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Haiti: The Science of a Seismic Storm

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Several factors came together to make Haiti's earthquake the most devastating seismic shock to hit the country in two centuries – ranging from sheer magnitude to sheer poverty. In purely scientific terms, the best comparison was the Loma Prieta earthquake that shook the Bay Area during the 1989 World Series. But the tragedy in Haiti isn't purely scientific.

The death toll seems certain to rise into the tens of thousands in the wake of Port-au-Prince's magnitude-7 quake, compared with a death toll of 63 after the magnitude-7 Loma Prieta quake. The difference clearly has to do with the woeful state of infrastructure in Haiti, the Western Hemisphere's poorest country.

"A large part of the death toll and destruction tends to be in the infrastructure. ... In developing countries, we don't know what kind of building infrastructure they have, but it's safe to assume that it's less safe there in terms of shaking activity," said Alex Hutko, a research seismologist at the U.S. Geological Survey's National Earthquake Information Center in Golden, Colo.

Experts say Tuesday's earthquake was the strongest shock to hit what is now known as Haiti since 1770. However, the Dominican Republic, Haiti's eastern neighbor on the island of Hispaniola, fell victim to a magnitude-8.0 tremor in 1946. That event killed about 100 people, with most of those lost in the tsunami created by the offshore quake. About 20,000 were left homeless.

Dominicans back then were relatively lucky in that the quake occurred in the early afternoon on a holiday, when most people were outdoors. In contrast, the Haiti quake was close to a perfect seismic storm:

The area where the shock occurred, known as the Enriquillo-Plantain Garden fault zone or EPGFZ, had not had a major rupture in more than a century. Haiti sits at the boundary between the North American and the Caribbean tectonic plates, which move across each other at a rate of nearly an inch (20 millimeters) per year. In the EPGFZ in particular, the average annual slippage is a third of an inch (7 to 8 mm). But all that strain has been building up for decades. The really eerie thing is that seismologists predicted almost two years ago that Port-au-Prince could be in for a 7.2 earthquake, due to the buildup of strain in the EPGFZ.

A magnitude-7 earthquake is toward the high end of the scale, but magnitude is not the only factor that determines how damaging a quake can be. A little more than two years ago, for example, a 7.7 quake in Chile killed just two people. This time, however, the epicenter was relatively close to the surface (6 miles or 10 kilometers deep) and relatively close to Haiti's biggest population center (10 miles or 15 kilometers from Port-au-Prince, with a population

of more than 2 million). Shallower seismic activity is much more dangerous than deep rumblings, and the level of shaking drops off substantially over distance. This quake was so strong that it reportedly broke water lines at the U.S. military's Guantanamo Bay base in Cuba, 200 miles away.

The geology of the area hit by the quake is also a big factor. "Soft ground tends to amplify the shaking and also can tend to break up the foundation of structures if the ground ruptures underneath them," Michael Blanpied, associate coordinator for the USGS Earthquake Hazards Program, said in a podcast about the Haiti earthquake. Hutko told me the USGS didn't have information about the soil geology in Port-au-Prince. However, the large number of collapsed structures would fit the pattern for a soft-ground quake.

The timing of the quake, at 4:53 p.m. Haiti time (ET) on a weekday, caught many people in their offices – the worst place to be when buildings are falling. Among those who were caught in that situation was the chief of the U.N.'s Haiti mission, who was meeting with a Chinese delegation at the five-story office building and was among those unaccounted for.

The state of infrastructure in Haiti was the real killer. After the tragic collapse of a school in 2008, Port-au-Prince's mayor estimated that about 60 percent of the city's buildings were shoddily built and dangerous under normal conditions. The country has been struggling with grinding poverty for years, due to decades of political instability as well as a series of natural disasters. Ironically, Haiti's horrible infrastructure is a disincentive for investment, creating a vicious circle of economic hardship.

The 1989 Loma Prieta earthquake provides several parallels for Tuesday's quake in Haiti: Both involved strike-slip faults – the Enriquillo-Plantain Garden fault in Haiti, and the San Andreas fault system in California. Both caused catastrophic damage to infrastructure: Twenty-one years ago, most of the quake victims died when Oakland's Cypress Street Viaduct collapsed. A day ago, hundreds of thousands of people were trapped in collapsed structures ranging from simple shacks to the National Palace.

The timelines for the two events could diverge dramatically during the aftermath.

Lessons learned from Loma Prieta were put to use in a wave of large-scale rebuilding projects, in the Bay Area as well as in other quake-prone areas such as Seattle. It will be a miracle if Haiti can recover as quickly, even with the millions of dollars of international aid likely to come its way. It's not a scientific certainty that the country will recover at all. That part of the story is up to all of us.

More about earthquake science:

Just how powerful was the earthquake? The estimates vary, but it's clear that a magnitude-7 quake packs many times more power than an atom bomb. This earthquake power calculator suggests that a 7.0 earthquake releases as much energy as 477,000 tons of TNT. (In comparison, some have estimated the power of the Hiroshima atom bomb at 12,000 to 18,000 tons.) Check out this video for more about the comparison and additional perspectives on the earthquake's energy. The main quake was followed by dozens of aftershocks, with the biggest rumble reaching a magnitude of 5.9. "These aftershocks are of moderate size in and of themselves," Blanpied said. "However, given that they're occurring during the time that the area has suffered a major shock, [with] many damaged buildings, rescue efforts going on, each of these can cause further damage." Because the quake took

place on land rather than on the sea floor, it didn't create a tsunami like the one that devastated Sumatra five years ago.

What's a strike-slip fault? They're geological faults where most of the ground movement occurs laterally rather than vertically. Some of the most infamous seismic events in history, including the 1906 San Francisco quake and the 1988 Armenia quake (which killed 25,000 people), involved strike-slip faults. For more about killer earthquakes, check out this online gallery.

Want to learn more about earthquake basics? Get more of the basics about the Haiti earthquake from this Q&A. Click through ourinteractive graphic on seismic science, or study this archived itemabout how magnitudes are measured. You can also browse through the National Earthquake Information Center online, or look at this snapshot of recent earthquakes worldwide. The USGS PAGER system estimates the alert level for recent quakes, based on population as well as seismology. USGS also links to a variety of seismic hazard maps.

Can earthquakes be predicted? We looked into that question a couple of years ago, and even checked in with some unorthodox seismic forecasters. "Earthquake sensitive" Cal Orey, for example, contends that she made a "bull's-eye" prediction about last weekend's magnitude-6.5 quake off the California coast, thanks in part to her pets. Even orthodox scientists accept that animals can sometimes pick up the early signs of an earthquake. Hutko, for example, pointed to an online video that shows a dog fleeing an office seconds before the serious shaking started in California. He says the effect is due to the way different seismic waves spread out. A quake's "P" wave is known to precede the slower-moving but more damaging "S" wave. In Haiti, the difference amounted to four seconds, Hutko said. This online gallery provides more perspectives on earthquake prediction.

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