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Space-time behavior of continental intraplate earthquakes and implications for hazard assessment in China and the Central U.S.

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Earthquakes in midcontinents and those at plate boundaries behave quite differently in space and time, owing to the geometry of faults and the rate at which they are loaded. Faults at plate boundaries are loaded at constant rates by steady relative plate motion. Consequently, earthquakes concentrate along the plate boundary faults, and show quasi-periodic occurrences, although the actual temporal patterns are often complicated. However, in midcontinents, the tectonic loading is shared by a complex system of interacting faults spread over a large region, such that a large earthquake on one fault could increase the loading rates on remote faults in the system. Because the low tectonic loading rate is shared by many faults in midcontinents, individual faults may remain dormant for a long time and then become active for a short period. The resulting earthquakes are therefore episodic and spatially migrating. These effects can be seen in many areas, with a prime example being a 2000-year record from North China, which shows migration of large earthquakes between fault systems spread over a large region such that no large earthquakes rupture the same fault segment twice.

Because seismic activity within mid-continents is usually much lower than that along plate boundary zones, even small earthquakes can cause widespread concerns, especially when these events occur in the source regions of previous large earthquakes. However, these small earthquakes may be aftershocks that continue for decades or even longer, because aftershock sequences often last much longer in midcontinents where tectonic loading is slow, than at plate boundaries. The recent seismicity in the Tangshan region in North China is likely aftershocks of the 1976 M7.8 Tangshan earthquake. Similarly, current seismicity in the New Madrid seismic zone in central U.S. appears to be aftershocks of a cluster of M $\sim$7.0 events in 1811-1812. These large events and similar events in the past millennium release strain much faster than it accumulates today, suggesting that they result from recent fault activation that releases prestored strain energy in the crust. If so, this earthquake sequence is similar to aftershocks in that the rates of energy release should decay with time and the sequence of earthquakes will eventually end. We use simple physical analysis and numerical simulations to show that the current New Madrid earthquake sequence is likely ending or has ended. Recognizing that mid-continental earthquakes have long aftershock sequences and complex spatiotemporal occurrences is critical to improve hazard assessments