Undersea rocks yield earthquake clues

August 6 2021

Peridotite is one of the most common rocks found in undersea fault zones. This image shows, at top, fresh peridotite along with a microscopic view of the mineral; and, at bottom, peridotite that has been altered from seawater that infiltrated deep within the fault. Credit: University of Delaware

Earthquakes shake and rattle the world every day. The U.S. Geological Survey (USGS) has estimated the number of earthquakes at some half a million a year, with some 100,000 that can be felt, and about 100 that cause damage. Some of these powerful temblors have devastated nations, cutting short thousands of lives and costing billions of dollars for economic recovery.

When will the next big earthquake occur? Answering that question has teams of scientists monitoring areas such as California's San Andreas Fault and Turkey's North Anatolian Fault. But these seismically active areas on land, at the boundaries of tectonic plates, are not the only places of intense study. Jessica Warren, associate professor of geological sciences at the University of Delaware, is exploring the middle of the ocean where earthquakes with a magnitude 6 on the Richter scale routinely occur, and what she is finding may help scientists predict earthquakes on land.

UDaily connected with Warren to learn more about her most recent study, which published in *Nature Geoscience* on Aug. 5, 2021.

How did you get started on this research?

Warren: This work grew out of a previous study with seafloor rocks and involved my colleagues Arjun Kohli, who is now a research scientist at Stanford University, Monica Wolfson-Schwehr, who is now a research assistant professor at the Center for Coastal and Ocean Mapping, and Cécile Prigent, a former postdoc in my group who is now a professor at the University of Paris. This interesting group of people had all different areas of expertise to bring to the project. The National Science Foundation provided funding support.

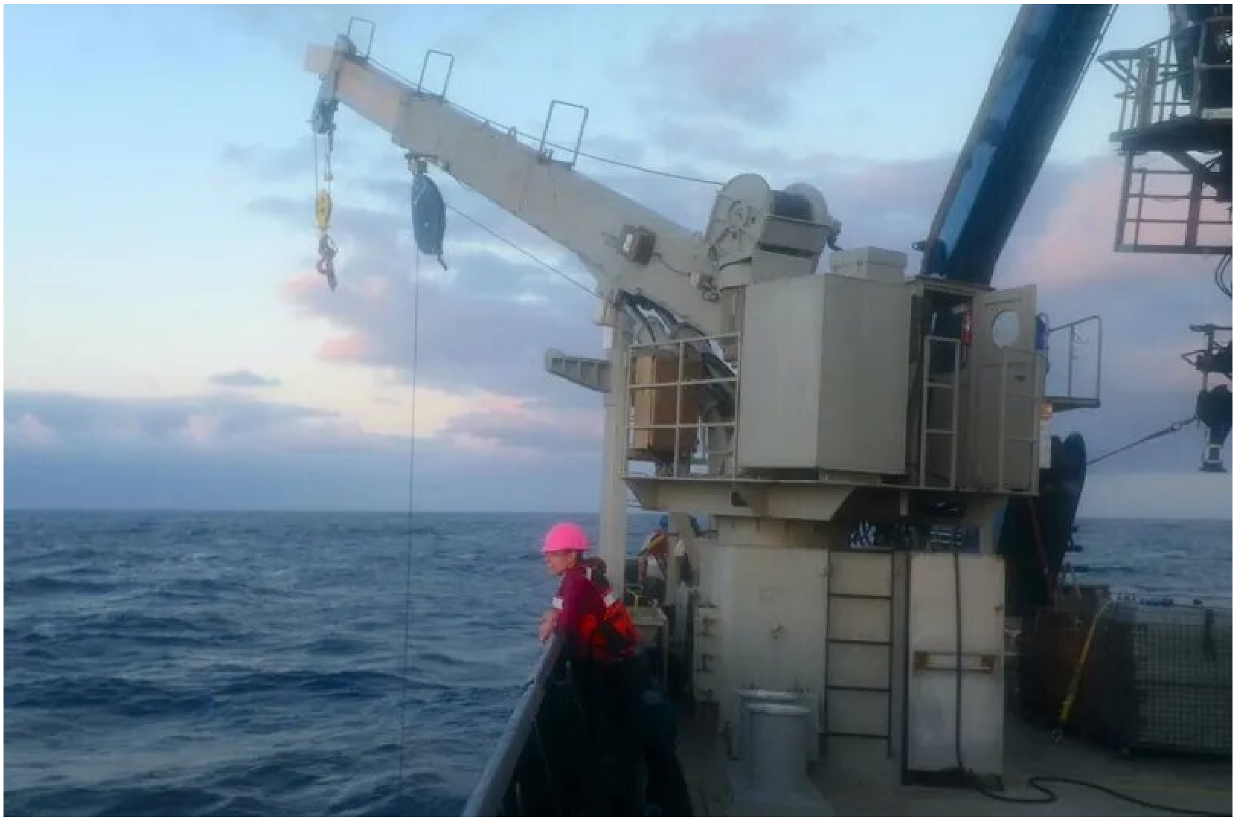
What kinds of rocks did you study and how did you get them?

Warren: The rocks came from big fault structures underwater that are on par with the San Andreas Fault. It's costly to get them because they are so far out at sea and it takes specialized equipment. At the end of 2019, we were in a research vessel in the Pacific Ocean above one of these faults on the East Pacific Rise, pulling buckets along the seafloor to collect samples. Most of the samples, however, had been sitting around in various collections—some were collected over 40 years ago from the seafloor.

Could you describe the rocks a bit?

Warren: Underwater ocean ridges are areas of volcanic activity where magma from deep within Earth's crust erupts and then cools and solidifies. The faults that we look at cut across these ocean ridges, creating steps in the ridge system. The top layer of rock on these ridges is basalt, a black, fine-grained rock rich in magnesium and iron, which is underlain by coarser-grained gabbro, and below it is peridotite, which is often dark green due to the quantity of the mineral olivine—another name for the gemstone peridot—that it contains.

As you go deeper, rocks in the crust actually flow, like glaciers flow. This occurs at 4 miles deep in the Pacific Ocean floor, and 10 miles deep in the seafloor of the Atlantic Ocean, which is colder. The rocks you see in the fault at that point are mylonites—they are dark gray, stretched-out, deformed rocks—some call them Silly Putty. They can flow much faster than the normal rocks because they are super fine-grained (atoms in the rock move around faster when the grains are smaller). They are absolutely beautiful rocks!



Jessica Warren aboard the research vessel Atlantis in the Pacific Ocean. Credit: University of Delaware

What do the rocks tell you about earthquakes?

Warren: The big finding we have made is that these faults, or cracks, have a lot of seawater going down into them very deep—more than 10 miles below the seafloor, which is very deep. When water gets into the rock, it reacts with it. This seawater infiltration is a weakening force, so the rock can flow almost as fast as it can slip.

Earthquakes are run-away slip events that occur as rocks slide past each other. We found that seawater infiltration causes the crystallization of tiny grains of minerals and these allow the rock to creep along instead of having a run-away slip event.

Could you draw on this finding to stop an earthquake from happening on land?

Warren: There's no way to stop large earthquakes from occurring. But it would improve our ability to predict—by understanding the properties—what gives us rock creep vs. a sharp slip. There is also a creeping segment of the San Andreas fault. We can't make the rest of the fault like that. But we could better predict how and when these various fault systems are going to fail.

What will happen to the information you've developed, and what's up next?

Warren: You have to know the rock properties to understand what happens in fault zones and earthquakes. We have done modeling work that is more a way to test and extrapolate how rocks deform against each other. We have done a lot of straightforward calculations validating the strength of the rocks. We now need more direct observations of the faults on the seafloor itself. The submersible Alvin would be one of the ideal vehicles for doing this. That would contribute to our understanding of the seismicity of certain patches versus other patches that sort of stop it.

What led you into this work?

Warren: I fell in love with geology through field work in college, and then I fell in love with going to sea to do field work in graduate school. I also love looking at samples in the lab, seeing the textures and uncovering the history of the rock and what it's telling us about the Earth.

More information: Arjun Kohli et al, Oceanic transform fault seismicity and slip mode influenced by seawater infiltration, *Nature Geoscience* (2021). DOI: 10.1038/s41561-021-00778-1

Provided by University of Delaware