Earth-Shaking Science

Seismology in Everyday Life

The earth rumbled. The ground—usually so solid, dependable, predictable—bucked and twisted. Far below, unfathomable amounts of dirt and rock scraped past each other. Buildings crashed and roads burst as the inhabitants of the surface found their world—too literally for comfort—turned upside down.

Somewhere else, the earth burst. Moments earlier, the fertile valley lay quiet and prosperous, but now it looked more like an ash-choked hellscape as the red lava-flow consumed everything in its path. Fire, not water, rained, and the air burned with poisonous gasses.

The Earth is alive. This is seismology.

But that is not all—when rain patters on the soil, it creates small energy waves in the ground, as if the bits of soil were molecules in a dense ocean. When the football team scores a touchdown at the stadium, the roars and cheers of the celebrating fans can be felt in the ground's rumbles on the other end of campus. On a smaller scale, the same happens when cars roll on the highway.

The Earth is alive. This, too, is seismology.

This everyday seismology is the research subject of Margaret "Molly" Maenner, a first-year master's student at the University of Delaware. She studies what's called passive seismology—the study of Earth's less dramatic movements, which characterize our more numerous, peaceful moments. "Instead of an actual earthquake happening based on a fault slipping, or going out in the field and striking the ground with a hammer, the Earth has always got a hum to it; it's never completely stationary or still. It's called an ambient seismic field."

Because of this ambient seismic field, the earth is always in motion. But it's not always the planet itself that is the source of this motion; instead, the planet acts as the medium through which the motion propagates. Maenner's undergraduate advisor, Dr. Tieyuan Zhu, an associate professor in the Department of Geosciences at Penn State University, found that human activity can be seen in seismological data: "[Zhu] has got this brilliant paper where you could see the effects of Covid because all the anthropogenic [human-created] activity just ceased," Maenner said.

Together, Maenner and Zhu used seismic data to track the path of Hurricane Ida's remnants in 2021 as they traveled across University Park in State College, Pennsylvania. Maenner continues to study the interplay between weather and seismology in graduate school, as she focuses on ambient seismic fields and using seismic waves to investigate stresses in the crust and upper mantle.

Despite being based in Delaware (which is not known for its seismic activity), Maenner and her advisor, Dr. Colton Lynner, an assistant professor in the University of Delaware's Department of Earth Sciences, can conduct seismic research as scientists in places like California or Alaska due to the open nature of geological research. Most research is publicly funded through government grants, so it is made easily available. Scientists who collect data can use it exclusively for two years, but then it becomes publicly available.

"Anyone has access to any seismic data that's ever been collected by any U.S. researcher," Lynner says. "It's freely available to, not just scientists, but anyone-anyone…You just need a good internet connection and an idea that somebody else hasn't already tried."

There is a strong opportunity in this field for citizen science; all it requires is a question and, depending on the question, perhaps some skill in coding. Lynner continues: "I think a lot of the really useful things in earth sciences are that they are tangible, in a way. They are things that impact our everyday world."

Passive seismology is a reminder that this planet is dynamic and alive; of the thousands of planets that scientists have discovered, none are quite like it. Not even Mars, a nearby rocky planet, is seismically active. The Earth's super-hot core—about 5,000-degrees Celsius, or 9,000-degrees Fahrenheit—heats the rock, or magma, in the mantle. Just like air, hot rock rises as the heat tries to escape into space. The cooler magma closer to the Earth's surface sinks, creating a convection cycle, which in turn moves the tectonic plates of the crust. Sometimes, when these plates collide, one is forced underneath the other in a process called "subduction." Because this process takes place within the Earth, it is not often easily seen from the surface, though it can be in certain areas. Features affected by subduction include the Andes Mountains in South America and the Ring of Fire—a path of active volcanoes and frequent earthquakes—around the Pacific Ocean, as colliding plates warp each other.

Lynner studies the upper mantle in subduction zones across the world, such as in South America and Alaska. These zones also tend to be regions of volcanic activity, because the interactions between the crust and mantle there make it possible for the magma to spew to the surface. When volcanoes fill with magma, they inflate, and they deflate when that magma flows out. It is similar to a balloon—as fluid is pushed in, the container swells, and when the fluid leaves, the balloon collapses. The resulting warping and stress produce cracks in the earth. Seismic waves cannot cross these cracks, because their propagation medium is the earth, not fluids like air or water, so seismologists can 'see' the locations, orientations, and sizes of these cracks in their data.

"When these cracks close up…the seismic wave can move faster. When those cracks get bigger, it's going to move slower," says Maenner. Her thesis proposal focuses on an island in the Alaskan Aleutian archipelago, where sensors have been placed that record seismic waves in the Earth. These waves are always present, such as due to precipitation, and this precipitation also affects the size of the cracks, which is called "loading": heavy snow may push down on the cracks and make them smaller, allowing seismic waves to move through them, but as it melts, it may fill them up and slow down the waves. Maenner is looking at the speed of these waves over time, and she has found a seasonal pattern, which she suggests has to do with the island's weather and climate. A preliminary finding from her study proposal shows that the changes in the waves' speed correlate with seasonal temperature variations. Surprisingly, they do not follow the temperature changes, but *precede* them.

"I don't know why that is, but it's pretty cool!," she says. "So we're gonna attempt to look into that." This study is an example of what is being observed at the volcano, and it is still very much in its beginning stages, though she hopes the information she finds will be useful to future scientists. Her research will provide a baseline of information about the volcanic island so that other seismologists can compare their data with hers to see if the volcano ever activates again.

By focusing on these baselines—on the volcanoes at rest and on the way small waves travel through the earth—Maenner and Lynner show that seismology is not just the dramatic disasters that make the history books, but the foundation of daily life here on this planet; indeed, Earth's seismic activity is what makes it unique among all of the planets which have so far been discovered.

“[Seismology is] a really, really powerful tool to understand what’s happening beneath our feet,” Lynner says. “When most people think about geology, it’s the rocks on the surface. But that is such a tiny fraction of what’s going on in the Earth, and ultimately, all the stuff that we see on the surface—the mountains, the trenches, the valleys, the rivers, all of that—is driven by what’s happening deeper down.”