The 2016 Mw 6.1 Petermann Ranges earthquake rupture, Australia: another "one-off" stable continental region earthquake

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SM2.2: Earthquakes and active tectonics in regions of slow lithospheric deformation: towards a re-evaluation of the Stable Continental Region concept in seismic hazard assessment
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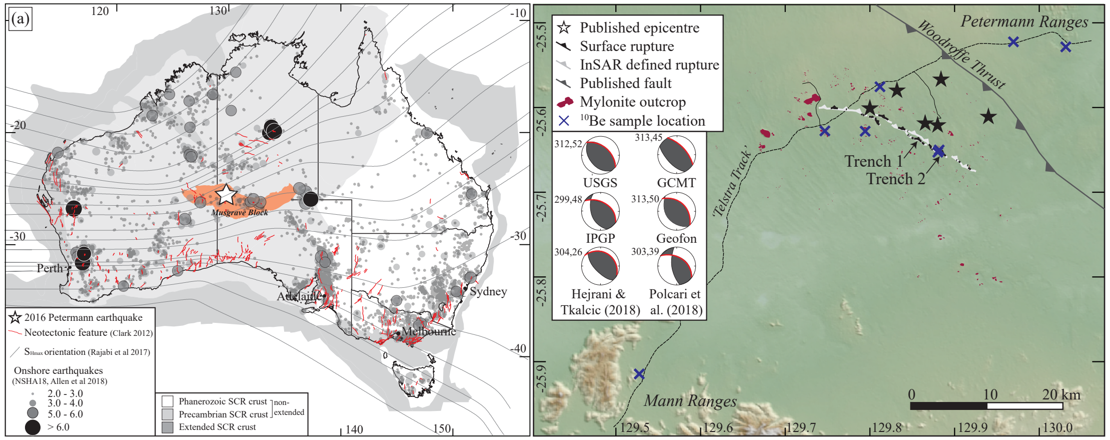
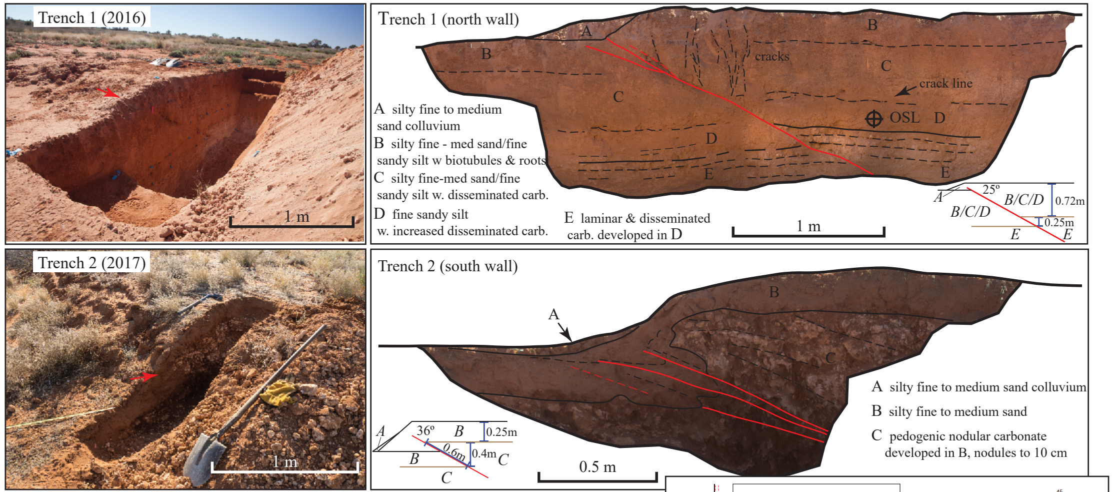
(1) Location & Summary

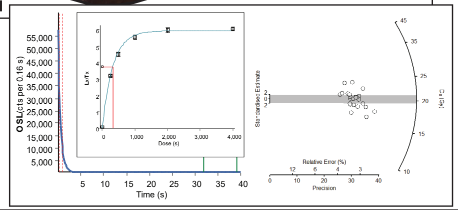


- 21st May 2016 Mw 6.1 Petermann Earthquake, reverse mechanism, 21 km surface rupture, 1m max. offset
- 2nd longest single-event historic Australian surface rupture and largest Mw on-shore earthquake in 28 years
- Rupture propagated along mylonite foliation planes in the hanging-wall of the Proterozoic Woodroffe Thrust zone
- The 10th of 11 historic surface rupturing earthquakes in Australia between 1968 - 2018
- No prior historic surface rupturing events show unequivocal evidence for previous earthquake events (King et al 2019)
- All events occurred in bedrock-dominated Precambrian SCR cratonic crust, on previously unrecognised faults
- A combination of traditional (trenching, OSL, geomorphic analysis) and non-traditional (^{10}Be erosion rates) techniques are used here to assess the recurrence history of the Petermann fault

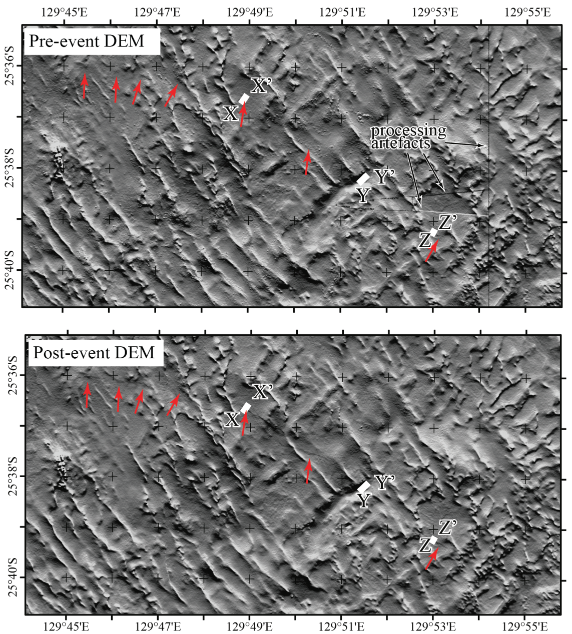
(2) Trench Logs and OSL Date

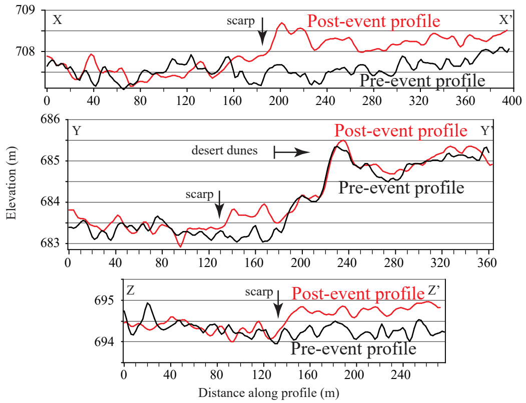


- Two trenches dug to constrain fault dip and prior rupture history
- Both trenches host only single-event displacements
- OSL age of aeolian sediment cover from Trench 1 = 10.6 ± 0.4 ka
- Provides minimum time interval without surface rupture
- I.e. prior ruptures may have occurred before deposition of aelian sediment and calcrete precipitation



(3) Pre- and Post- event Topographic Comparison & Geomorphic Analysis

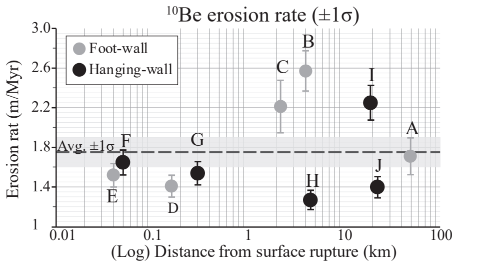


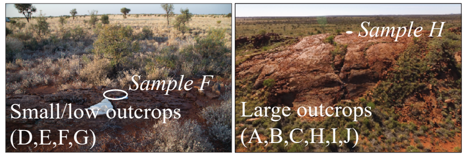


- Pre- & post-event Worldview 1 & 2 derived digital elevation models (DEMs from Gold et al. (2018))
- Profiles show no prior topography related to rupture on the Petermann fault
- No evidence in the topography or dune systems suggesting incising drainage or migrating nick-points across the region of hanging-wall uplift
- No evidence for prior rupture preserved in topography or geomorphology (i.e if prior rupture exists, it has been removed from the landscape)

(4) Cosmogenic ^{10}Be Nuclide Erosion Rates

- Sampling survey to test if bedrock in the vicinity of the historic rupture preserves locally increased hanging-wall erosion rates due to (i) in-situ rock fragmentation/shattering (ii) relative hanging-wall uplift
- Seven erosion rates from an 8.5 km long transect across the surface rupture & three background rates (19 - 50 km away)
- No evidence for increased hanging-wall or fault-proximal erosion rates related to prior events
- Erosion rates do not correlate with distance from the fault trace
- Rates provide a test for the longevity of a similar bedrock scarp in this landscape (e.g. no topographic/geomorphic evidence of pre-2016 scarp)
- We estimate that a bedrock scarp could persist as a distinguishable feature for 0.4 to 1 Myr





(5) Conclusions

- Trenching, topographic & geomorphic analysis, and cosmogenic ^{10}Be erosion rates suggest no prior rupture on the Petermann fault within the last 0.4 - 1 Myrs
- This event may represent the first rupture on this bedrock 'fault' (i.e. prior to the 2016 event, this bedrock structure (mylonitic foliation fabric) was unrecognisable as a 'fault')
- A lack of evidence for prior rupture on all historic surface rupturing faults in Australian Precambrian crust suggests pre-existing bedrock structures may be capable of hosting one-off, or at least, first-of-their-kind, earthquakes
- This raises issues in similar crustal settings for:
    - Using active fault databases in probabilistic seismic hazard assessments in similar crustal settings
    - Using slip-rate in PSHA in the absence of prior rupture (i.e. no 'rate' is determinable)