Near-field directionality of earthquake strong ground motions measured by displaced geological objects

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SM7.3 Physics-based earthquake modelling and engineering
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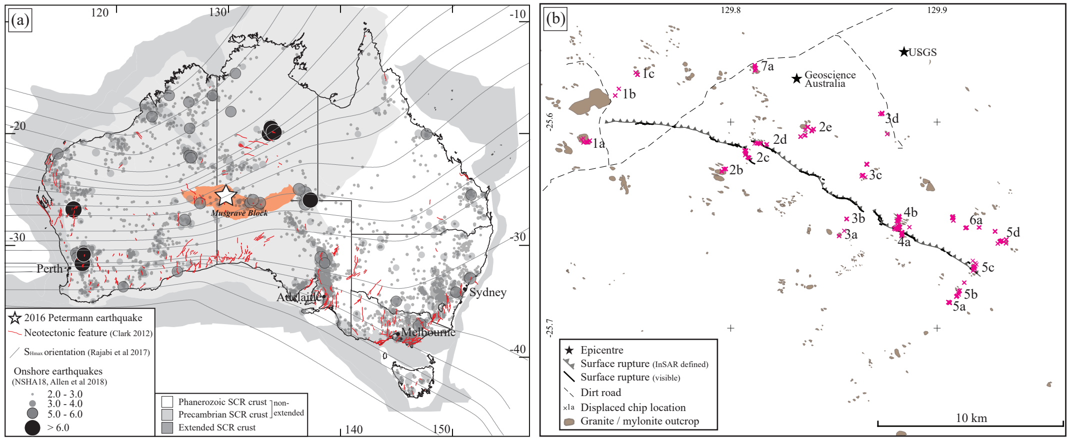
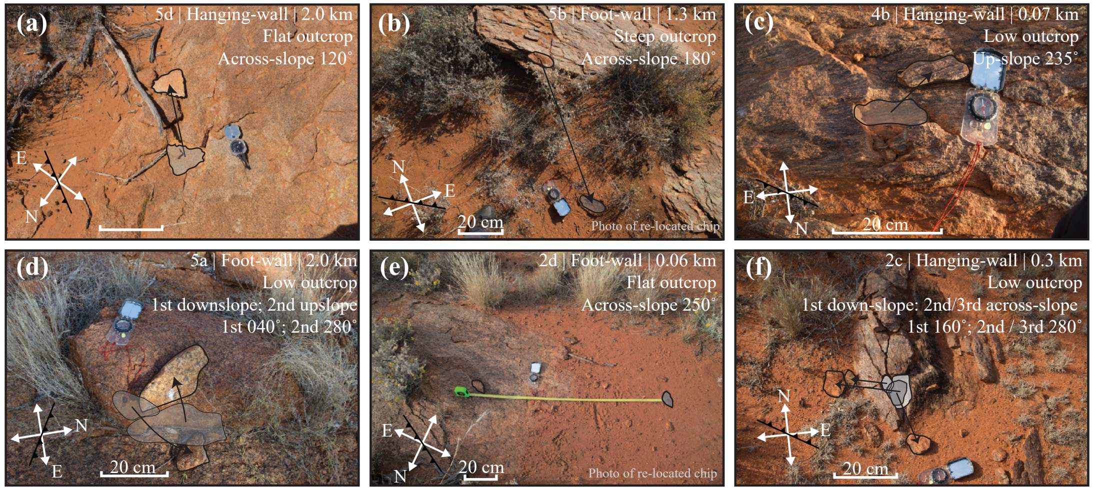
(1) Location & Summary



- 21st May 2016 Mw 6.1 Petermann Earthquake. Reverse mechanism, 21 km surface rupture, 1m max. offset
- Granitic mylonite at surface, eroding predominately through exfoliation of 1 - 6 cm thick sheets
- Rock fragments (exfoliation sheets) inferred as coseismically displaced from bedrock based on field-observations
- Interpreted to result predominately from mainshock based on aftershock and rock fragment distribution
- Previous displaced rock studies (e.g. Borrego Mountain 1968 (Clark 1972); Hector Mine 1999 (Michael et al. 2002)) were spatially limited, the Petermann data span ~ 100 km^2 area along & across rupture, with a dense dataset (n=1495)

(2) Field data & Methods

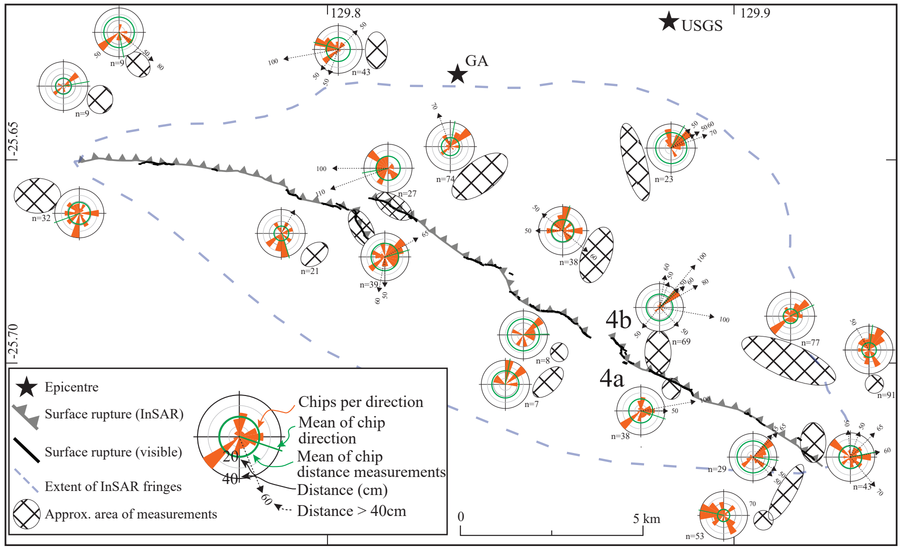


Observations:
- Displaced rock fragments up to 5km on hanging-wall, 2 km on foot-wall
- Coseismic timing from crushed fresh vegetation, fresh impact sites, etc

Field methods: n=251 rocks
- Fragments relocated (e.g. jigsaw puzzle)
- Distance & direction measured
- GPS located photographs taken
- Brief rock & outcrop description

Digital methods: n=1187 rocks
- GPS photos used to locate data
- Distance and direction estimated from compass in photo
- Brief rock & outcrop description
- Confidence / uncertainties recorded

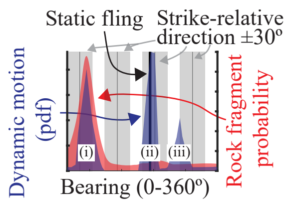
(3) Field Directionality and Distance Data

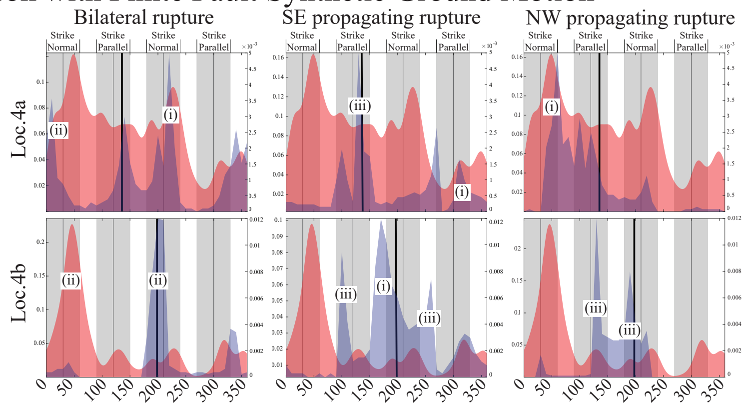


- Strong NE directed signal in near-rupture hanging-wall locations central to the surface rupture
- No clear directionality signals on foot-wall outcrops, and in the north-west extent of surface rupture (where slip is minimal)
- Difficult to correlate number of observed chips to location, due to dependence on number of outcrops, rock type, etc
- Generally though, more chips are observed offset close to the surface rupture on the hanging-wall
- Difficult to interpret offset distance due to individual complexity of outcrop/chip/ground motion interaction (e.g. site effects)
- Generally though, larger distances are measured closer to the surface rupture on the hanging-wall

(4) Directionality Comparison with Finite Fault Synthetic Ground Motion

- Dynamic and static displacements are derived for bilateral & unilateral (SE propagating, NE propagating) rupture models
- Bilateral rupture best supports hanging-wall rock directions, resulting from strong fling + dynamic motions
- Foot-wall rocks and ground motions show less directionality, as expected for a reverse fault rupture





(i) dynamic motions and rock displacment peaks in the same direction
(ii) static and/or dynamic motion peak opposite direction to rock displacement peak
(iii) dynamic motion peaks are not opposite or overlapping rock displacements

(5) Conclusions

- Displaced rocks in the near-field (< 5 km) of this Mw 6.1 earthquake reverse fault surface rupture exhibit non-random displacements attributed to co-seismic ground displacements
- Bilateral finite-fault rupture is the preferred model for explaining rock directionality data
- Rock data act as dense near-field strong groung motion records, preserving directionality in dynamic and static (fling) motions
- Data demonstrate hanging-wall effects, with less directionality on the foot-wall, and intensification of motion and offset with proximity to the surface rupture
- Rock displacement data may help resolve seismic near-field directionality for use in seismic hazard and infrastructure planning, in the absence of dense near-field instrumentation