that might be the cause of changes in animal's behavior.
2. Rise in water level
3. Uplifting of earth surface
4. Large fluctuation of oil flow from oil wells
5. Sudden change in temperature of the surroundings
6. Foreshocks or minor shocks before the major earthquake

In the Philippines, PHIVOLCS's *National Earthquake Monitoring and Information* provides accurate and timely information on significant earthquakes and tsunami events that may considerably impact the Philippines. It also ensures the accessibility and integrity of earthquake data. Earthquake monitoring in our country has been improved with the operation of ninety two (92) Seismic Network, ten (10) Seismic Stations of which were made in 2016.

Effects of Earthquake

Depending on its size and location, earthquakes can cause physical movements like ground shaking, rupture of surface fault, and ground failure and, in some coastal areas, tsunamis. Huge earthquakes near towns or cities can cause severe damage to properties, structures and other fixtures to crumble, and sometimes loss of life. Smaller earthquakes called aftershocks, may follow after the main shock, which sometimes come in several hours, months, or even several years later.

1. **Ground Rupture** – refers to the deformation on the ground that marks the intersection of the fault with the earth's surface. This result to fissuring or cracking, and displacement of the ground due to movement of the fault.



Figure 1.5. An example of ground rupture where the ground was deformed and displaced

Source: Catigbian 2 earthquake. Wikimedia Commons. Accessed September 6, 2020.

https://commons.wikimedia.org/wiki/File:Catigbian_2_earthquake.JPG



2. **Ground Shaking** – the irregular movement- up, down, sideways- and vibration of the ground during an earthquake. This event can cause damage or collapse of a structure. It may also cause other hazards such as liquefaction and landslide.



Figure 1.6. When the ground vibrates, it results to ground shaking

Source: Haiti Earthquake building damage. Wikimedia commons. Accessed September 6, 2020. https://commons.wikimedia.org/wiki/File:Haiti_Earthquake_building_damage.jpg

3. **Liquefaction** – is a phenomenon wherein sediments, especially those near bodies of water, behave like liquid similar to a quicksand that cause the structure above it to tilt or sink.



Figure 1.7. An example of liquefaction

Source: Soil-liquefaction at Shinkiba after 2011 Tohoku Pacific Ocean offshore earthquake. Wikimedia Commons. https://commons.wikimedia.org/wiki/File:Soil-liquefaction_at_Shinkiba_after_2011_Tohoku_Pacific_Ocean_offshore_earthquake.jpg

4. **Earthquake-induced Landslide** – refers to the down slope movement of rocks, solid, and other debris commonly triggered by strong shaking. This event may lead to erosion, burial, and blockage of roads and rivers.



Figure 1.8. An example of landslide due to earthquake

Source: Fukuoka Earthquake 20050605 Shikanoshima. Wikimedia Commons. Accessed September 6, 2020. https://commons.wikimedia.org/wiki/File:Fukuoka_Earthquake_20050605_Shikanoshima.jpg



5. **Subsidence** – or also known as land subsidence is a gradual settling or sudden sinking of the Earth's surface. Naturally, it is caused by natural events such as earthquakes, soil compaction, erosion, and sinkhole formation. Sometimes, it is often caused by the removal of water, oil, natural gas, or mineral resources out of the ground by pumping, or mining activities.



Figure 1.9. An example of land subsidence due to earthquake

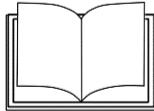
Source: Manhole shows subsidence occurred by 2011 Sendai earthquake. Wikimedia Commons. Accessed September 6, 2020. https://commons.wikimedia.org/wiki/File:Manhole_shows_subsidence_occurred_by_2011_Sendai_earthquake.jpg

6. **Tsunami** – is series of waves caused usually by an earthquake under the sea. This can result to flooding, coastal erosion, damage to properties, and even drowning of people and animals.



Figure 1.10. An example of tsunami due to earthquake

Source: Sendai Airport after the tsunami. Wikimedia Commons. Accessed September 6, 2020. https://commons.wikimedia.org/wiki/File:Sendai_Airport_after_the_tsunami.jpg



What's More

Since you already know the causes and effects of earthquakes, try to answer the following activity to check your understanding of the said concepts.

Activity 1.3. See the Area

As a top notch real estate broker, you were hired by MLR Corporation to assess a certain land which will be bought by the company. The land will be used for building guest's houses for the company's visitors. According to the land assessors, the land called Lanuza Town is safe from all earthquake hazards such as ground shaking, liquefaction, and others, that is why there are still houses and some structures found which can be ready for renovation instead of constructing new ones, hence, minimizing expenses.

Your job is to evaluate all sites where the houses are located. Your assessment will be the basis in deciding the best places to put the guest houses. Use the available information in the diagram below. Based on the diagram above, answer the following questions in a separate sheet of paper.

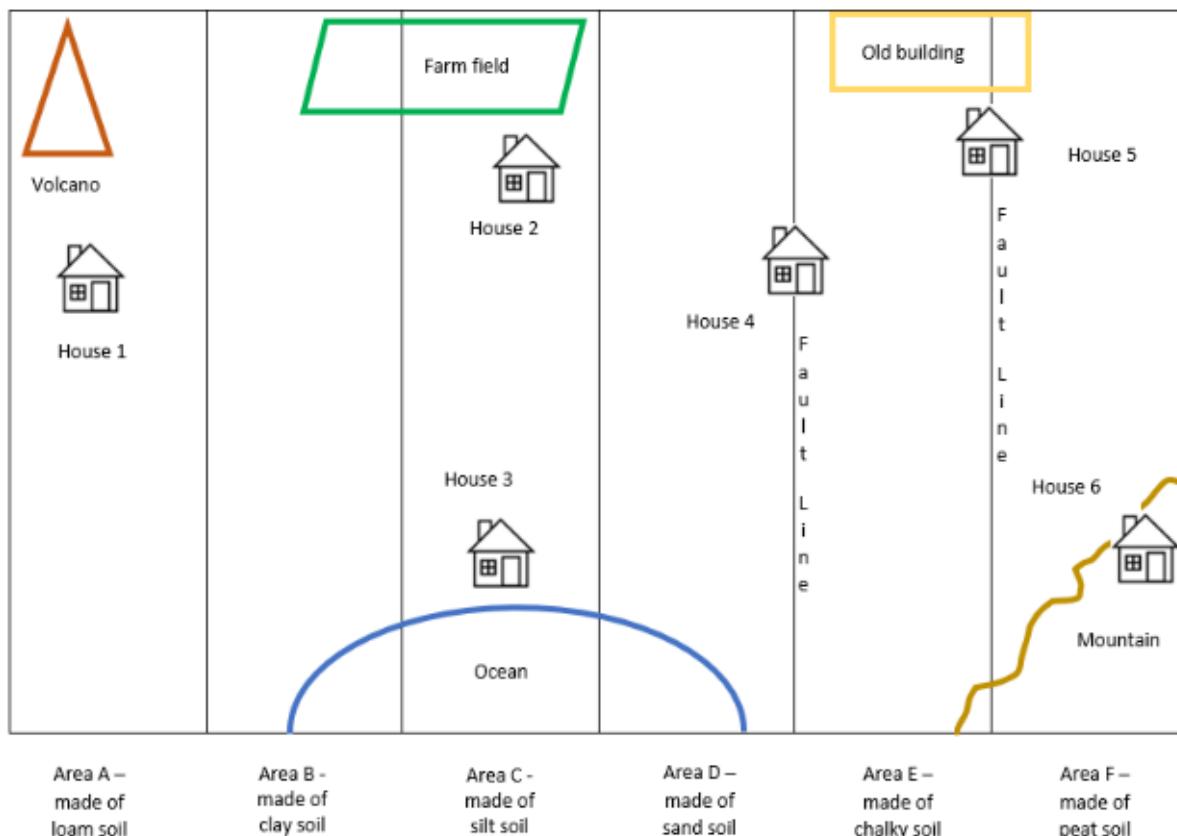


Diagram 1.1. Layout of Lanuza Town



1. Which house/houses is/are more prone to ground rupture?
2. Which house/houses is/are susceptible to ground shaking?
3. Which house/houses is/are vulnerable to liquefaction?
4. Which house/houses is/are more likely to experience landslide?
5. Which house/houses is/are exposed to tsunami?
6. Which house/houses is/are in danger of undergoing subsidence?
7. Which house/house is/are likely to be affected by:
 - a. tectonic earthquake?
 - b. volcanic earthquake?
 - c. human-induced earthquake?



What I Have Learned

Activity 1.4. Sentence completion

Complete the following statements below based on what you have learned about earthquake hazards. Write your answers on a separate sheet of paper.

1. Earthquake is _____.
2. Some causes of earthquake are _____.
3. The different earthquake hazards are _____.



What I Can Do

Activity 1.5. Which is which?

Based on Diagram 1.1, which house or houses would you recommend to MLR Corporation to purchase? Copy and complete the following table below on a separate sheet of paper.

Fill up the following table of pros (in favor) and cons (not in favor) in purchasing each house. Consider the following conditions in completing the table.



Conditions:

- a. if the company will have renovation or additional construction on given area
- b. location of the house (near the volcano, besides the farm field, etc.)
- c. how the house is likely to be affected by different causes of earthquake
- d. type of soil which the area is made up of

House number	Pros	Cons
1		
2		
3		
4		
5		
6		

CRITERIA FOR GRADING:

CRITERION	4 (EXCEEDS EXPECTATIONS)	3 (MEETS EXPECTATIONS)	2 (NEEDS IMPROVEMENT)	1 (NOT VISIBLE)
Presented pros and cons in purchasing the house and assessment of the area under the given conditions	Presented 4 or more pros and 4- more cons in purchasing the house and assessment of the area under the given conditions	Presented 3 pros and 3 cons in purchasing the house and assessment of the area under the given conditions	Presented 1-2 pros and 1-2 cons in purchasing the house and assessment of the area under the given conditions	Did not presented pros and cons in purchasing the house and assessment of the area under the given conditions





Assessment

Read each question carefully and encircle the letter of the correct answer.

1. What kind of earthquake hazard is described when sediments or soil behave in a liquid manner, like a quicksand?
 - A. Earthquake-induced landslide
 - B. Ground rupture
 - C. Ground shaking
 - D. Liquefaction

2. Which of the following earthquake hazards causes flooding, erosion in coastal areas, damage to properties, and loss of lives due to drowning?
 - A. Ground rupture
 - B. Ground shaking
 - C. Landslide
 - D. Tsunami

3. Last July 1990, Hyatt Terraces Hotel in Baguio collapsed due to a magnitude 7.7 earthquake causing great damage to nearby structures. What phenomenon did the structures near the hotel experienced during the said earthquake?
 - A. Ground shaking
 - B. Liquefaction
 - C. Subsidence
 - D. Landslide

4. When ground shaking occurs in high and sloping areas like mountains, what other earthquake hazard is likely to occur next?
 - A. Ground rupture
 - B. Liquefaction
 - C. Landslide
 - D. Tsunami

5. Which earthquake hazard can cause deformation of roads, railways, severely damage underground structures like pipelines?
 - A. Ground rupture
 - B. Ground shaking
 - C. Liquefaction
 - D. Subsidence



Lesson 2

Tsunami Hazards



What's In

In previous lesson, you have learned that tsunami is one of the effects of earthquake. What is a tsunami?

Tsunami (pronounced soo-NAH-mee) is a series of waves created when water is moved quickly. Its heights could be greater than 5 meters. Tsunami is a Japanese word which means harbor (*tsu*), and wave (*nami*). This might be the reason why it was erroneously identified as tidal waves, storm surges, or seismic sea waves but these three are very different from tsunami. Tsunami is fairly common in Japan, hence the origin of the word. Tsunami can occur due to different reasons that probably resulted to its many previous names.



What's New

Activity 2.1. Unscramble me

Unscramble the following letters to find some of the causes of tsunami. Write your answers on a separate sheet of paper.

1. ERKTQHUAEE - _____
2. LNSDLDIAE - _____
3. VLNCAOIC EUTPIRON - _____
4. IECFLALS - _____
5. HAVEY RILNFAAL - _____
6. MTEEOR IPAMCT - _____





What Is It

Tsunami is a series of catastrophic sea or ocean waves that occur near or under the water. It is a major geographic event caused by the following phenomenon:

1. large earthquakes- may occur near or under the ocean
2. landslide – examples: submarine landslides, great mass movement
3. volcanic eruption
4. icefalls
5. heavy rainfall or storm/typhoon
6. cosmic impact- example: meteor (very rare)

Tsunami may occur even when the earthquake is not that strong but great enough to displace some parts of the seabed resulting to disturbance of the mass of water over it. Furthermore, tsunami can also occur in onshore landslides in which large volumes of debris fall into the water and create a mega wave. Many countries near coastal areas maintain warning systems for tsunami so that local governments can establish evacuation plans. These warning systems give the type of tsunami that is about to fall on the land, and can provide useful evacuation information.

Types of tsunami

There are three types of tsunami. Scientists classify tsunami according to how fast it reaches the shoreline, and how widespread it can go.

(1) Local tsunami causes damage in an area relatively close to tsunami-causing event, or simply confined to coasts within a hundred kilometers of the source. This may be caused by earthquake, landslide, or pyroclastic flow from volcanic eruption. Tsunami can reach the shoreline within 2 to 5 minutes, which does not provide sufficient time for evacuation, resulting to severe damages. The coastal areas surrounding our country, particularly those near Pacific Ocean, South China Sea, Sulu Sea, and Celebes Sea are most likely to experience this kind of tsunami due to local earthquakes.

(2) Regional tsunami can cause damages within 100 to 1,000 kilometers from the underwater source. The landfall occurs between 1 to 3 hours, giving ample warning time to evacuate to safety than local tsunami.

(3) Distant or far field tsunami differs from the first two types of tsunami in terms of reaching the shoreline. It is also called as *tele-tsunami* or *ocean-wide tsunami*, distant tsunami is extremely powerful and destructive even at 1,000 kilometers away from landfall. Distant tsunami may appear a local tsunami



at first, but it can travel across a wide path of ocean basin. It can also travel from 1 to 24 hours before it reaches the coast. There can be enough time to evacuate from distant tsunami but since it covers a larger land, it can still cause massive destruction.

Other facts about tsunami are as follows:

- Scientists can estimate the time of arrival of tsunamis in different parts of the world based on their knowledge of water depths, distances, and when the event that generated them happened.
- In deep parts of the ocean, a tsunami can have speed up to 800 kilometers an hour can travel but still unnoticed on the surface, and may cross an ocean in a day or less.
- As it reaches shallow water near the coast, the tsunami slows down, where the top waves move faster than those at the bottom, causing the sea to rise radically.
- Geological features such as reefs, bays, river entrances, and undersea formations can cause decrease in energy of a tsunami.
- Tsunamis may look like a very rapidly rising tide, accompanied by underwater turbulence, pulling people under, and throwing heavy objects around.
- Flooding can extend inland by a thousand feet (300 meters) or more. The massive energy of a tsunami can lift huge boulders, flip vehicles, and destroy houses.
- According to the U.S. National Oceanic and Atmospheric Administration (NOAA), the Pacific is by far the most active tsunami zone, but tsunamis have been generated in other bodies of water like in the Caribbean and Mediterranean Seas, and so are the Indian and Atlantic Oceans.

So, how would one know if there will be an incoming tsunami here in our country? Experts from the Philippine Institute of Volcanology and Seismology (PHIVOLCS) and Advance Science and Technology Institute (ASTI), both of the Department of Science and Technology (DOST) developed an equipment to prepare for possible tsunami (events) in the Philippines. They called it the Community Tsunami Detection and Warning System, which were installed last 2012 in high-risk coastal communities in provinces of Pangasinan and Albay. The system provides real-time information and warning signals. Now known as **Tsunami Early Warning System (TeWS)**, the technology was placed to provide a cost-efficient and also a reliable system device for forecasting tsunami, allowing timely disaster response.

Information gathered by the system reaches the Local Government Units (LGU) in near real-time. When an earthquake is strong enough to cause a tsunami in certain areas, the LGU can sound off the warning siren to warn those living near



or around coastal areas to give them ample time to prepare for evacuation. This step helped improved our country's situation in terms of disaster preparedness and management.

A guide in knowing the indicators of an incoming tsunami, and what to do in case of tsunami is shown in Table 1.2 The Philippine Tsunami Information.

PHILIPPINE TSUNAMI INFORMATION

Tsunami Information	Threat to the Philippines	Recommended Action for Affected Places
Advisory NO TSUNAMI THREAT	A large earthquake is generated but either (1) there is no tsunami generated by this event or (2) a tsunami was generated but will not reach the Philippines.	No evacuation needed. The advisory is issued for information purposes only.
Advisory SEA LEVEL CHANGE MONITORING	PHIVOLCS will monitor sea level changes and provide updates.	No evacuation order is in effect. Public is advised to wait and listen for updates.
Advisory MINOR SEA LEVEL DISTURBANCE	Minor sea level disturbance is expected in some coastal areas with wave heights of less than one (1) meter above the expected ocean tides.	People are advised to stay away from the beach and not to go to the coast. People whose houses are located very near the shoreline are advised to move farther inland. Owners of boats in harbors, estuaries or shallow coastal waters of the affected provinces should secure their boats and move away from the waterfront. Boats already at sea are advised to stay offshore in deep waters until further notified.
TSUNAMI WARNING	Destructive tsunami is generated with life threatening wave heights. (A destructive tsunami is expected to arrive to Philippine coastlines with wave heights of greater than one (1) meter above the expected ocean tides.)	Immediate evacuations of coastal communities that maybe affected are strongly advised. Owners of boats in harbors, estuaries or shallow coastal waters of the affected provinces should secure their boats and move away from the waterfront. Boats already at sea are advised to stay offshore in deep waters until further notified.



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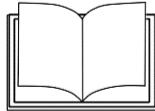
April 2012

Table 2.1. Philippine Tsunami Information

Source: <https://www.phivolcs.dost.gov.ph/index.php/tsunami/tsunami-preparedness#>



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What's More

To check your understanding of tsunami, do the following activity.

Activity 2.2. Which is which?

Look at the following map of the Philippines on the next page. Answer the following questions that follow based on what you have learned about tsunami. Place your answers in a separate sheet of paper.

1. Which province is more vulnerable to tsunami, Tacloban or Manila? Explain your answers.
2. If Calbayog and Palawan are to experience tsunami, which province will be more affected by tsunami? Why?
3. Aside from being located near a body of water, what can be the other cause or causes of tsunami in the province of Legazpi? Explain your answers.



Figure 2.1. Philippine Map

Source: <https://www.mapsofworld.com/answers/geography/what-are-the-key-facts-of-philippines/>





What I Have Learned

Activity 2.3. Letter Game

Using the letter from the word tsunami, write down what you have learned in this module. You may use keywords or sentences for your answers. Place your answers on a separate sheet of paper.

T _____
S _____
U _____
N _____
A _____
M _____
I _____



What I Can Do

Activity 2.4. Infographic time

Think that you and your family live near a coastal area. As a means of your family's preparedness, create an infographic showing three (3) things to do on each instance: before, during, and after a tsunami. See to it that all members of your family have their respective roles in doing your plan as shown in your infographic. Place your infographic in a short bond paper. You can place some illustrations and color it. Make sure to make your output complete, and organize.

CRITERIA FOR GRADING:

Criterion	4 Exceeds Expectations	3 Meets Expectations	2 Needs Improvement	1 Not Visible
The infographic shows things to do before, during, and after a tsunami	The infographic shows three (3) things to do for each instance: before, during, and after a tsunami.	The infographic shows two (2) things to do for each instance: before, during, and after a tsunami.	The infographic shows one (1) thing to do for each instance: before, during, and after a tsunami.	The infographic doesn't show any of the following instance: what to do before, during, and after a tsunami.





Assessment

Read each question carefully and encircle the letter of the correct answer.

1. Which of the following best describes a tsunami?
 - A. It is similar to storm surges.
 - B. It is a series of water waves.
 - C. It is the same as tidal waves.
 - D. It is also known as seismic waves.
2. Which of the following is **NOT TRUE** about tsunami?
 - A. Tsunami is the same as tidal waves.
 - B. Tsunami name originated from Japan.
 - C. Tsunami can occur due to different reasons.
 - D. Tsunami are named by Japan because they are very common on the said country.
3. Which of the following **CANNOT** help decrease the energy of tsunami?
 - A. Ships
 - B. Coral reefs
 - C. River entrances
 - D. Undersea formations
4. Which of the following **DOES NOT** shows the effect of tsunami?
 - A. Heavy objects being lifted
 - B. Water level suddenly increases
 - C. Sudden change of air temperature
 - D. Presence of underwater turbulence
5. According to Philippine Tsunami Information, how many tsunami warnings are there?
 - A. 4
 - B. 3
 - C. 2
 - D. 1



Posttest

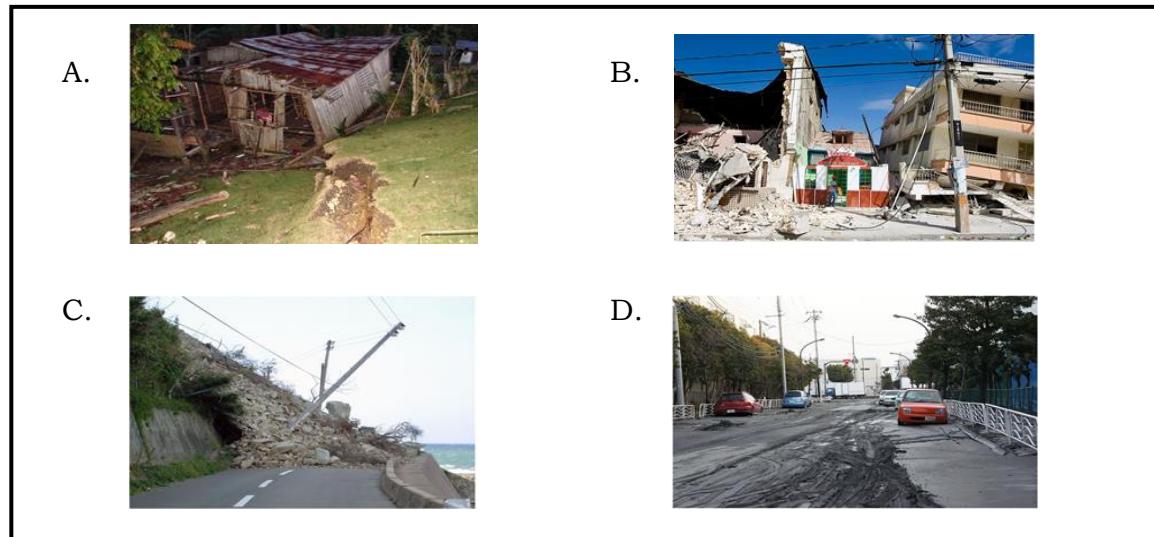
Read question carefully and encircle the letter of the correct answer.

1. The seismic activity of an area exposed to earthquake over a period of time is dependent on the following factors **EXCEPT** for what?
 - A. Size of earthquake
 - B. Type of earthquake
 - C. Location of earthquake
 - D. Frequency of earthquake
2. Which of the following is **NOT** the cause of earthquake in the Philippines?
 - A. Our country lies between two tectonic plates.
 - B. Philippines is within the subduction zones called the ring of fire.
 - C. Our country is an archipelago consisting of almost 7100 islands and islets.
 - D. The areas surrounding the Philippine Sea plate are very active, producing numerous geological processes.
3. Which kind of earthquake is likely to happen if a certain house is located near an area where construction is always ongoing?
 - A. Tectonic earthquake
 - B. Volcanic earthquake
 - C. Human-induced earthquake
 - D. Earthquake-induced landslide
4. Which of the following is **NOT** an indication of an incoming earthquake?
 - A. Change in the color of the soil
 - B. Sudden uplifting of earth surface
 - C. Presence of large oil flow from oil wells
 - D. Rise in water level at any bodies of water
5. Which of the following is **NOT TRUE** about earthquake's intensity?
 - A. It is written in Roman Numerals (ex: I, IV, or X).
 - B. It is the energy released by an earthquake at the focus.
 - C. It refers to the strength of earthquake as felt by people in certain area.
 - D. It is a rating based on the effects of earthquake to people and properties.
6. After an earthquake, you found your floor moist, and there were some water coming out of the cement cracks. What resulted to this event?
 - A. Your house is actually too old.
 - B. There was water overflow nearby.



- C. Liquefaction occurred beneath your house.
- D. The cement used in your house was of low quality.

For numbers 7-9, use the following pictures inside the box.



7. Which of the following pictures show an example of liquefaction?
8. Which of the following pictures show an example of ground shaking?
9. Which of the following pictures show an example of ground rupture?

10. Which of the following is **NOT** the cause of a tsunami?
 - A. Icefalls
 - B. Landslide
 - C. Ground rupture
 - D. Volcanic eruption

11. Which of the following statements is **NOT TRUE** about a tsunami?
 - A. It can cause flooding to lowlands.
 - B. It can lead to greater earthquakes.
 - C. It can result to erosion in coastal areas.
 - D. It can be the reason to loss of lives due to drowning.

12. Which of the following is **NOT** a factor used by the scientists to estimate the time of arrival of tsunami?
 - A. Depth of water
 - B. Height of tsunami
 - C. Distance from the coastline
 - D. When the tsunami happened

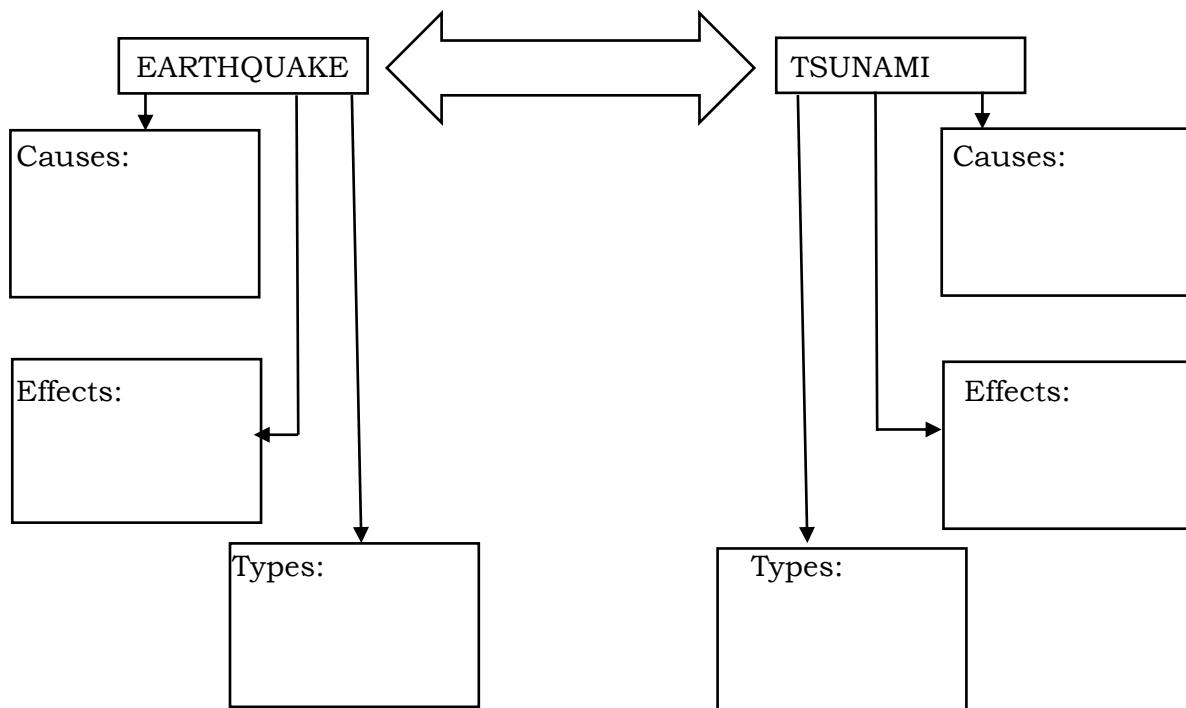


13. Which of the following kinds of tsunami is relatively close within a hundred kilometers from the source of tsunami?
- A. Local tsunami
 - B. Distant tsunami
 - C. Regional tsunami
 - D. Far Field tsunami
14. Which of the following is **NOT** an indicator of an incoming tsunami?
- A. Rapidly rising tide
 - B. Present of water turbulence
 - C. Some heavy objects being thrown
 - D. Sudden change in air temperature
15. Which of the following statements **DOES NOT** describe distant tsunami?
- A. It can travel wide across a wide path.
 - B. It is also known as ocean-wide tsunami.
 - C. It is an extremely powerful kind of tsunami.
 - D. It can reach the coast so fast that there will be no enough time to evacuate.



Additional Activities

Make concept maps showing your understanding about earthquake and tsunami. And in the figure , write the connection between earthquake and tsunami. How are these two concepts related to one another? Place your answers on a separate sheet. The diagrams below can serve as your guide.





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