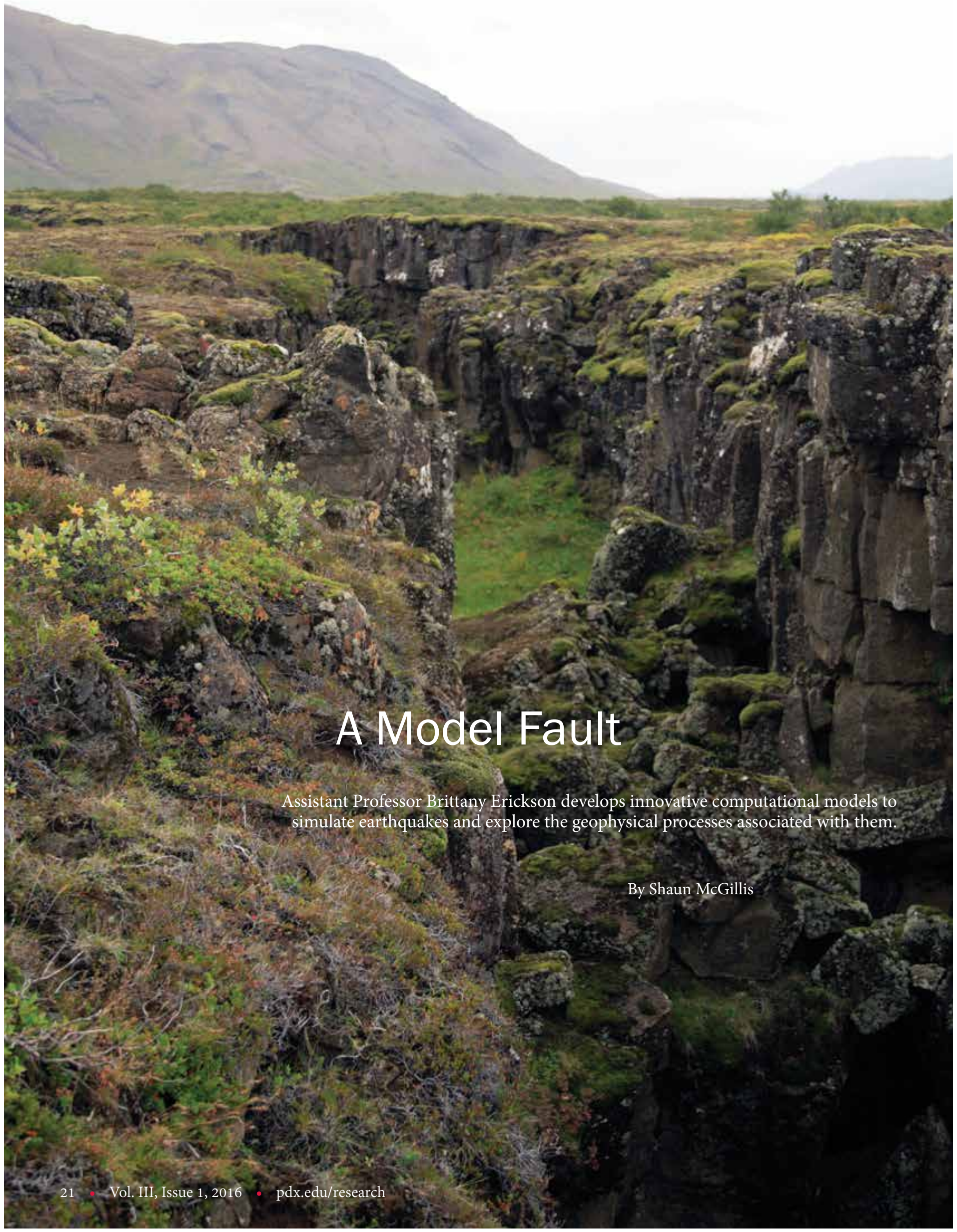

A Model Fault

Assistant Professor Brittany Erickson develops innovative computational models to simulate earthquakes and explore the geophysical processes associated with them.

By Shaun McGillis

Last summer, when journalist Kathryn Schulz published her *New Yorker* article "The Really Big One" about a Cascadia subduction zone earthquake, the story instantly became topic #1 around water coolers, dinner tables and board rooms throughout the Pacific Northwest. "Our operating assumption is that everything west of Interstate 5 will be toast," warned one FEMA official quoted in the story.

In contrast to the nearby Cascade volcanoes that send clear signals weeks or months before erupting, earthquake faults can rupture with little to no warning. Most of what we know about earthquakes comes from looking at historical records and geologic maps. For instance, the danger of Cascadia quakes was only recognized relatively recently when geologists determined that partially submerged forests on the Washington and Oregon coast had died suddenly about 300 years ago after dropping several meters. The only explanation for this drop was that a major earthquake had occurred. Further study of geologic layers seen in trenches, and examination of Japanese tsunami records, showed that similar events had happened many times in the past, repeating every few hundred years.

Developing theoretical models that explain the observed frequencies and magnitudes of earthquakes at a given location is thus a top priority of seismologists. Ideally, a well-constrained model could tell us when and where the next quake would occur, but in practice, we are far from that level of understanding. The scale of overall risk from a Cascadia quake is not in question, but how and when specific areas will be affected depends on details of the local geology, including what the bedrock is composed of, and the geometry of the fault itself. To date, even the most sophisticated computational models have not taken into account these critical factors.

A PSU mathematician hopes to change this, shaking up the way geoscientists test their hypotheses about what happens along faults before, during, and after earthquakes. Mathematics Assistant Professor Brittany Erickson, in collaboration with Dr. Jeremy Kozdon of the Naval Postgraduate School in Monterey, California, has received a three-year grant from the NSF to develop a new earthquake simulation framework that takes into account factors such as the irregular geometry of many faults, the complex material properties of rocks within the earth's crust, and the influence of fractured rocks deep within the fault on future seismic events.

"There are a lot of really good earthquake models out there that can simulate the full [earthquake] cycle in one computational framework," Dr. Erickson said. "But one of the major drawbacks of those models is that their power and efficiency is based on the assumption that you have a single planar fault embedded in a homogenous elastic medium. That's just not how earthquakes work in reality. Our plan is to develop code that achieves a more realistic simulation, including irregular fault geometries, heterogeneous material properties, and the deformation of inelastic rocks within the fault."

The model, which will be one of the most sophisticated ever developed, combines two separate approaches developed independently by Drs. Erickson and Kozdon. One simulates the "loading" period during which pressure accumulates on the fault. The other replicates the earthquake itself. Together, they'll be able to simulate the whole earthquake cycle in two and three dimensions for any fault anywhere in the world.

"Ultimately, what we're trying to figure out is if earthquakes actually conform to our current understanding of the physics we think govern them," added Dr. Erickson.

Over the course of the three-year study, Drs. Erickson and Kozdon will explore the relationships between the material beneath the surface of a fault and earthquake nucleation. Their model will address how a mix of materials influences the amount of slip that occurs between adjacent sections of the earth's crust during an earthquake. They'll investigate how the compositional makeup of materials along faults affects where and when ruptures happen. They'll study the way seismic waves travel through geometrically complex fault networks as well as survey the ways preexisting damage within faults affect nucleation and the propagation of seismic waves.

With time, a more robust understanding of the spatial and temporal interactions between the physical and material characteristics of faults in general and specific faults, like that along the Cascadian Subduction Zone, could lead scientists, city planners, and state and federal officials to more accurate expectations about the damages that may result from future earthquakes. While science still cannot predict when the next big one will happen, with contributions like those Drs. Erickson and Kozdon are making, we are inching closer to a better state of preparedness. And perhaps with continued work and greater understanding of the geophysical processes at play in earthquake cycles, when the next Cascadia earthquake strikes it won't be, as Kathryn Schulz puts it in her article, "the worst natural disaster in the history of the continent."