San Bernardino basin focal mechanisms reveal signals of interseismic loading and the 1812 Wrightwood earthquake

Michele L. Cooke, Jennifer L. Hatch and Hanna M. Elston
Normal slip focal mechanisms?

Microseismicity (Yang et al. 2012 and subsequent updates) has unexpected normal slip events within the San Bernardino basin between two major strike-slip faults.

Forward interseismic models with 20 km locking depth predict strike-slip events at the locations of the observed microseismicity.

From Cooke and Beyer (2018)
Catalog Completeness

- Reverse Strike-slip
- Normal

1981-2002:
- Frequency
- Magnitude
- Log(N)
- Magnitude
- 1.9

2002-2011:
- Frequency
- Magnitude
- Log(N)
- Magnitude
- 1.5

2011-2020:
- Frequency
- Magnitude
- Log(N)
- Magnitude
- 1.1
3514 declustered events

Threshold $\eta_o = 10^{-5}$ from Zaliapin & Ben Zion (2013)

4620 focal mechanisms in complete catalog

3514 declustered focal mechanisms

- K-means using squared Euclidean distance to identify clusters
- Choose largest magnitude event in each cluster
Depth variation within the San Bernardino basin

Within the depths of 8-14 km normal slip events are as prevalent as strike-slip events.

Interseismic loading produces strike-slip stress state above the locking depth.

From Abolfathian et al 2018
Long-term basin extension

Long term deformation over multiple earthquake cycles shows dilation within the San Bernardino basin.

Since normal slip events occur primarily below 8 km depth could the San Jacinto have creep below this depth?

From Cooke and Beyer (2018)
With SJ locking depth 10km SA 20 km

Complete & declustered focal mechanisms

Interseismic forward model predictions

uniform random noise (+/- 0.5) added to the model predictions to account for heterogeneity

From Cooke and Beyer (2018)
Wrightwood 1812 earthquake


Hatch et al. (2020) show that recent earthquakes contribute to total stress state on nearby faults
Two contributions to stress state

Focal mechanisms

Interseismic loading

1812 Wrightwood event

Uniform random noise added to model results +/- 0.5
Recent events & interseismic loading → stress state

Focal mechanisms

Interseismic loading

1812 Wrightwood event

microseismicity may change over EQ cycle

time
Regional stress state unreliable where fault behavior and geometry are complex

The regional stress state inaccurately predicts strike-slip microseismicity in the San Bernardino basin.

Stress state depends on interseismic loading & recent earthquakes ← on and off of faults

From Hatch et al. (2020)