

March 15, 2021

## Earthquakes in Divers Places



**Figure 1 - Croatian Earthquake, December 2020 <sup>1</sup>**

*For nation shall rise against nation, and kingdom against kingdom: and there shall be earthquakes in divers places, and there shall be famines and troubles: these are the beginnings of sorrows. <sup>2</sup>*

When Jesus of Nazareth warned his followers of what to expect in the future, he included earthquakes among the many troubles that were coming their way. This isn't surprising, since in Jesus' day, and indeed for most of human history, earthquakes and other natural disasters were seen as divine punishment or warning that something important was coming our way. However, with the development of the modern science of geology, we have a better understanding of earthquakes as natural processes.

### **Faults**

So, what is an earthquake? An earthquake is a movement of a portion of the earth's crust, usually along a pre-existing break in the crust that we call a *fault*. The animations below show the three main kinds of faults.

*Strike-slip faults*, also called *transform faults* are vertical (or nearly vertical) fractures where the blocks have mostly moved horizontally. If the block opposite an observer looking across the

fault moves to the right, the slip style is termed right-lateral; if the block moves to the left, the motion is termed left-lateral. [Animation link](#) <sup>3</sup>



strikeslip.mp4

*Normal*, or Dip-slip, faults are inclined fractures where the blocks have mostly shifted vertically. If the rock mass above an inclined fault moves down, the fault is termed normal, whereas if the rock above the fault moves up, the fault is termed a *Reverse* fault. [Animation link](#) <sup>4</sup>



normalfault.mp4

A *thrust* fault is a reverse fault with a dip of 45° or less, a very low angle. The animation shows a reverse fault which is a steeper-angle fault, but it moves the same way. [Animation link](#) <sup>5</sup>



thrustfault.mp4

## **Causes of Earthquakes**

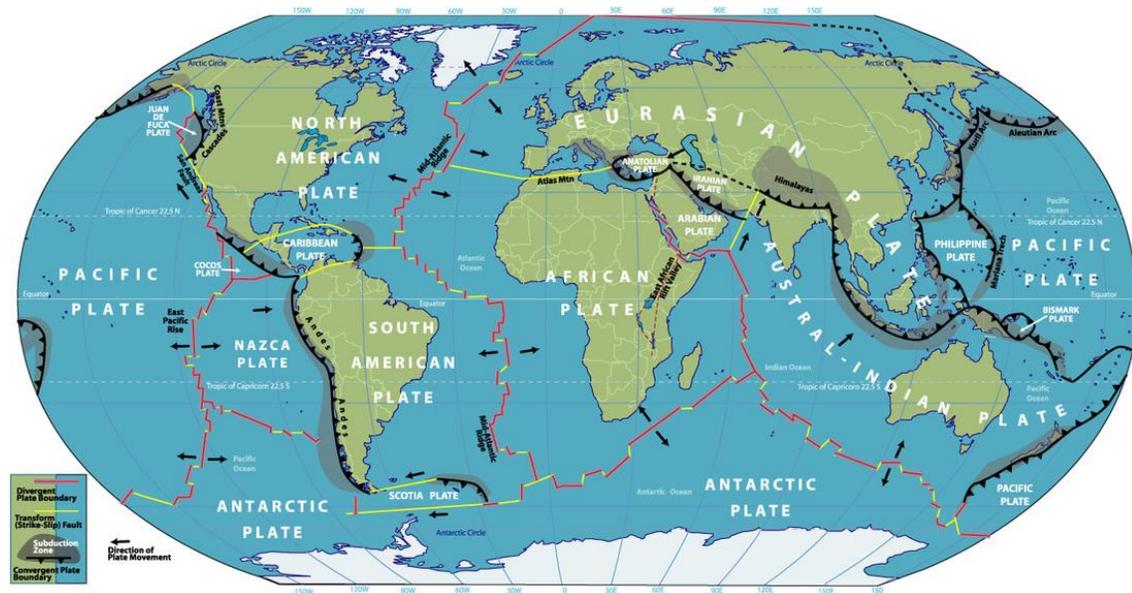
So what can cause the earth's crust to move? There are four main causes:

1. Movement of tectonic plates
2. Volcanism
3. Isostatic rebound
4. Anthropogenic causes

## ***Tectonic Plate Movement***

The earth's crust is divided into a number of distinct plates. Plate tectonics is worth at least one blog post, maybe more, and I shall discuss it in future postings. For now, it is enough to note that the plates move. Earthquakes caused by tectonic activity occur where tectonic plates move next each other.

Figure 2 shows the major tectonic plates in the world and the direction of movement.



**Figure 2 - Tectonic Plates** <sup>6</sup>

### ***Volcanism***

The movement of magma and lava before and during volcanic eruptions can cause many earthquakes. As I discussed last week, current earthquakes at the Reykjanes Peninsula in SW Iceland portend volcanic eruptions there <sup>7</sup>.

### ***Isostatic Rebound***

When the continental glaciers began melting around 15,000 years ago, a great weight was taken off the earth. Once that weight was removed, the earth's crust rebounded. It isn't a gradual process but occurs as intermittent movements. These movements cause earthquakes, generally minor. Many of the earthquakes in Canada, especially those occurring east of the Rockies, are due to glacial rebound.

There is a good summary of isostatic rebound on the Wikipedia page [Post-glacial rebound](#) <sup>8</sup>.

### ***Anthropogenic Causes***

Human activities can cause earthquakes, these activities include

- Mining: collapsing mine tunnels in underground coal mining
- Mining and construction: excavation with explosives
- Oil and natural gas extraction: formation fracturing (fracking)
- Waste Disposal: injecting waste fluids underground
- Dams: the weight of water behind a dam

- Weapons: nuclear weapons testing

One concern is that human activity can trigger existing faults and inadvertently cause large earthquakes<sup>9</sup>. This can happen with the activities listed above.

### **Infamous Earthquakes**

When earthquakes occur in densely populated areas, huge numbers of people can be killed, either by collapsing buildings or by knock on effects such as tsunamis. Here is a list of the 10 deadliest earthquakes in history<sup>10</sup>:

1. Shaanxi, China (1556)

With an estimated strength of 8.0 on the Richter Scale, this earthquake killed approximately 830,000 people on the morning of 23rd January, 1556. Many people in the Shaanxi region lived in caves dug in the loess soil and the earthquake collapsed many of these caves. Also, the earthquake triggered landslides, killing more people.

2. Haiyuan, China (1920)

In the evening of December 16th, 1920, an earthquake measuring 7.5 to 8.5 on the Richter Scale struck Gansu Province in China. Estimates of the total death toll attributed to the earthquake range between 240,000 and 275,000 and include people who perished from exposure in the harsh winter weather following the earthquake.

3. Tangshan, China (1976)

Often called *The Great Tangshan Earthquake*, this earthquake struck the city of Tangshan, China on July 28th, 1976 at 4:00 AM. Measuring 7.8 on the Richter Scale, the initial earthquake was followed by an aftershock 16 hours later. Of the approximately 1 million inhabitants of Tangshan, approximately 255,000 people were killed, mostly by collapsing buildings.

4. Antioch, Eastern Roman Empire (526)

Located at modern day Antakya in Turkey, ancient Antioch was a major city in the Eastern Roman Empire. The initial 7.0 magnitude earthquake in 526 was followed by aftershocks that lasted for 18 months. Approximately 250,000 people were killed, mostly by falling buildings.

5. Indian Ocean (2004)

On Boxing Day 2004, a 9.3 magnitude earthquake lasting almost 10 minutes occurred under the Indian Ocean triggering a massive tsunami. Approximately 230,000 people were killed in Indonesia, Sri Lanka, India and Thailand.

6. Aleppo, Syria (1138)  
Located at the north end of the Dead Sea rift system, Aleppo, Syria is prone to periodic earthquakes. Several earthquakes hit the region from October 1138 to May 1159 leading to the deaths of approximately 230,000, mostly from collapsing buildings.
7. Haiti (2010)  
The main 7.0 magnitude earthquake occurred January 12, 2010 and was followed by 52 aftershocks, some with a magnitude of 4.5 . The estimated death toll was more than 160,000.
8. Damghan, Persia (856)  
Occurring at Damghan in modern day Iran, The 856 earthquake had an estimated magnitude of 7.9. the earthquake affected an area with a 350 km radius around the epicentre. Approximately 200,000 people were killed in the towns of Ahevanu, Asta, Tash, Bastam and Shahrud as well as in surrounding villages.
9. Dvin, Armenia (893)  
Dvin, the capital of ancient Armenia, (now ruins near Verin Dvin, Armenia) was hit by an earthquake on December 26, 893. Approximately 150,000 people were killed.
10. Messina, Italy (1908)  
Hitting the city of Messina with an estimated magnitude of 7.1, the December 28, 1908 earthquake destroyed up to 90% of the buildings in the city and generated a 12 m high tsunami. About 123,000 people died as the result of the building collapses and tsunami.

As always, feel free to follow up on the references listed below to learn more about earthquakes.

## References

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