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**Research Note**

# Pacific Northwest Earthquake Risk

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**Abstract** – Over the past two years, major earthquakes have devastated Haiti, Chile and Japan. The Pacific Northwest has unique geological conditions that make it susceptible to deep, shallow and megathrust earthquakes. The Seattle Fault and liquefaction pose an additional threat to the greater Seattle area. Research indicates that high building codes and warning systems can help mitigate damages and minimize casualties. Individuals and organization should research regional threats and ensure appropriate disaster recovery plans have been prepared.

## Introduction

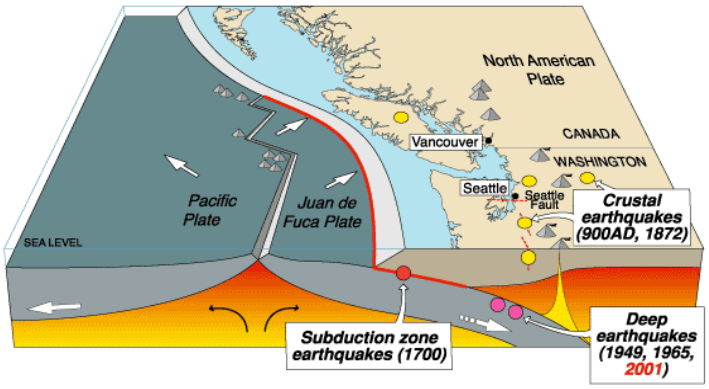
The past two years has been witness to multiple major earthquakes that tore their way through Haiti, Chile and Japan. These quakes took thousands of lives, destroyed homes, businesses and major infrastructure, and required billions of dollars in recovery costs.[1] Natives of Washington probably remember the Nisqually earthquake of 2001, a 6.8 magnitude quake that caused $2 billion in damage, more than any other event in state history.[2] These events stand as stark reminders of the importance of preparing crisis management, disaster recovery, or continuity plans, should a major quake hit closer to home. This research note will focus on the geological factors that make the Pacific Northwest and the West Coast particularly susceptible to earthquakes, and will then highlight precautionary efforts that have been taken to better mitigate this threat.

## Earthquakes and the Pacific Northwest

To begin with, an earthquake is a "shaking of the ground caused by the sudden breaking and movement of large sections (tectonic plates) of the earth's rocky outermost crust. Most earthquakes occur along the fault lines when the plates slide past each other or collide against each other."[3] The Pacific Northwest is unique in terms of earthquake vulnerability primarily because of its geologic setting. The Cascadia

Subduction zone is "a 680-mile fault that runs 50 miles off the coast of the Pacific Northwest – from Cape Mendocino in California to Vancouver Island in southern British Columbia,"[4] and is a collision of the Juan de Fuca plate, which forms the floor of the northeastern Pacific Ocean, and the North American plate.[5] The Juan de Fuca plate is sliding underneath the American Plate at an average rate of two inches per year.[6] This type of movement makes the Northwest susceptible to three different types of earthquakes: shallow, deep and megathrust quakes.

**Cascadia earthquake sources**




| Source | Affected area | Max. Size | Recurrence |
|---|---|---|---|
| Subduction Zone | W.WA, OR, CA | M 9 | 500-600 yr |
| Deep Juan de Fuca plate | W.WA, OR, | M 7+ | 30-50 yr |
| Crustal faults | WA, OR, CA | M 7+ | Hundreds of yr? |

[7]

## Deep Earthquake

The Seattle Office of Emergency Management defines deep quakes as earthquakes that occur at depths of approximately 35 to 70km.[8] "Since they are further from the surface, they are not felt as intensely, but are experienced over a wider area than shallow quakes."[9] The 2001

Nisqually earthquake was a product of movement from the Juan de Fuca plate, and is an example of a deep quake.[10] It is estimated that Juan de Fuca fault has the potential to produce an earthquake that reaches 7.5 in magnitude.[11] According to researchers with the Cascadia Region Earthquake Workgroup (CREW), there is an 84% chance of a magnitude 6.5 or higher deep earthquake occurring in the Puget Sound region sometime within the next 50 years.[12]

### Shallow Earthquake

A shallow quake occurs at depths from 0 to 30km.[13] Compared to deep or megathrust, a shallow quake may come across as sounding weak, but that is definitely not the case. Because the fault is closer to the surface, shallow quakes have the potential to cause severe damage. The 7.0 magnitude earthquake that struck near Port-au-Prince, Haiti in 2010 is an example of a shallow quake.[14] The "epicenter – the spot on a map where the earthquake occurs – was only 10 miles from Port-au-Prince… The hypocenter – the spot in the ground from which the vibrations spread – was so shallow," at only nine miles beneath the surface.[15] This quake impacted 3.5 million people, injuring over 300,000 and finished with a death toll close to 220,000.[16] The fault line that

caused the Haiti quake is similar in structure to the San Andreas Fault that slices through much of California.[17]

### Megathrust Earthquake

A megathrust earthquake is caused by a sudden slip in a subducting and overriding plate and represents the largest type of potential earthquake.[18] Magnitude of megathrust quakes can range from 8.0 to over 9.0 and generally occur at intervals of 200 to 1,100 years.[19] The 2011 earthquake in Japan is an example of this type of quake. The 9.0 magnitude quake "ruptured near the boundary between the Pacific and North American tectonic plates… where the Pacific plate drove underneath Japan at the Japan Trench. The seafloor was pushed away from Japan sending waves roaring toward Hawaii and the West Coast of the United States."[20] A thirty foot tsunami hit Japan shortly after the quake and more than 275 aftershocks of magnitude 5 or greater continued to rock the country in the days that followed.[21]

The interface between the Juan de Fuca and North American plates has the potential to slip in a similar manner.[22] In a 2010 interview, Bill Steele, the Seismology Lab Coordinator for the Pacific Northwest Seismograph Network at the University of Washington's Department of

Earth and Space Sciences, described the effects of subduction zone slip in this way:

> "That strain builds up until it can't stay locked together anymore, a break begins, and boom! So right away the coastline falls, the seafloor pops up and that displaces this huge column of water above there, generating a tsunami, which will affect the entire Pacific Basin if we have a magnitude 9 again."[23]

Steele went on to describe a possible megathrust quake in the Pacific Northwest in this way: "Rather than 17 seconds or 30 seconds we're going to be dealing with ground motion running perhaps six minutes total for the rupture to occur, that starts on one end and goes to the other, and strong ground motion in our area of maybe three minutes."[24] Based on historical averages, researchers estimate the odds of a megathrust quake occurring off the coast of the Pacific Northwest to be roughly 10 -14 percent in the next fifty years.[25]

### The Seattle Fault and Liquefaction

The Seattle Fault is a crustal fault that runs east-west through Seattle from Issaquah to Bremerton and is also potentially concerning as experts speculate that it was the cause of very large earthquake approximately 1,100 years ago.[26] The Seattle Fault is complicated further by the high potential for liquefaction. Liquefaction is a term that describes how the strength and stiffness of a soil deposit are

reduced as a result of pressure, a phenomenon most commonly induced by earthquakes.[27] Liquefaction can manifest itself in the form of land slides or by causing foundations and retaining structures to settle or tilt.[28] The Sodo district of Seattle has been identified as an area that may be highly susceptible to liquefaction as it is underlain with artificial fill.[29] The King County Flood Control District labels most of South and West Seattle as areas that have high vulnerability to liquefaction.[30]

## Precautions

Governments, educators and businesses are learning the value of precautionary efforts in order to better prepare for catastrophic events. The following sections of this research note take a look at the ways implementing stronger building codes and utilizing warning systems can better protect and prepare the public when a natural disaster takes place.

## Building Codes

The earthquakes in Chile and Haiti bring attention to the possible implication associated with better building codes. As mentioned, the Haiti earthquake registered at 7.0, while the Chile earthquake came in at 8.8.[31] Despite the fact that the Chile earthquake was more powerful,

the Chilean death toll was less than 1% that of Haiti.[32] This discrepancy is likely a product of multiple variables, but the "economic answer is that Chile is a modernized and industrialized nation, with a per capita economic output that's more than 10 times larger than Haiti's. As such, building codes are far stricter and better-enforced, emergency resources are more available, and the population is better educated as to the safest place to take refuge."[33] Similarly, since 2005 all Japanese buildings are required to be able to withstand a magnitude 8.0 earthquake.[34]

### Warning Systems

In late 2011, the University of Washington and two other California schools were the recipients of a $6 million grant for an earthquake early warning system that would alert the public seconds to minutes before the ground starts shaking.[35] The warning systems are expensive, and some argue that they "would do Seattle little good in the case of a quake on the shallow fault that underlies the city but could benefit Olympia and other cities."[36] Perhaps this grant will lead to a system similar to that of Japan. In 2007, Japan launched the world's most sophisticated early-warning system, a nationwide online system that "detects tremors, calculates an earthquake's epicenter and sends out

brief warnings from its 1,000-plus seismographs scattered throughout the country."[37] Alert messages are automatically issued via locations like factories, TV networks, radio stations and mobile phones.[38] Providing even a few seconds of warning would allow people time to take shelter, "prompt railroads to stop trains before they cross vulnerable bridges or even prompt physicians to stop a surgery," actions that could potentially save thousands of lives and millions of dollars.[39] An early warning might provide even more value in the event of a major quake off the coast. John Vidale, director of the Pacific Northwest Seismic Network at the University of Washington, says that an early warning system could provide Seattle with "as much as five minutes' warning of a coastal megaquake such as the one that rocked Japan and unleashed a deadly tsunami."[40] Those extra few minutes of preparation could make a dramatic difference to those scrambling to safety.

## Conclusion

Discussing the probabilities of earthquakes and the damages associated with them can cause a sense of vulnerability and alarm. According to Steele:

> "It's tough when you say it could be centuries before it happens or it could be tomorrow. That's an awful big window for people to get their arms around, right? Should I be totally panicked or not care at all? What we're hoping is that people find some middle ground there."[41]

Finding this "middle ground" will result in different behaviors depending on your situation and needs. There are several resources available online, in books, or through emergency preparedness experts that can help you better understand ways to prepare your home and business to respond to emergency situations. Take the time to research threats that may be more prevalent in your specific region and ensure your plans account for higher probability events.

Organizations will want to ensure they have a disaster recovery plan in place and that necessary precautions have been taken to protect their employees and preserve their critical assets. Individuals will also want to develop a neighborhood or family disaster plan and assemble an emergency supplies kit. As Annie Searle indicates in her book, **Advice From A Risk Detective**, "The best way to think about what goes into an emergency kit is to assume that you will not have power or grocery or medical services for three to five days."[42]

In addition, many governments and universities already have emergency warning systems in place. For example, the University of Washington has a UW Emergency Management Alert system that warns of severe weather and other alarming activities. Researching similar services that are already available in your own region will help you be better prepared and allow you to respond with more confidence.

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