Triggered slip and afterslip in the July 2019 Ridgecrest earthquake sequence

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1. Triggered Slip

XMR Melendy Ranch
resolution 3 µm, sample 1/minute
range 1.8 m

11 creepmeters
resolution 3 µm
sample rate 1/minute
range 1.8 m

2. Mezzocentral Afterslip

7 Ridgecrest creepmeters
resolution 3 µm
sample rate 1 min (10s initially)

3. Surprise findings
creepmeter: 3 hr installation, alkaline cells 1 yr, 1 min. sample, 3 µm resolution, 1.8 m range
Carbon rod
Triggered slip onset and duration

Quarry SE (274.3km) SAF Mecca Hills
Mw=7.1
peak velocity 3.38 mm/min.
duration 2 minutes

Ross Road (388 km) Imperial Fault
Mw=6.4
peak velocity 60 µm/min.
duration 7 minutes

data-> analysis-> travel time graph etc.
Teleseismic triggering from the Ridgecrest earthquake
Triggered slip amplitude?

depends on tectonic setting and previous history, not distance

Mw7.1 slip $\approx 3 \times$ Mw6.4 slip
Mezzocentral afterslip

3 creepmeters on Mw6.4, Mw7.1 ruptures

4 creepmeters on Garlock fault
Afterslip decays roughly same rate as cumulative regional moment release.

Mw6.4 rupture (RA,RB). Mw7.1 rupture (R7), and Garlock post-seismic creep.
surprise #1  propagating events follow triggering

QE and QW 870 m apart in NW Mecca Hills

events propagate in opposite directions days after triggering

subevents 1.68 days and 2.29 days after triggering
QE and QW 870 m apart in NW Mecca Hills events propagate after 1.7 days and 2.29 days in opposite directions. Afterslip continues for two months.
surprise #1 propagating events follow triggering

QE and QW 870 m apart in NW Mecca Hills events propagate after 1.7 days and 2.3 days in opposite directions: afterslip continues

Mecca Hills aftermath

propagating creep event #2

NW to SE @ 5 cm/s

2 µm/minute

T+2.29 days

T+2.29 days

T+1.68 days

SE to NW 55 cm/s

Mecca Hills aftermath
surprise #2 fault zone contracts during aseismic slip

Two creepmeters measure fault slip at Salt Creek

Caveats: Assumes AC invariant. Just one site (could be unique)

Problem: strain tensor incompletely defined

creepmeter c
12.8 m @ 103°

creepmeter a
11.8 m @ 61°

San Andreas Fault 133°

B

1.66 mm Chiapas
1.1 mm Ridgecrest

dextral

0.44 mm Chiapas
0.29 mm Ridgecrest

convergence

22.7 km
is dilated fault gouge responsible for contraction?

Phacoidal foliation (Bosworth 1981)

polished concave/convex surfaces
slickensides
lozenge shaped clay clasts
long axes ≈45° to fault strike

Mecca Hills phacoid
1. aseismic shear dilates fault zone (years)
2. creep event releases flank shear (hours)
3. dilation reversed, fault zone contracts

Heavy rain reduces fault zone friction and interclast friction facilitating counter-clockwise clast rotation, and fault zone contraction.

Phacoidal fabric controls en echelon surface cracks.
Summary: blue indicates new insights from Ridgecrest sequence

Triggering follows surface wave arrival
Triggered slip travel time (≈1.7 km/s)
Triggered slip duration increases with distance (surface wave dispersion)
Fault zone contracts during creep (?)
Triggering amplitude related to Mw and history, less on remoteness.
Triggering followed by continued afterslip (7 weeks on southern SAF)
Triggered afterslip includes north and south propagating events
Ridgecrest mainshock ruptures – negligible afterslip in south (0.5 mm)
Garlock fault microns of stability (Garlock-ed!)
En-echelon surface cracks likely controlled by phacoidal fabric