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Do Intraplate and Plate Boundary Fault Systems Evolve in a Similar Way with Repeated Slip Events?

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As repeated slip events occur on a fault, energy is partly dissipated through rock fracturing and frictional processes in the fault zone and partly radiated to the surface as seismic energy. Numerous field studies have shown that the core of intraplate faults becomes wider on average with increasing total displacement (and hence slip events). In this study we compile data on the fault core thickness, total displacement and internal structure (e.g., fault core composition, host rock juxtaposition, slip direction, fault type, and/or the number of fault core strands) of plate boundary faults to compare to intraplate faults (within the interior of tectonic plates). Fault core thickness data show that plate boundary faults are anomalously narrow by comparison to intraplate faults of the same displacement and that they remain narrow regardless of how much total displacement they have experienced or the local structure of the fault. By examining the scaling relations between seismic moment, average displacement and surface rupture length for plate boundary and intraplate fault ruptures, we find that for a given value of displacement in an individual earthquake, plate boundary fault earthquakes typically have a greater seismic moment (and hence earthquake magnitude) than intraplate events. We infer that narrow plate boundary faults do not process intact rock as much during seismic events as intraplate faults. Thus, plate boundary faults dissipate less energy than intraplate faults during earthquakes meaning that for a given value of average displacement, more energy is radiated to the surface manifested as higher magnitude earthquakes. By contrast, intraplate faults dissipate more energy and get wider as fault slip increases, generating complex zones of damage in the surrounding rock and propagating through linkage with neighboring structures. The more complex the fault geometry, the more energy has to be consumed at depth during an earthquake and the less energy reaches the surface.