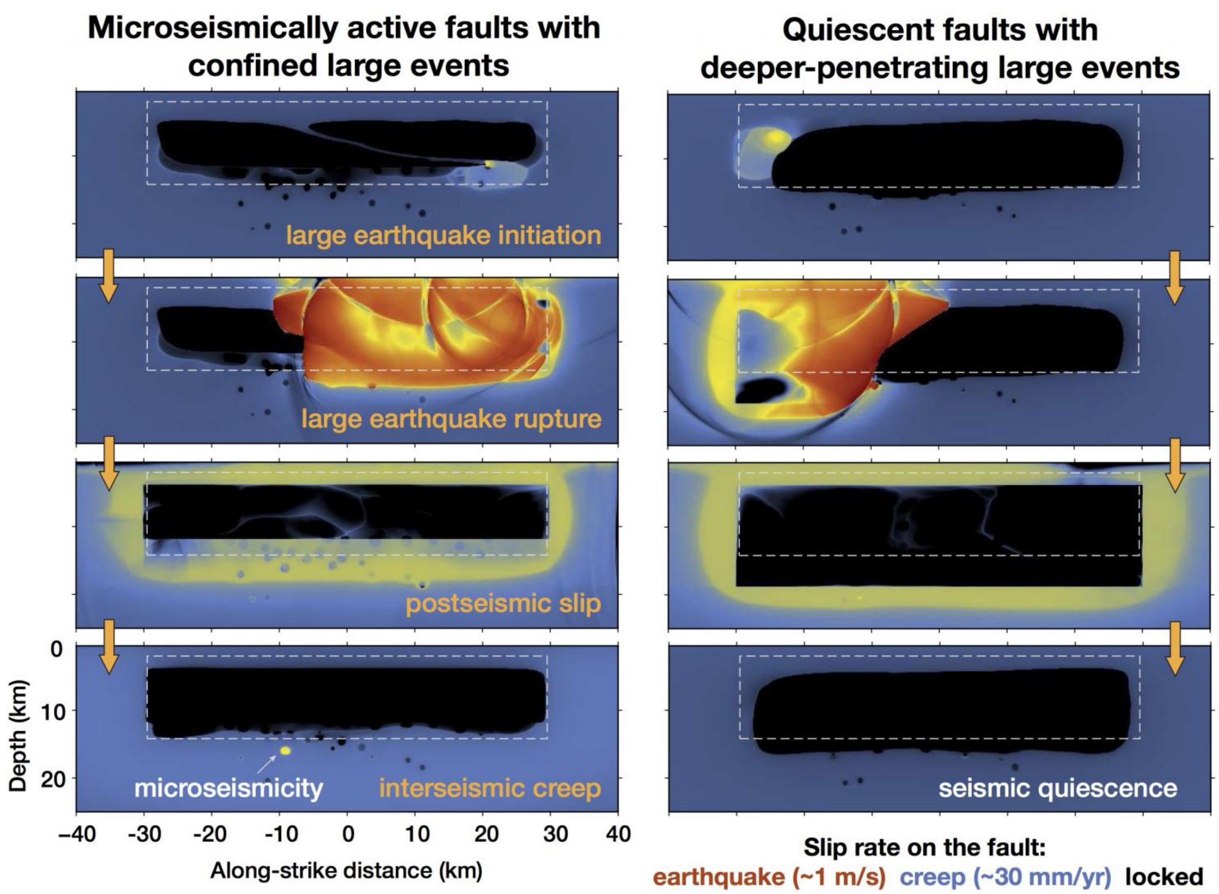
New theory to explain why some fault segments remain quiet between quakes

June 10 2016, by Bob Yirka



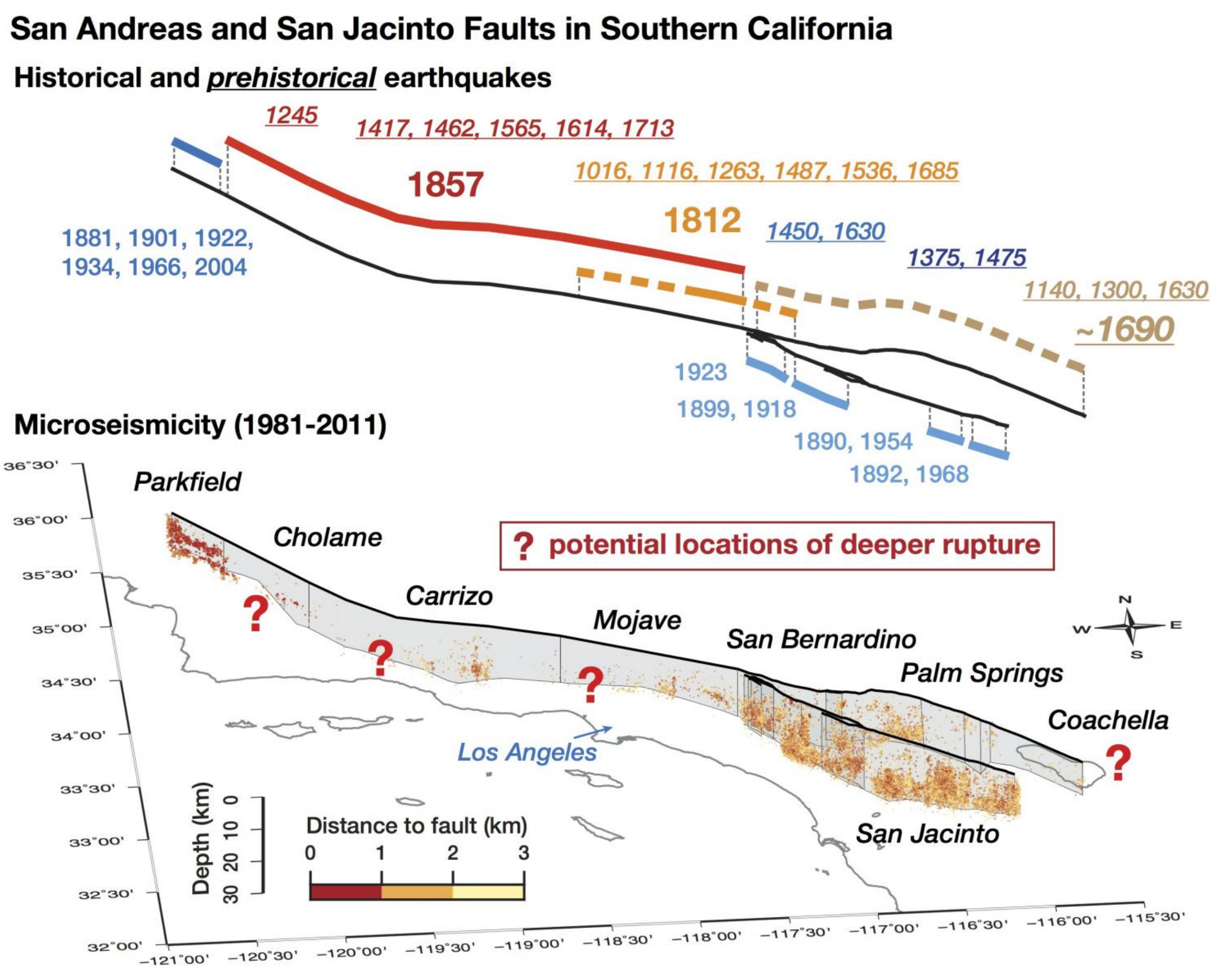
Numerical simulations of earthquakes on seismogenic faults, with different stages in the fault behavior illustrated by snapshots of fault slip rates. (Left) In a conventional model, the rupture extent of large earthquakes is confined in the "seismogenic zone", which supports the initiation of earthquakes (dashed outlines). Active microseismicity occurs frequently at the base of the seismogenic zone due to concentrated loading from below. (Right) On major faults, large earthquakes can sometimes penetrate deeper than the seismogenic zone, leading to quiescence of microseismicity in the long interseismic period that follows. Credit: Junle Jiang

(Phys.org)—A pair of researchers with the California Institute of Technology has developed a new theory to explain why some fault segments, such as parts of the San Andreas Fault, remain seismically silent between quakes. In their paper published in the journal *Science*, Junle Jiang and Nadia Lapusta describe their theory and how they tested it.

Over the past several decades scientists have installed a lot of sensors meant to listen to the Earth as tectonic plates push up against one another, hoping to find a pattern that might lead to a means for predicting earthquakes. By doing so, they have learned a lot about the different noises that faults make depending on which types of materials are found at their borders and other factors. And one disturbing thing they have learned is that some fault segments make almost no noise at all between quakes—why this is has remained a mystery. In this new effort the research pair proposes a new theory, one that is based on what happens in such areas during their most recent quake.

Most earthquakes in California are rather shallow, it has been noted, they get their start just eight or nine miles below the surface, where rigid rocks fracture when a certain amount of pressure builds. Below those rocks there is typically a layer of layer of minerals that under such pressure behave as pliable plastics, which tend to slow quakes and stop them. But, the researchers note, some quakes may cause shaking that goes deeper, deep into the malleable layer, leaving behind stored energy. In such cases, the stresses above would have been relieved by the prior quake, leaving the mineral layer holding onto the stress that would normally be held in the rock above. As time passes, because the malleable layer can flow, more energy builds, but none is released, thus there are no noises seeping up to the surface for researchers to hear. Eventually, of course, that energy is released into the rock above, and the plate moves, and a large earthquake occurs.

The researchers report that this theory appears plausible—they simulated the whole thing by inputting historical data for the San Andreas Fault at its quiet points and found that it showed a quiet buildup and then a sudden large quake was possible. Further research will be needed to add credence to the theory of course, but if it turns out to be true, it seems reasonable to assume that a really long probe pushed deep into the ground at quiet fault zones that measure pressure in the malleable zone, might offer some degree of prediction assistance.



(Top) Historical and prehistorical large earthquakes and (bottom) microseismicity that occur between 1981 and 2011 on the San Andreas Fault and the San Jacinto Fault in Southern California. Active microseismicity is observed at great depths on the Parkfield and San Bernardino segments on the San Andreas Fault and most parts on the San Jacinto Fault. Cholame, Carrizo, Mojave, and Coachella segments have been seismically quiescent for decades. The 1857 and ~1690 events probably penetrated below the seismogenic zone, and similar behavior can occur in future events. Credit: Junle Jiang

More information: J. Jiang et al. Deeper penetration of large

earthquakes on seismically quiescent faults, *Science* (2016). DOI: 10.1126/science.aaf1496

Abstract

Why many major strike-slip faults known to have had large earthquakes are silent in the interseismic period is a long-standing enigma. One would expect small earthquakes to occur at least at the bottom of the seismogenic zone, where deeper aseismic deformation concentrates loading. We suggest that the absence of such concentrated microseismicity indicates deep rupture past the seismogenic zone in previous large earthquakes. We support this conclusion with numerical simulations of fault behavior and observations of recent major events. Our modeling implies that the 1857 Fort Tejon earthquake on the San Andreas Fault in Southern California penetrated below the seismogenic zone by at least 3 to 5 kilometers. Our findings suggest that such deeper ruptures may occur on other major fault segments, potentially increasing the associated seismic hazard.