Aftershocks of the 2016 Mw 7.8 Ecuador earthquake reveal earthquake cycle is controlled by long-lived structures

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Seismotectonic Context

- 2016 Mw 7.8 Earthquake
- Interseismic Coupling
- Past Ruptures: 1906 M~8.6, 1942 M7.8, 1958 M7.7, 1979 M8.2
- Diversity of Slip Processes SSE, Repeating Eqs., Swarms

Interseismic coupling (Nocquet et al., 2014)
Coseismic rupture (Nocquet et al., 2016)
Rupture areas of past earthquakes (Kanamori and McNally, 1982; Mendoza and Dewey, 1984)
Processing

1-year Aftershock Deployment
60 Temporary Stations + Permanent Ecuadorian Network

Processing in Seiscomp3
STA/LTA + DBSCAN

Relocation in NonLinLoc
10k aftershocks
Local Magnitude ($M_L$) 0.7 – 6.9    $Mc = 2.5$
Aftershocks Distribution

Coseismic rupture (Nocquet et al., 2016)
40 cm afterlip patches (Rolandone et al., 2018)
Seismotectonics and Moment Tensors

- Mw = 4
- Mw = 5
- Mw = 6
- Strike-slip
- Normal
- Reverse

- Mw=4.9 Foreshock

- Mean = 22
  Sigma = 16

- Reverse Fault Events

- Coastline Position

- Distance Along Profile (km)

- Depth (km)
Earthquake Density

Coseismic rupture (Nocquet et al., 2016)
40 cm afterlip patches (Rolandone et al., 2018)
Relation to Afterslip

Close linear temporal dependency between afterslip and aftershocks

Cumulative Moment (N m)

Moment Rate (N m d\(^{-1}\))
Relation to Afterslip

Log-time expansion of aftershocks along-strike

Theoretical and numerical simulations (e.g. Perfettini and Avouac, 2004; Ariyoshi et al., 2007; Kato et al., 2007; Perfettini et al., 2018)

Observational Studies (e.g. Peng and Zhao, 2009; Franck et al., 2017)

⇒ Afterslip drives aftershock activity
Residual bathymetry (Oniangue, 2016; Basset and Watts, 2015)
The Big Picture

Interaction between seismic and aseismic processes along the earthquake cycle

Bimodal slip segmentation both along-strike and along-dip, controlled by structural features such as incoming oceanic relief
The Big Picture

Along-strike

Large megathrust earthquakes that can rupture up to the trench.

No large megathrust earthquakes that can rupture up to the trench. Presence of aseismic slip processes.
The Big Picture

Along-dip

No large megathrust rupture, or if any, contained between ~15 to 35 km depth.

No large earthquakes. Aseismic slip, repeating earthquakes, swarms
Conclusion

1 year postseismic activity, +10,000 events, M<6.9

Aftershocks constrained within coseismic rupture and up-dip

Persistent seismicity patterns over the earthquake cycle (IS & PS)

Linear temporal dependency between afterslip and aftershocks
Log-time expansion of aftershocks
   ➔ aftershocks evolution governed by afterslip

Interaction of seismic and aseismic processes along the earthquake cycle

Variability of slip modes controlled by subducted oceanic relief

Bimodal slip segmentation along-strike and along-dip
Relation to Coseismic Slip Distribution

Coseismic rupture (Nocquet et al., 2016)