

Tiny clays curb big earthquakes

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California's San Andreas fault is notorious for repeatedly generating major earthquakes and for being on the brink of producing the next "big one" in a heavily populated area. But the famously violent fault also has quieter sections, where rocks easily slide against each other without giving rise to damaging quakes.

The relatively smooth movement, called creep, happens because the fault creates its own lubricants---slippery clays that form ultra-thin coatings on rock fragments, geologist Ben van der Pluijm and colleagues at the University of Michigan and Germany's Ernst-Moritz-Arndt Universität Institut für Geographie und Geologie report in the July issue of *Geology*.

The question of why some fault zones creep slowly and steadily while others lock for a time and then shift suddenly and violently, spawning earthquakes, has long puzzled scientists. Some have speculated that fluids facilitate slippage, while others have focused on serpentine---a greenish material that can alter to slippery talc.

But when van der Pluijm and colleagues analyzed samples of rock from an actively creeping segment that was brought up from a depth of two miles below the surface as part of the San Andreas Fault Observatory at Depth (SAFOD) project, they found very little talc. Instead, they found that fractured rock surfaces were coated with a thin layer of smectitic clay, less than 100 nanometers thick, that acts something like grease on ball bearings.

"For a long time, people thought you needed a lot of lubricant for creep

to occur," said van der Pluijm, who is the Bruce R. Clark Collegiate Professor of Geology and Professor of the Environment. "What we can show is that you don't really need a lot; it just needs to be in the right place. It's a bit like real estate: location, location, location." The nanocoatings occur on the interfaces of broken-up bits of rock in exactly the places where they affect the fault's "weakness"---how easily it moves.

The technique of argon dating provided key evidence, when the researchers determined that these clays, found only in fault rock, formed relatively recently.

"The clays are growing in the fault zone, and the fault is coating its own pieces of fragmented rock," van der Pluijm said. "At some point there's enough coating that it begins to drive the behavior of the fault, and creeping kicks in."

If the fault is greasing itself, then why do earthquakes still occur?

"The problem is that the fault doesn't always move at strands where the coating sits," van der Pluijm said. The [San Andreas fault](#) is actually a network of faults, with new strands being added all the time. Because it takes some time for the slick nanocoatings to develop in a new strand, the unlubricated, new strand "gets stuck" for a time and then shifts in a violent spasm.

Although the samples obtained through SAFOD are from a depth of only about two miles, van der Pluijm and colleagues think it's likely the clay nanocoatings also are forming and driving fault behavior at greater depths. What's more, analyses of older, inactive strands suggest that the coatings have been facilitating creep for the millions of years of fault activity.

The SAFOD project, which is establishing the world's first underground [earthquake](#) observatory, is a major research component of EarthScope, an ambitious, \$197-million federal program to investigate the forces that shaped the North American continent and the processes controlling earthquakes, volcanoes and other geological activity.

More information: Geology: geology.gsapubs.org/

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