

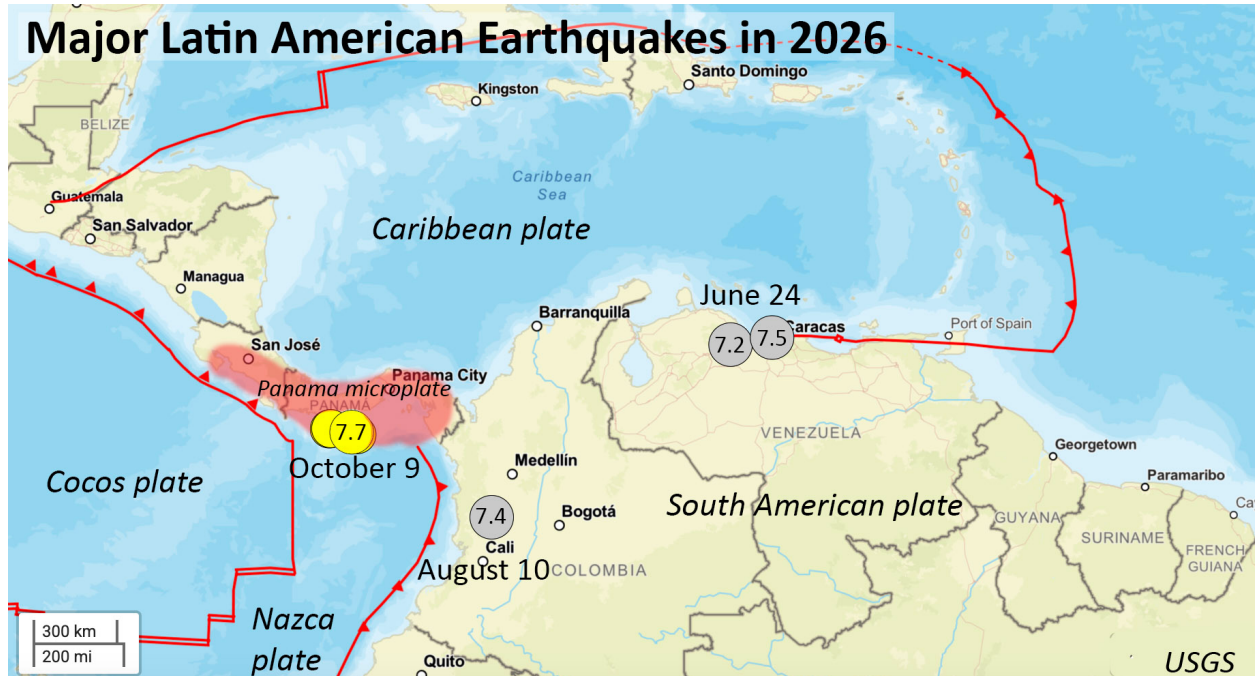
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Not My Fault: Lessons from another major earthquake in Latin America.

Lori Dengler for the Times-Standard

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USGS epicenters of the June Venezuela earthquakes, the August Colombia earthquake, and last week's Panama earthquake sequence (in yellow). Red lines are boundaries between the four major plates in the region: Caribbean, Cocos, Nazca, and South American. The Panama earthquake was centered in a complex transition region called the Panama microplate, shown in red.

A magnitude 7.7 earthquake occurred on the Azuero Peninsula of southern Panama on October 9th. It was the largest known earthquake to occur on land in Panama's historic record, damaged several hundred buildings, caused one death and 27 injuries. It was the third major earthquake sequence in the complex tectonic region comprising northern South America, the Caribbean, and Central America in the past five months. Although larger than the Venezuela earthquakes in June and the Colombia earthquake in August, the impacts were not nearly as great. Why was the damage so much less and are these earthquakes related?

I first learned about the Panama earthquake when a text popped up on my phone from the National Tsunami Warning Center (NTWC) that a magnitude 8 earthquake had occurred in Panama and was being reviewed to determine whether it posed a tsunami risk to the U.S. West Coast and Alaska. We haven't had any earthquakes that big in 2026, and the text caught my eye. Estimating the magnitude of big earthquakes is harder than smaller ones because they take longer to rupture and the seismic wave train is more complicated. NTWC is under pressure to get an assessment of tsunami threat out quickly and doesn't have the time for detailed

analysis. It's not unusual for their preliminary magnitude to be a few decimal points larger or smaller than the final magnitude determination.

I let out a small sigh of relief when the USGS reviewed solution came out ten minutes later with a magnitude of 7.6 and the final assessment put it at 7.7. That's still a big earthquake but far less likely to cause a major tsunami capable of reaching coastlines thousands of miles away. NTWC soon followed with a second bulletin officially stating no tsunami danger to our region. A tsunami threat message was in place for the Pacific coast of Panama where surges up to 9 feet were considered possible and waves of two feet or less along other coastlines of Central and South America. The threat message was canceled less than two hours later when no tsunami was observed on regional tide gauges. Panama officials did order evacuations in some areas, and several eyewitnesses reported higher-than-normal wave activity at Isla Cañas, an island 90 miles away from the fault rupture zone, but no tsunami damage was reported.

It's now just over a week after the earthquake and seismologists have had time for a more detailed analysis. The earthquake occurred at a depth of about eight miles beneath the surface on the Azuero-Sono fault, an east-southeast oriented strike slip fault that cuts across the entire Azuero Peninsula and extends offshore on both sides. The NASA-ISRO Synthetic Aperture Radar satellite passed over Panama about six hours after the earthquake and detected ground displacements with the southern part of the peninsula south of the fault moving as much as 16 feet to the east relative to areas north of the fault. Field surveys are planned in the area soon, but I have yet to see any photographs or ground data.

The Azuero Peninsula is a relatively sparsely populated area of Panama. Its largest city is Chitre, population 46,000 centered only 18 miles from the fault. The USGS PAGER analysis of population exposure and likely damage estimates 200,000 people were exposed to intensity VII (very strong) or greater ground shaking. In contrast, the PAGER estimates for both Venezuela and Colombia for this category was over 7 million. Significant damage was reported in Chitre and other communities on the Peninsula where Panamanian official estimate at least 4,000 structures suffered structural impacts. The compromised buildings included homes, schools, government buildings, and hospitals. The Church of Atansio, a National Heritage site, completely collapsed. The Azuero Peninsula was not the only area affected, and some damage was reported throughout the country, but Panama City, and other major metropolitan areas were not heavily impacted. The Panama Canal zone, a major driver of the Panamanian economy, suffered no damage.

By all accounts, response to the Panama earthquake was immediate and robust. A State of Emergency was declared by President Mulino the day of the earthquake immediately making over \$100 million dollars available for use in response and recovery efforts. Panama's National Civil Protection System is a mature organization that activated its trained network of over 1,500 professionals and volunteers, evacuating coastal areas that were at possible tsunami threat, assessing damage, and establishing field hospitals. The country participates in the Caribbean Catastrophic Risk Insurance Facility, triggering a \$17.5 million payout that was available to government response efforts within days.

It wasn't all smooth sailing; response and relief efforts were hampered by severe rains that triggered mudslides, adding to the infrastructure disruption caused by the earthquake. Nearly 4,000 people have been displaced and providing food, shelter, and sanitation in the midst of the

rainy season is challenging. But a well-coordinated collaboration with United Nations relief organizations is focused on filling gaps and preventing disease outbreaks.

The total losses in the Panama earthquake have yet to be tallied but could reach over a billion dollars and is estimated to be somewhere between 1 and 10% of the country's gross domestic product (GDP). That's a significant hit but Panama's main economic sectors were not affected, and the country's economic health is strong, leading Central America in GDP growth. The inflation rate is stable and at 1.8%, less than half the current U.S. rate.

The Venezuela M7.2 and 7.3 earthquakes together released about two-thirds the seismic energy of the Panama M7.7 yet were far more devastating. At the top of the reasons why is location and population density. When 35 times more people experience very strong shaking, the impacts will be greater. But the losses in Venezuela far exceeded that metric.

The official death toll in the Venezuela quakes is 6,509, but with as many as 50,000 people still unaccounted for, the real toll is certainly higher. Other factors exacerbated vulnerability. Directivity of the fault rupture and the soft coastal sediments amplified shaking strength. Engineering standards and building code enforcement in Venezuela were far less stringent than in Panama where the many years of U.S. Canal Zone connections created a building standards comparable to those here. The final blow was a Venezuelan economy in tatters and no government ability to mount the response required. There is little verified information about post-earthquake conditions, but Al Jazeera has reported that the many makeshift encampments still housing survivors have suffered from lack of clean water, bad sanitary conditions, and disease outbreaks.

The situation in Colombia following the August M7.4 earthquake is intermediate to Panama and Venezuela. With an official death toll of 335 (111 missing), it was a significant blow to the Colombian department of Choco, and caused significant damage to the cities of Cali, Pereira, and others nearby. The difference in population exposure between the Colombia earthquake and Panama can explain much of the difference in impacts, but Colombia was lucky in one important way, and the damage could have been far worse. Both Panama and Venezuela were shallow earthquakes centered in the upper crust at depths of less than 10 miles. The Colombia earthquake was much deeper, in the earth's mantle 67 miles deep. Deeper quakes are felt over a wider area, but the depth dampens the shaking strength and filters out the high frequencies that cause the most damage.

A quick glance at an epicenter map of these three earthquakes might lead one to ask are they related? The answer is yes and no. All three are caused by the complex tectonic setting of the region where four plates (Nazca, Caribbean, Cocos, South American) interact. But each of these earthquakes were on or near different plate boundaries and were unlikely to be triggered by each other. The Venezuela quakes were on the transform boundary between the Caribbean and South American plate. Colombia was centered on the subduction interface between the Nazca and South American plates, and Panama in the very murky transition zone between all four plates.

Panama is an oddity when it comes to plates. If you look at the USGS tectonic map of the country, no clear boundary line separates the Nazca and Caribbean plate. Geologists consider Panama to be sitting on a separate little plate or deformation zone all of its own, buffering the interaction between its larger neighbors. The southern edge of the Panama microplate where

the October 9th earthquake was located abuts the Nazca plate, but the zone is diffuse. The Azuero-Sono fault is only one of a number of faults marking the boundary. There have been few earthquakes here in historic times which makes it hard to parse out the details of its structure.

Three take-away lessons from the Panama earthquake: larger magnitude earthquakes don't always cause the most damage, vulnerability is related to population density and the built environment, and economic health of a country makes a huge difference in the ability to build resilient communities and respond to disasters. The bottom line – be like Panama and make preparedness a priority.

Note: More details on the Panama fault rupture and satellite analysis of slip at <https://earthquakeinsights.substack.com/p/surface-rupture-of-the-m77-azuero>

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