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Complex spatiotemporal patterns of intracontinental earthquakes: a different game

Mian Liu[1], Yuxuan Chen[1], Seth Stein[2], Gang Luo[3], and Hui Wang[4]
[1]Dept. Geological Sciences, University of Missouri, Columbia, MO 65203 USA (lium@missouri.edu)
[2]Northwestern University, Department of Earth & Planetary Sciences, Evanston, IL 60208 USA
[3]School of Geodesy and Geomatics, Wuhan University, Wuhan 430079 China
[4]Institute of Earthquake Forecasting, China Earthquake Administration, Beijing 100036, China

Intracontinental earthquakes show complex spatiotemporal patterns. In North China, no large (M>7) earthquakes ruptured the same fault segments in the past 2000 years; instead they roamed among widespread fault systems. In Australia, morphogenic evidence indicates clusters of earthquakes separated by tens of thousands of years of dormancy. In central and eastern United States, paleoseismic studies suggest that large Holocene earthquakes occurred in places that are seismically inactive today. Such seismicity does not fit existing earthquake models that assume steady tectonic loading and cyclic stress release on fault planes. Intracontinental fault systems are widespread and collectively accommodate slow tectonic loading. A major fault rupture both transfers stress to the neighboring faults and perturbs loading conditions on distant faults. Thus, the loading rate on each individual fault can be variable. Slow tectonic loading means that local stress variations from fault interaction or nontectonic processes, or changes of fault strength, could trigger an earthquake. Furthermore, large intracontinental earthquakes usually rupture multiple fault segments or faults, which vary for each event. For these earthquakes, commonly used concepts such as recurrence intervals and characteristic earthquakes, all based on earthquake models assuming cyclic elastic rebound, are inadequate or inapplicable. On the other hand, the general patterns of intracontinental earthquakes can be described by the theory of complex dynamic systems, in which all faults interact with each other. The rupture of individual fault or fault segment cannot be predetermined, but the system behavior can be studied based on the records of previous events. We found that large intracontinental earthquakes, either on a fault system or in a region, are usually clustered and separated by long but variable periods of quiescence. The lengths of the quiescence periods inversely correlate with tectonic loading rates, and the characteristics of earthquake clusters depend on fault geometry and crustal rheology, through fault interaction and viscoelastic relaxation. Spatially, large intracontinental earthquakes are not limited to faults that are active recently, although weak regions tend to have more earthquakes. Intracontinental earthquakes require a different approach, one that focuses on stress interactions between faults in a complex dynamic system rather than stress accumulation and release on individual faults.