Chain Reaction: Earthquakes that Trigger Other Natural Hazards

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A fire destroys much of a major city. The side of a mountain collapses and then explodes. A train of waves sweeps away coastal villages over thousands of miles. All of these events are disasters that have started with or been triggered by an earthquake. Some of the triggers were among the largest earthquakes ever recorded. But the disasters that followed were often so large that the earthquakes were overshadowed, and so, we hear about the eruption of Mount St. Helens; devastating landslides in Washington and Pakistan; and tsunamis in Chile, Japan and the Indian Ocean. To understand these events, we need to remember the earthquakes.

Tsunamis

On Dec. 26, 2004, an earthquake ruptured an 800-mile length of the sea floor from northern Sumatra to the Andaman Islands. A monstrous series of waves rolled across the Indian Ocean. Together, the earthquake and tsunami took more than 200,000 lives in 11 countries.

In 1960, the largest earthquake ever recorded, a magnitude-9.5, hit Chile. Many survived the earthquake, only to perish in the tsunami that followed. The leading wave hit Hawaii in 15 hours. It struck Japan nearly 24 hours after the earthquake. More than 2,000 people were killed in Chile, 61 in Hawaii and 138 in Japan. Hawaii reported $75 million in damage (1960 dollars), Japan $50 million. In the Philippines, 32 people were killed or missing, and the United States suffered $500,000 in damage.

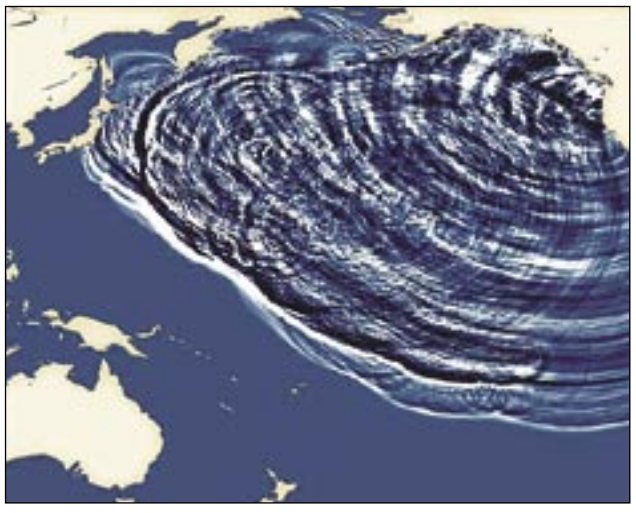
Hundreds of years earlier, on January 26, 1700, America's Pacific Northwest was unknown to most of the world — a blank spot on maps of that time. Beneath the shallow waters offshore, an enormous earthquake unleashed, sending a series of waves that would engulf the Pacific Ocean. About 10 hours after the earthquake, the tsunami's leading wave reached Japan. The waters swept away houses, flooded fields and inundated crops, frightening villagers with a disaster that seemed to have come from nowhere. That this tsunami had been triggered by an earthquake off the West Coast of North America would remain unknown until the 1990s, when the link was established through a combination of North American geology and Japanese historical research.

Volcanoes

Volcanoes produce a variety of hazards — hot-ash and mudflows, landslides, tsunamis, lava flows and volcanic gases. And quite often, small-to-moderate earthquakes serve as a warning of an impending eruption. Volcanoes erupt when hot, liquid rock, called "magma," moves upward through cracks in the Earth's surface. This motion, and the building up of pressure, generates volcanic earthquakes. Monitoring volcanoes for these tremors has proven a powerful tool in the prediction of volcanic eruptions.

Scientists have known that movement of magma often triggers earthquakes, but they are discovering that this relationship may also work in reverse. Scientists are looking at earthquakes that meet very specific criteria: a magnitude of 6 or higher; a location on major fault zones near a volcano; and a later eruption of a nearby volcano. They are finding evidence that these earthquakes might have triggered the eruptions.

In the early morning of Nov. 29, 1975, a magnitude-7.2 earthquake struck the Big Island of Hawaii. Less than 45 minutes later, Kilauea Volcano starting erupting. That eruption ended after about 17 hours. The small volume of magma and brief duration suggest that the eruption was triggered by the earthquake.



In January 1700, a mysterious tsunami hit Japan without the warning that a nearby earthquake usually provides. Nearly three centuries later, discoveries in North America revealed its source. The evidence tells of a catastrophe that helps guide preparations for future earthquakes and tsunamis in the United States and Canada. Read the scientific detective story in "The Orphan Tsunami of 1700."

This was not the first eruption on Hawaii that appears to have been triggered by an earthquake. Other scientists have linked Hawaii's largest historic earthquake, estimated to have a magnitude of at least 7.5, in 1868 to a small eruption from Kilauea.

On June 15, 1991, Mount Pinatubo in the northern Philippines exploded, sending a column of ash into the atmosphere. About 11 months earlier, a magnitude-7.8 earthquake had struck about 60 miles from the volcano. Scientists from the USGS and the Philippine Institute of Volcanology and Seismology have found that these two events were related. According to the study, compression from the earthquake might have squeezed a small volume of magma into the volcano's reservoir. Strong ground shaking might have also compressed the reservoir or triggered movement along previously stressed faults that allowed magma to ascend into the volcano.

Following a massive eruption, a volcano can collapse, as the empty magma chamber cannot support the weight of the material above. The result is a large, concave structure called a "caldera." These structures are found around the world. Yellowstone and Crater Lake are two examples in the United States. Research shows that activity at calderas often occurred within months or even hours of large regional earthquakes, sometimes as a precursor to the earthquakes and sometimes as a result of them.

Landslides

Heavy rain, wildfires, volcanic eruptions and human activity often work together to cause landslides. In hilly terrain, earthquakes can easily cause landslides, and these landslides are often more destructive than the triggering event.

In 1964, the magnitude-9.2 earthquake that violently shook southern Alaska also induced huge landslides throughout Anchorage, including the downtown business district. The 1994 Northridge earthquake triggered more than 10,000 landslides in the hills around Los Angeles.

On May 18, 1980, a magnitude-5.1 earthquake triggered the collapse of the north flank of Mount St. Helens, resulting in the largest landslide ever recorded. Debris raced down the mountain at speeds in excess of 180 miles per hour. Within about 10 minutes, enough debris to fill 250 million dump trucks traveled up to 14 miles down the valley, destroying buildings, bridges and many miles of highway. The debris dammed the North Fork Toutle River and its tributaries and posed hazards to downstream communities because of the possible failure of the dams and catastrophic flooding. With an earthquake, a massive landslide, a volcanic blast and flooding — Mount St. Helens was truly a multi-hazard disaster.

The Clear Case for Multi-Hazard Science

From the 1700 orphan tsunami to the 1991 Mount Pinatubo eruption, these examples show that, to be truly understood, hazards cannot be studied in isolation. By developing a better understanding of how one hazard event has triggered others in the past, we are working to identify potential hazards before they become multi-hazard disasters.

The USGS, along with numerous partners, carries out research and monitoring designed to reduce losses from future hazards. From improving building codes to identifying hazard zones and evacuation routes, integrated science can provide emergency managers with the information they need to continue to make America safer from natural hazards. After the tragic events of 2004 and 2005, scientists have redoubled their efforts to help the public learn how to recognize the danger and survive natural hazard events. These hazards will always be with us, but by examining both individual hazards and how they relate to one another, scientists are building a bigger picture and a better understanding that is helping to save lives and property.