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What triggers earthquakes in stable continental regions (SCR)? An example of the New Madrid seismic zone, Central-Eastern U.S.

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Stable continental regions (SCR) are characterized by negligible present-day tectonic loading. However, large earthquakes have been recorded in SCR such as four M>7 in the New Madrid Seismic Zone (NMSZ) in 1811-1812. The triggering mechanism of these earthquakes remains poorly understood and whether external stress perturbations are required to explain fault reactivation is unclear. Here, on the basis of a Mohr-Coulomb stress analysis of 34 well-determined 2.1<M<5.3 focal mechanisms since 1962, we seek to determine if pore-fluid overpressure or fault weakness are required for explaining fault reactivation in the NMSZ. To do, we developed a parametric approach to determine the ability of fault to be reactivated by varying the stress tensor, differential stress and phi ratio. We optimize these three parameters to explain the slip direction as given by the rake of the nodal planes while maximizing the differential stress before the intact rock fails. This approach allows us to determine the conditions allowing fault reactivation under the lowest stress perturbation. Our results show that present-day reactivation of faults in this earthquake magnitude range in the NMSZ requires either pore-fluid overpressures or weak faults. If one considers that fault friction obeys Byerlee's law, then more than half of the earthquake faults studied here are not close to reactivation and require up to 80 MPa of pore-fluid overpressure to rupture. We infer the origin of these fluid overpressures to be internal since such overpressure magnitudes cannot be achieved by rainfall itself.