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Ancient rocks provide critical clues about modern earthquakes

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At first glance, there's nothing remarkable about the rocky Maine blueberry field in which University of Maine graduate student Nancy Price does her research. But those rocks are crucial to our understanding about how faults work nearly 10 miles below the surface of the Earth. Indeed, that’s where rocks are supposedly the strongest.

Price’s findings suggest that geophysical assumptions about the strength of faults at different depths may need to be reevaluated. And if we better understand faults, we may be able to better predict the behavior that causes large earthquakes.

Price is studying the Norumbega fault system, a line of ancient faults that cuts across Maine from Calais to Casco Bay. The now extinct faults were seismically active millions of years ago. Today, the Norumbega system is considered an ancient analog for major earthquake faults, such as the San Andreas fault in California and the North Anatolian fault in Turkey, which have produced some of the deadliest quakes in our time.

Like the San Andreas, the Norumbega is a strike-slip fault where only the shallowest parts are exposed or can be reached by drilling. To study deeper fault rocks, an ancient, extinct zone must be found where the depths have been exposed through exhumation and erosion.

Price is studying a part of the Norumbega fault in Windsor, Maine, that more than 300 million years ago was situated about 10 miles below the surface, but is now exposed. In a strike-slip fault, two tectonic plates slide against each other. They do not slide smoothly and stress builds up as the plates snag on each other.

Close to the surface, where the rocks are relatively cold, the plates are brittle and rocks break, easily releasing the stress. Temperature increases with depth in the Earth, and at a certain temperature the rock weakens and stretches like chewing gum. The strongest part of the crust lies at the depth where the rock starts to stretch, but can also still crack, a region called the frictional-viscous transition. This is the depth level Price is studying.

“How this region behaves is the key to how the fault works,” says Price, who earned a master’s degree at the University of Massachusetts Amherst. “If we understood it, we wouldn’t have to rely on how often an earthquake ruptures. We could model the fault based on what we understand of the physics of how the rock will behave and predict what will happen.”

Working with geologist Scott Johnson, chair of UMaine’s Department of Earth Sciences, Price originally set out to model the fault using data collected from hundreds of rock samples that were once in the transition zone. These sheared fault rocks contain thin, gray veins called pseudotachylyte — evidence of ancient earthquakes.

But when Price's samples revealed more pseudotachylyte than expected, she turned her attention to identifying how much of the rock contained these veins and how this might change assumptions of fault strength at these depths.

Price found the process of pseudotachylyte formation causes the size of the mineral grains in the rock to be smaller and the percentages of the minerals to change, causing the thin gray layer to be weaker than the rest of the rock. If enough pseudotachylyte from earthquakes is created over millions of years, the fault itself becomes weaker than is generally accepted.

"This change in perspective will help drive discussion," Price says.

Provided by University of Maine

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