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Neotectonic constraint on models of strain localisation within Australian Stable Continental Region (SCR) crust

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The mechanisms that lead to the localisation of stable continental region (SCR) seismicity, and strain more generally, remain poorly understood. Recent work has emphasised correlations between the historical record of earthquake epicentres and lateral changes in the thickness, composition and/or viscosity (thermal state) of the lithospheric mantle, as inferred from seismic velocity/attenuation constraints. Fluid flow and the distribution of heat production within the crust have also been cited as controls on the location of contemporary seismicity. The plate margin-centric hypothesis that the loading rate of crustal faults can been understood in terms of the strain rate of the underlying lithospheric mantle has been challenged in that a space-geodetic strain signal is yet to be measured in many SCRs. Alternatives involving the release of elastic energy from a pre-stressed lithosphere have been proposed.

The Australian SCR crust preserves a rich but largely unexplored record of seismogenic crustal deformation spanning a time period much greater than that provided by the historical record of seismicity. Variations in the distribution, cumulative displacement, and recurrence characteristics of neotectonic faults provide important constraint for models of strain localisation mechanisms within SCR crust, with global application. This paper presents two endmember case studies that illustrate the variation in deformation characteristics encountered within Australian SCR crust, and which demonstrate the range and nature of the constraint that might be imposed on models describing crustal deformation and seismic hazard.

The ~0.5 m high 2018 M_W 5.3 Lake Muir earthquake scarp in southwest Western Australia is representative of a class of ruptures in the Precambrian SCR of Australia where the scarps are isolated from neighbouring scarps and there is little or no landscape evidence for recurrence of morphotectonic earthquakes, or of the construction of regional tectonic relief. In contrast, scarps in the Phanerozoic SCR of eastern Australia typically occur within a scarp-length of neighbouring scarps, and demonstrate extended histories of recurrence of morphotectonic events. For example, the ~75 km-long Lake George fault scarp is associated with a vertical displacement of ~250 m which accrued as the result of many morphotectonic earthquakes over the last ca. 4 Myr. The scarp links into neighbouring scarps, forming a belt-like arrangement that defines the topographic crest of the southeast Australian highlands. The limited data available indicates that recurrence is highly episodic, with periods of fault activity potentially coinciding with changes at the plate boundaries.