Large earthquakes in stable continental regions

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Abstract

Large earthquakes within stable continental regions (SCR), where tectonic loading rates are negligible, show that significant amounts of elastic strain can be released on geological structures far from plate boundary faults, where the vast majority of the Earth's seismic activity takes place. In the absence of a more appropriate model, they are traditionally viewed as analogous to their plate boundary counterparts, occurring when the accrual of tectonic stress localized at long-lived active faults reaches failure threshold.
Here we present an ensemble of observations in support of the following (testable) hypotheses:
- SCR earthquakes do not persist on any single fault system.
- SCR faults do not localize stress or strain accrual.
- SCR faults are at failure equilibrium.
- SCR earthquakes often require the presence of fluids at seismogenic depth.
- SCR crust is a reservoir of "fossil strain" stored over long geological times as a result of slowly varying tectonic forces.
- SCR earthquakes are triggered by transient variations of local stress that modulate the slowly-varying, background tectonic stress.
We argue that SCR earthquakes are better explained by transient perturbations of local stress or fault strength that release elastic energy from a prestressed lithosphere than by localized accrual and release of tectonic stresses on individual fault systems. As a result, SCR earthquakes can occur in regions with no previous seismicity and no surface evidence for strain accumulation. They need not repeat, since the tectonic loading rate is close to zero. Therefore, concepts of recurrence time or fault slip rate do not apply. As a consequence, seismic hazard in SCRs is likely more spatially distributed than indicated by paleoearthquakes, current seismicity, or geodetic strain rates.

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