Earth is 'lazy' when forming faults like those near San Andreas

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Cooke's UMass Amherst lab is one of only a handful worldwide to use a relatively new modeling technique that uses kaolin clay rather than sand to better understand the behavior of Earth's crust. Credit: UMass Amherst

Geoscientist Michele Cooke and colleagues at the University of

Massachusetts Amherst take an uncommon, "Earth is lazy" approach to modeling fault development in the crust that is providing new insights into how faults grow. In particular, they study irregularities along strike-slip faults, the active zones where plates slip past each other such as at the San Andreas Fault of southern California.

Until now there has been a great deal of uncertainty among geologists about the factors that govern how new faults grow in regions where one plate slides past or over another around a bend, says Cooke. In their study published in an early online edition of the *Journal of Structural Geology*, she and colleagues offer the first systematic exploration of fault evolution around fault bends based on modeling in a clay box.

Testing ideas about how the Earth's crust behaves in real time is impossible because actions unfold over many thousands of years, and success in reconstructing events after the fact is limited. A good analog for laboratory experiments has been a goal for decades. "Geologists don't agree on how the earth's crust handles restraining bends along faults. There's just a lack of evidence. When researchers go out in the field to measure faults, they can't always tell which one came first, for example," Cooke says.

Unlike most geoscience researchers, she takes a mechanical efficiency approach to study dynamic fault systems' effectiveness at transforming input energy into force and movement. For example, a straight fault is more efficient at accommodating strain than a bumpy fault. For this reason Cooke is very interested in how the efficiency of fault bends evolves with increasing deformation.

Her data suggest that at restraining bends, the crust behaves in accord with "work minimization" principles, an idea she dubs the "Lazy Earth" hypothesis. "Our approach offers some of the first system-type evidence of how faults evolve around restraining bends," she says.

Further, Cooke's UMass Amherst lab is one of only a handful worldwide to use a relatively new modeling technique that uses kaolin clay rather than sand to better understand the behavior of Earth's crust.

For these experiments, she and colleagues Mariel Schottenfeld and Steve Buchanan, both undergraduates at the time, used a clay box or tray loaded with kaolin, also known as china clay, prepared very carefully so its viscosity scales to that of the earth's crust. When scaled properly, data from clay experiments conducted over several hours in a table-top device are useful in modeling restraining bend evolution over thousands of years and at the scale of tens of kilometers.

Cooke says sand doesn't remember faults the way kaolin can. In an experiment of a bend in a fault, sand will just keep forming new faults. But clay will remember an old fault until it's so inefficient at accommodating the slip that a new fault will eventually form in a manner much more similar to what geologists see on the ground.

Another innovation Cooke and colleagues use is a laser scan to map the clay's deformation over time and to collect quantitative data about the system's efficiency. "It's a different approach than the conventional one," Cooke acknowledges. "I think about fault evolution in terms of work and efficiency. With this experiment we now have compelling evidence from the clay box experiment that the development of new faults increases the efficiency of the system. There is good evidence to support the belief that faults grow to improve efficiency in the Earth's crust as well. "

"We're moving toward much more precision within laboratory experiments," she adds. "This whole field is revolutionized in past six years. It's an exciting time to be doing this sort of modeling. Our paper demonstrates the mastery we now can have over this method."

The observation that a fault's active zone can shift location significantly over 10,000 years is very revealing, Cooke says, and has important implications for understanding seismic hazards. The more geologists understand fault development, the better they may be able to predict earthquake hazards and understand Earth's evolution, she points out.

Provided by University of Massachusetts Amherst