San Gorgonio Pass Special Fault Study Area

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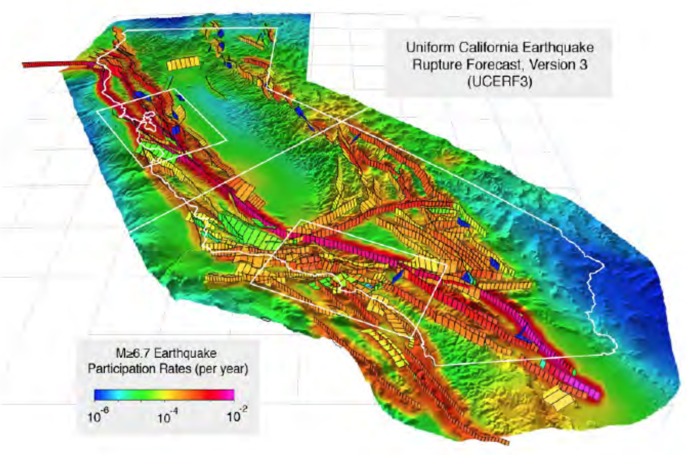
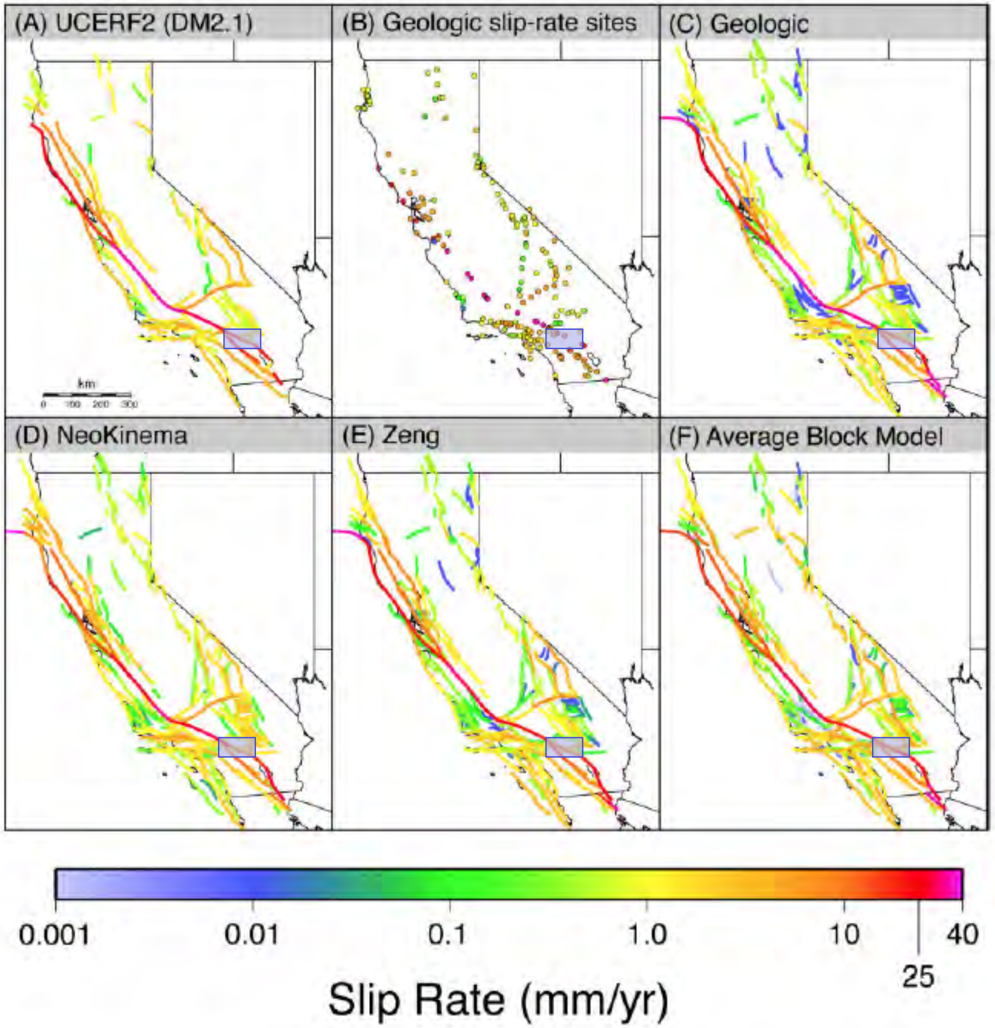
Small region within a large system

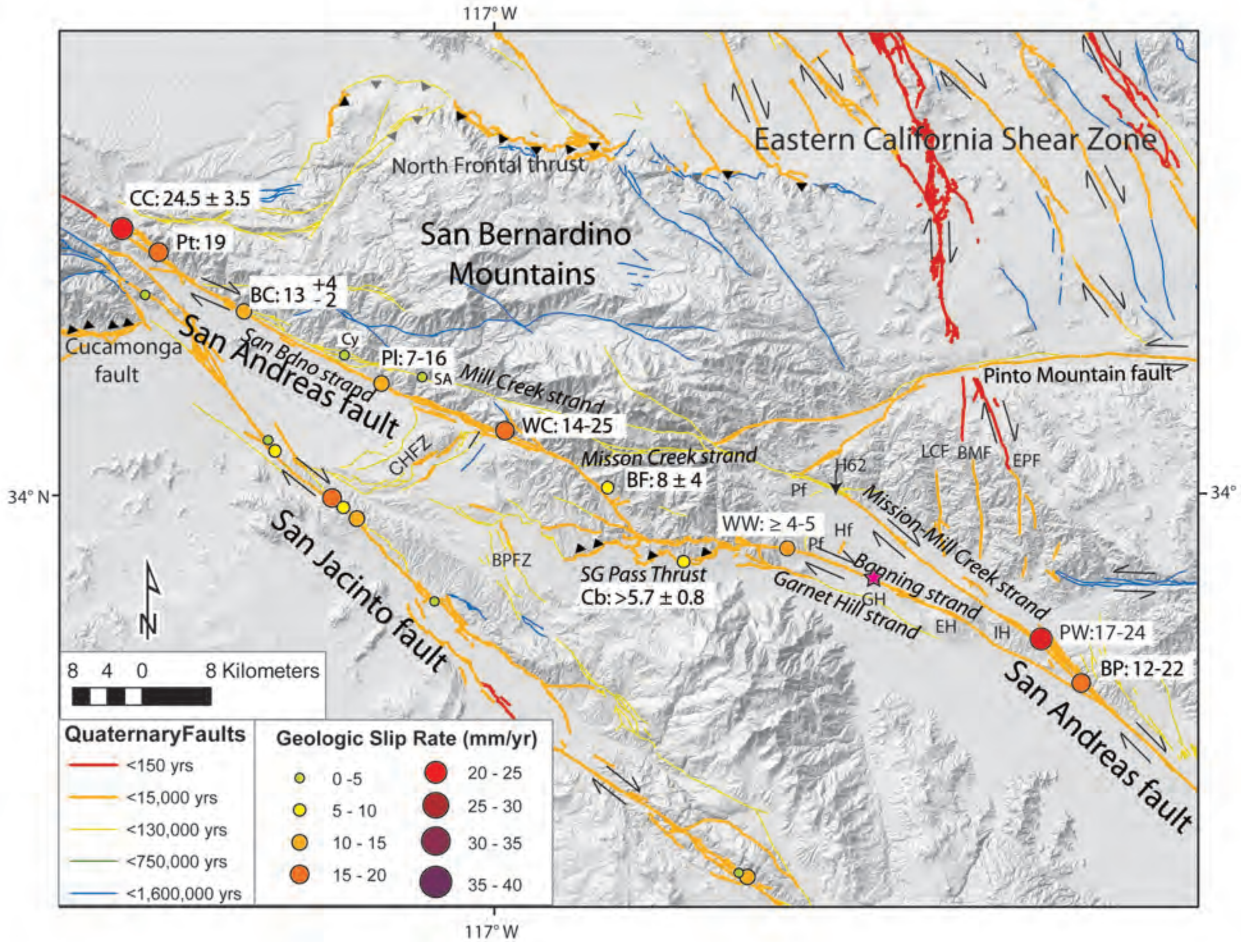
The San Gorgonio Pass comprises the southern Big Bend of the San Andreas fault





Field et al., 2014, UCERF3

The San Gorgonio Pass

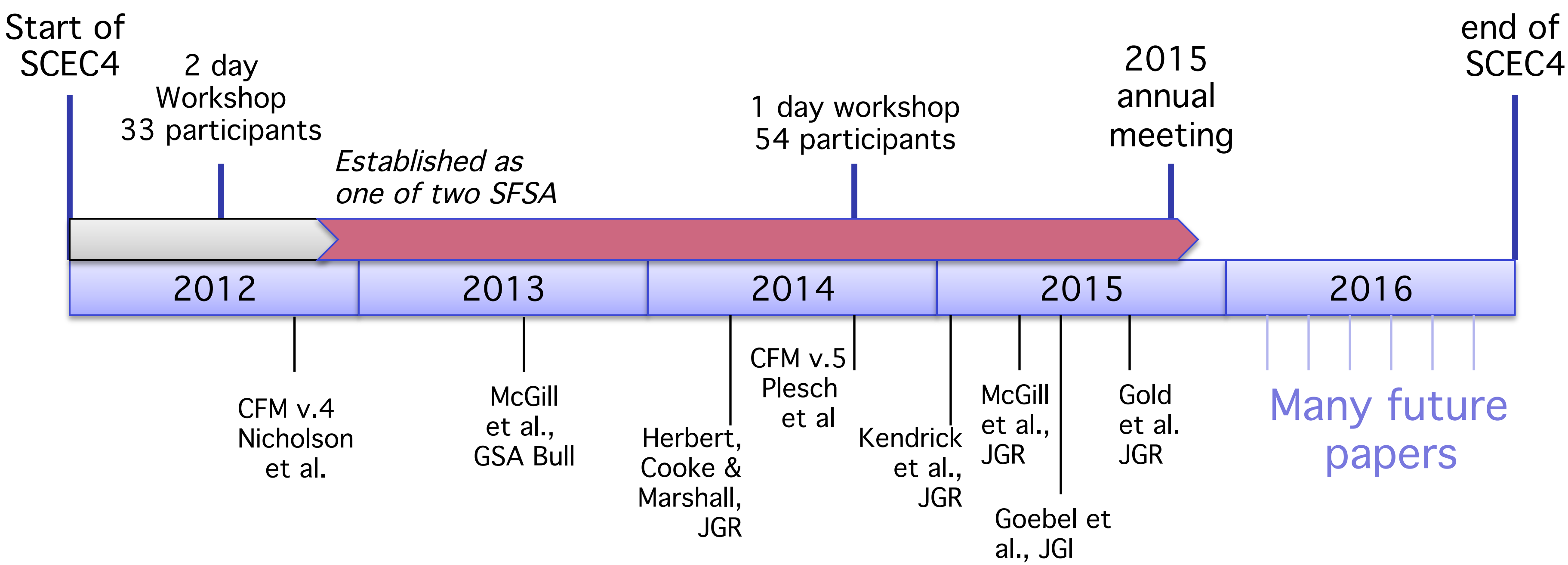


(modified from McGill et al., GSA Bull. 2013)

Guiding questions

- What is the subsurface geometry of active faulting through the San Gorgonio Pass?
- What is the earthquake potential in the San Gorgonio Pass?
- What is the probability of a through-going San Andreas rupture?

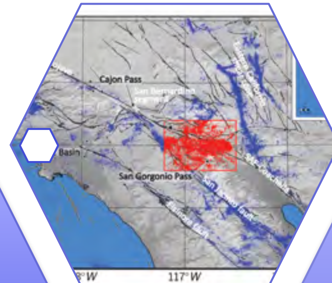
Time line of activity



Data and tools

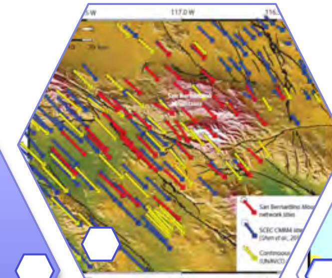
Nicholson
Hauksson
Goebel
Carena

seismicity



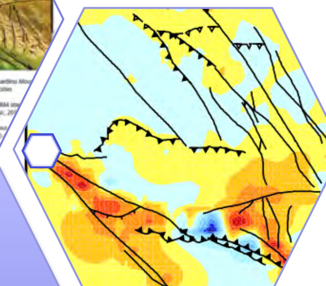
Spinler
McGill

Geodesy

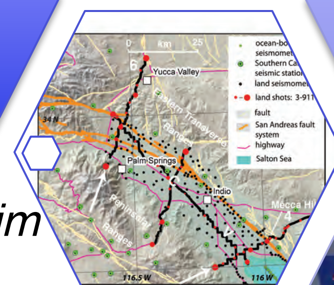


Cooke

Crustal deformation models



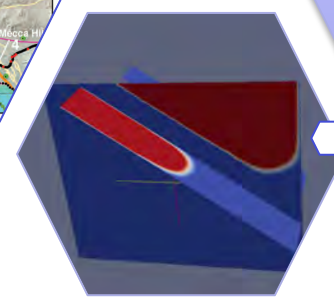
geophysics



geology

Fuis
Langenheim
Oglesby

Dynamic rupture models

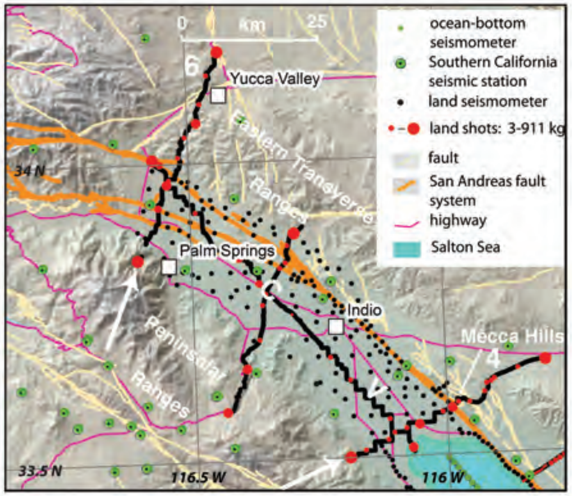


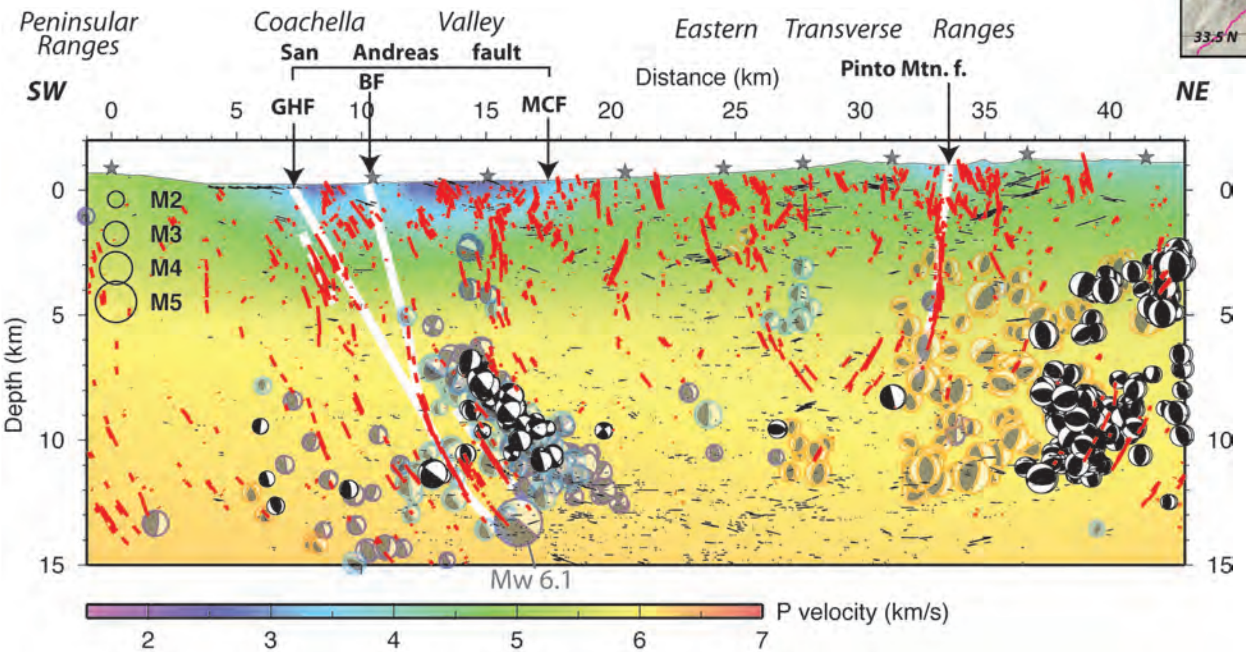
Behr, Blisniuk, Brune, Chester, Gold, Heermance, Kendrick, Lifton, Matti, McGill, Oskin, Scharer, Sharp, Sieh, Rymer, Yule

Shi, Day, Oglesby, Tarnowski

What is the active geometry of faults?

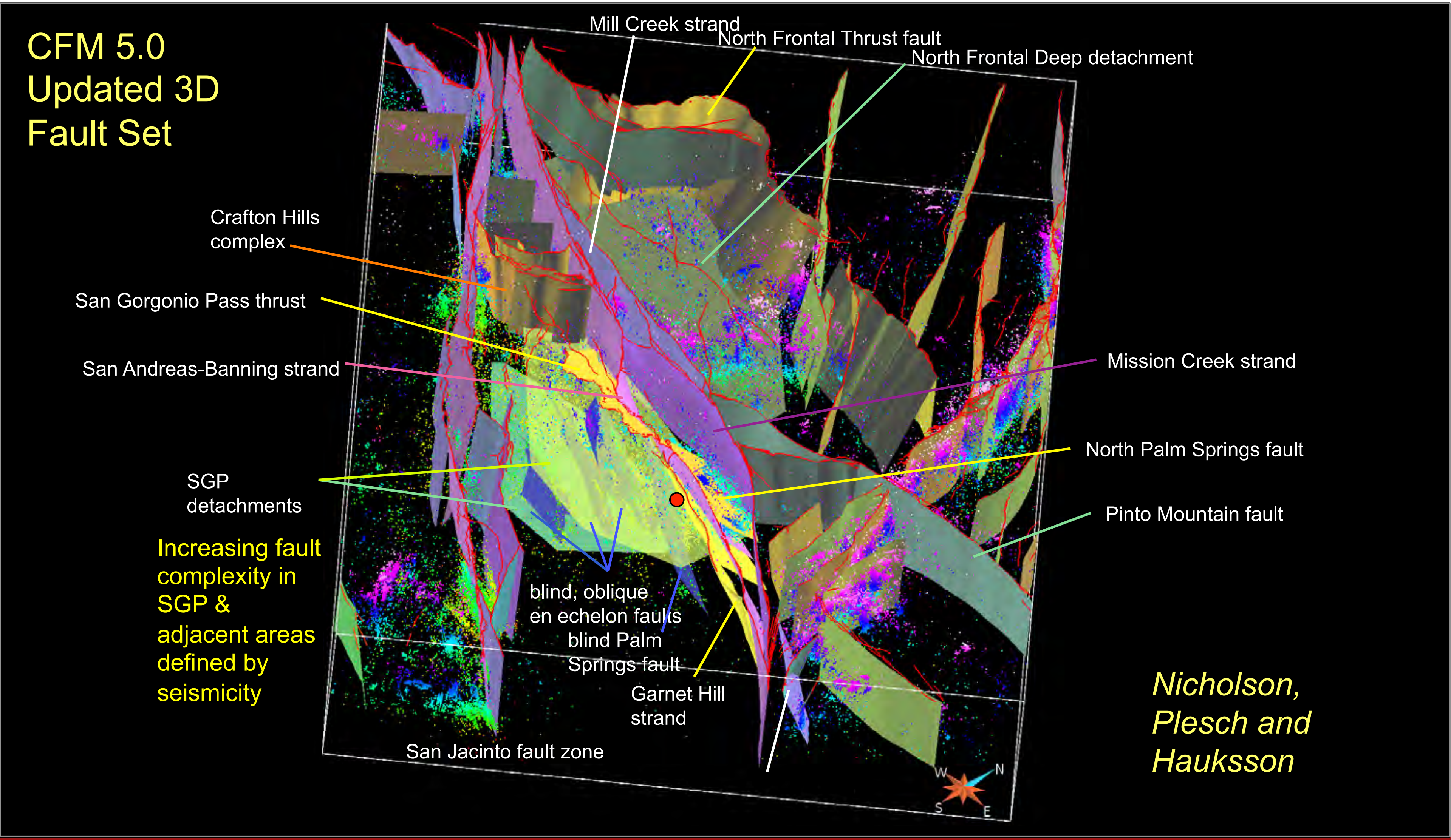
- SSIP seismic line 6 crosses within the SGP SFSA
- Reveals multiple NE dipping strands of the San Andreas



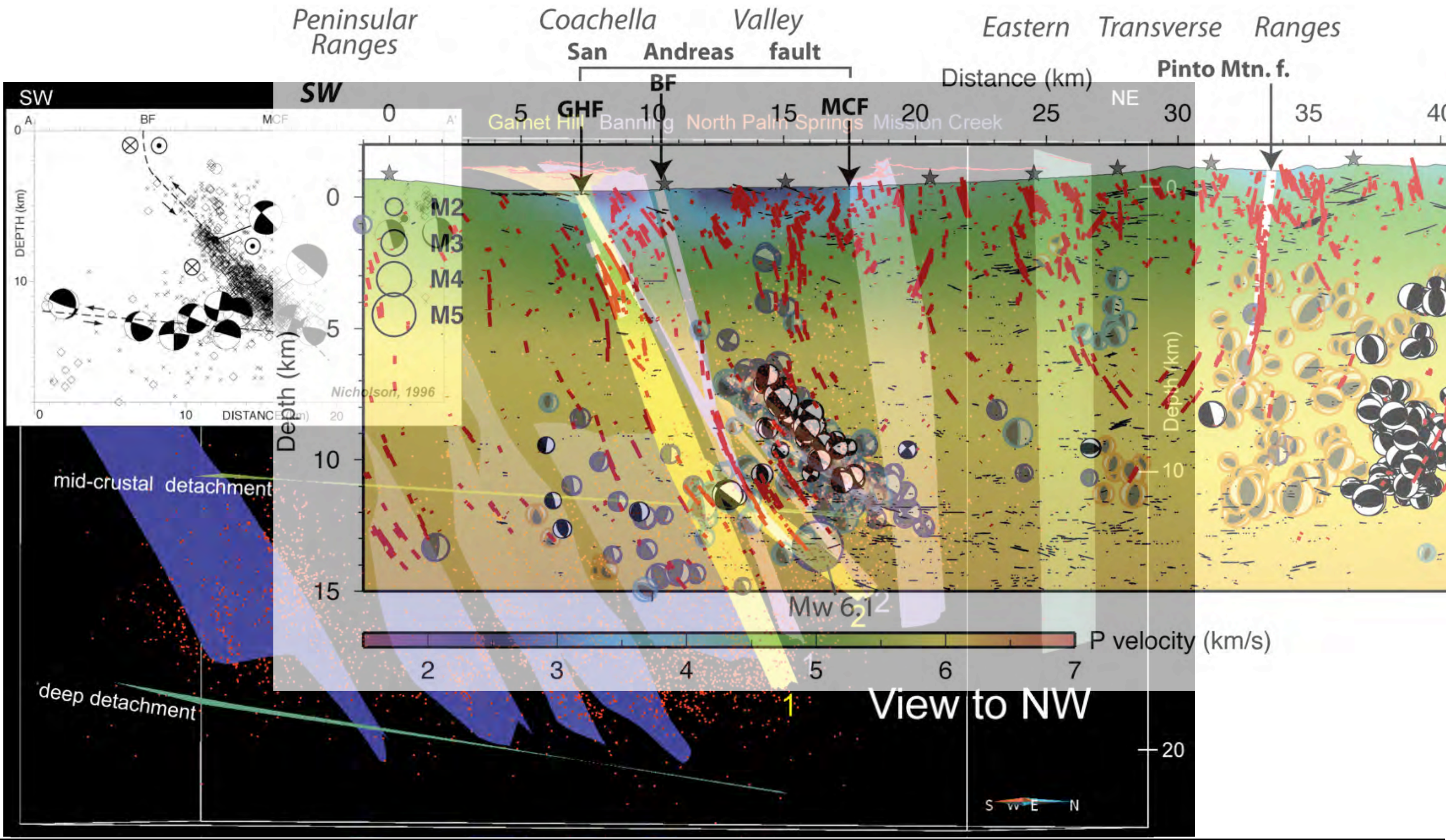


Fuis, Bauer, Goldman, Ryberg, Langenheim, Scheirer, Rymer, Stock, Hole and Catchings, submitted

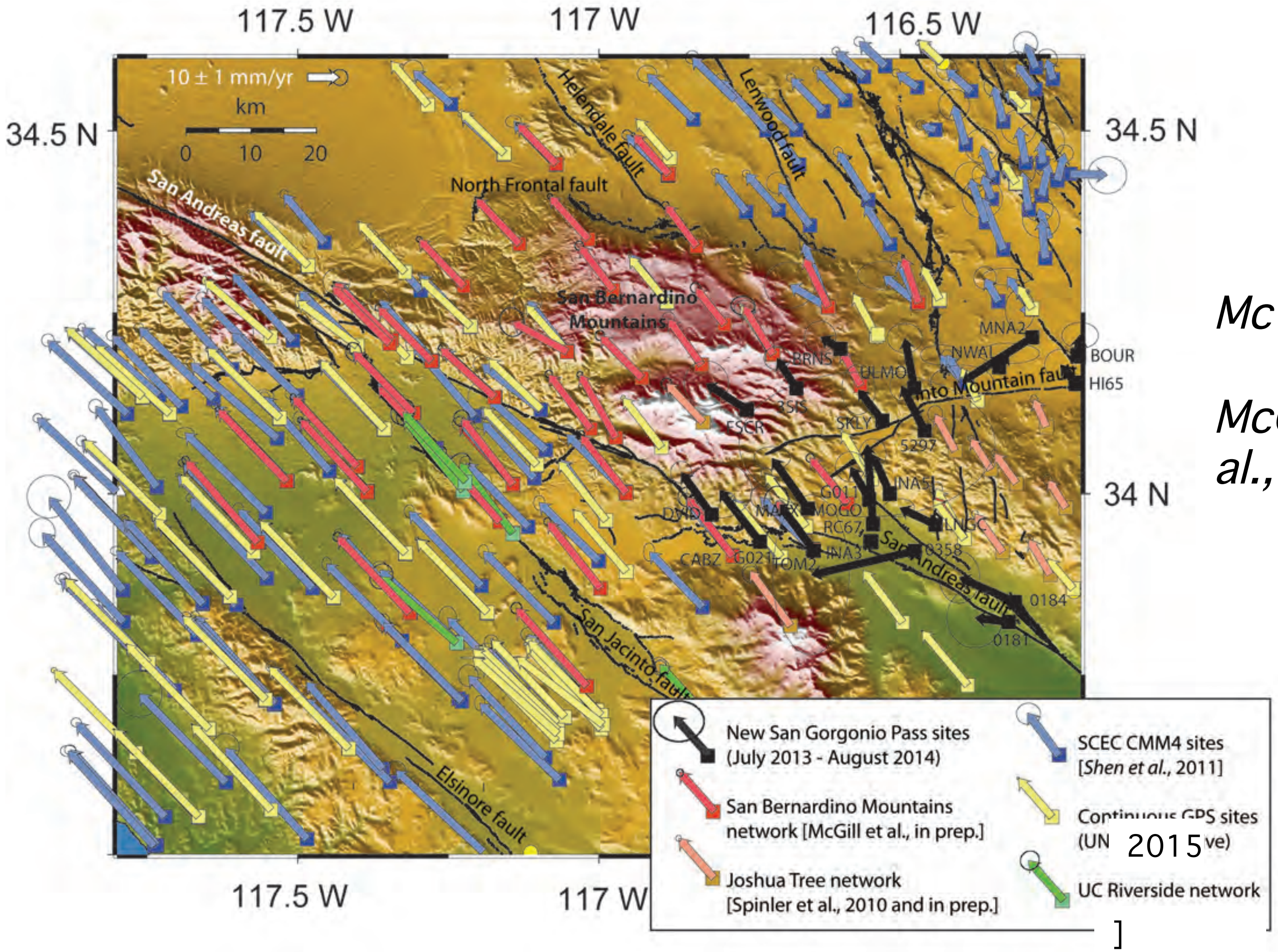
What is the active geometry of faults?



What is the active geometry of faults?



How is slip partitioned?

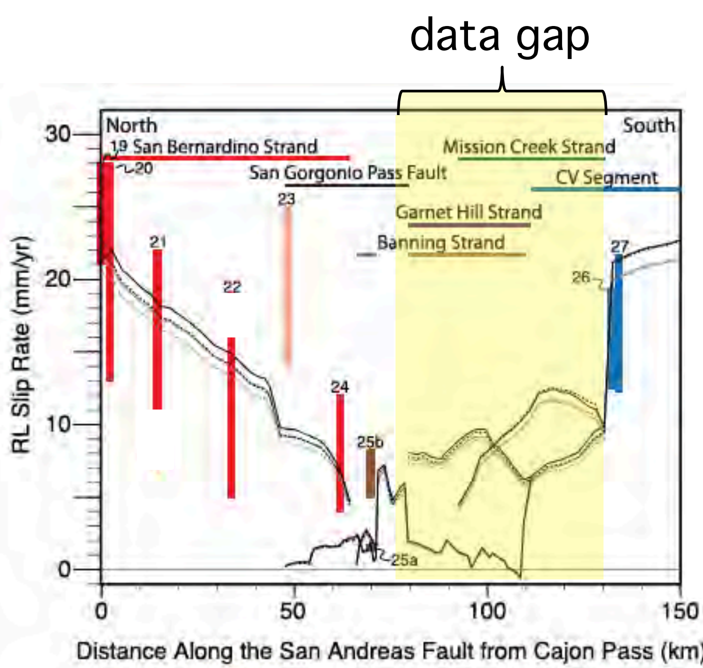


Mc Gill et al., 2015

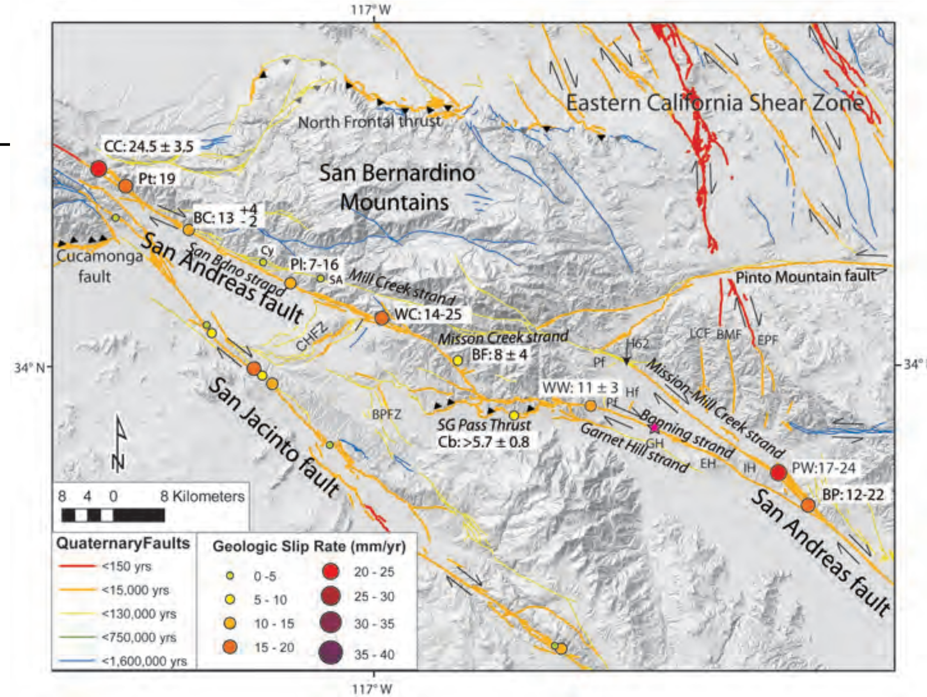
McGill, Spinler et al., unpublished

How is slip partitioned?

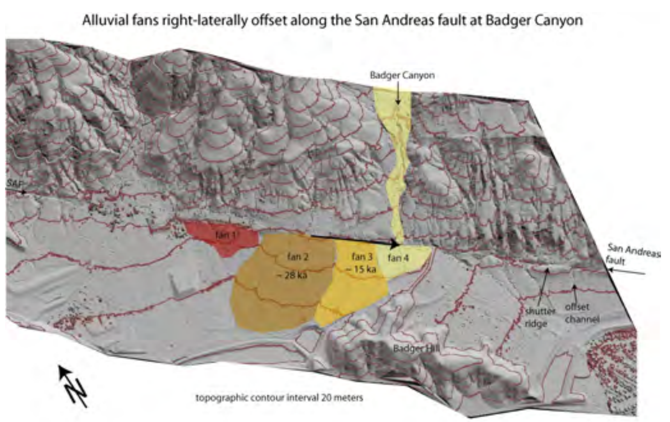
- Variable slip rates along the San Andreas through the San Gorgonio Pass.
- Mechanical models match this variability



(modified from Herbert & Cooke, BSSA 2012)



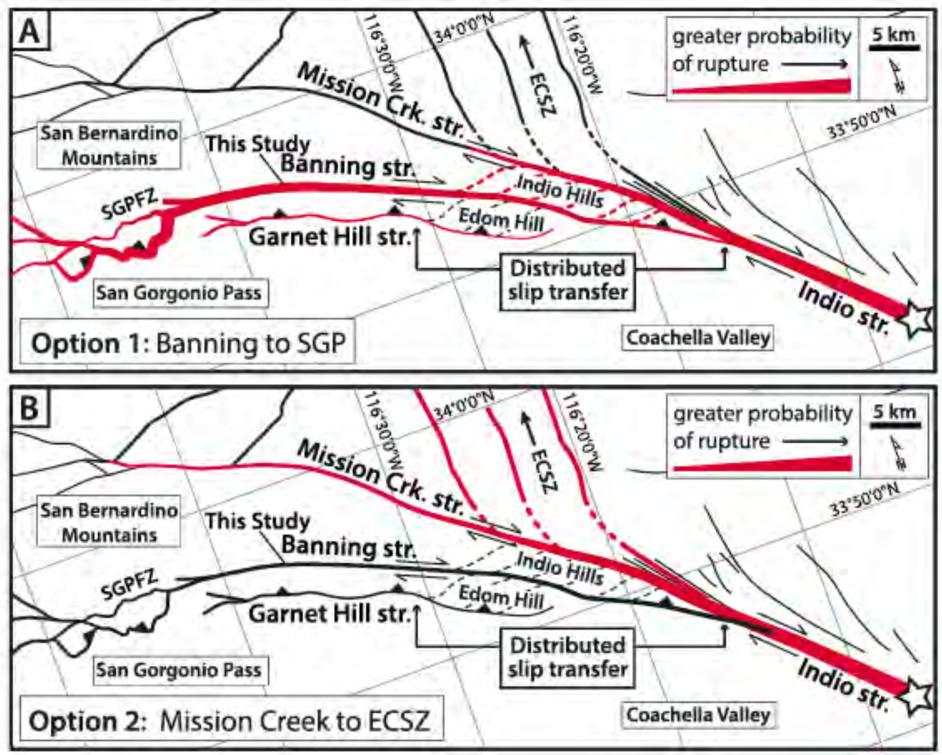
(McGill et al., GSA Bull. 2013)



(McGill et al., in prep)

How is slip partitioned?

- Active strands
  - Mill Creek-Mission Creek
  - Banning-Garnet Hill

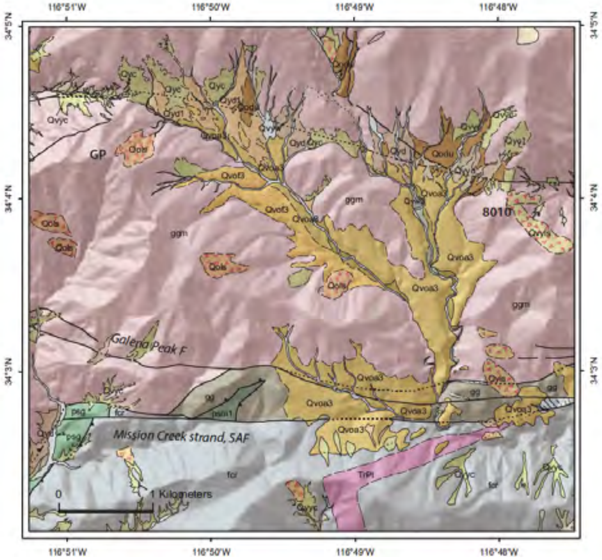


(Gold, Behr et al., JGR 2015)

How is slip partitioned?

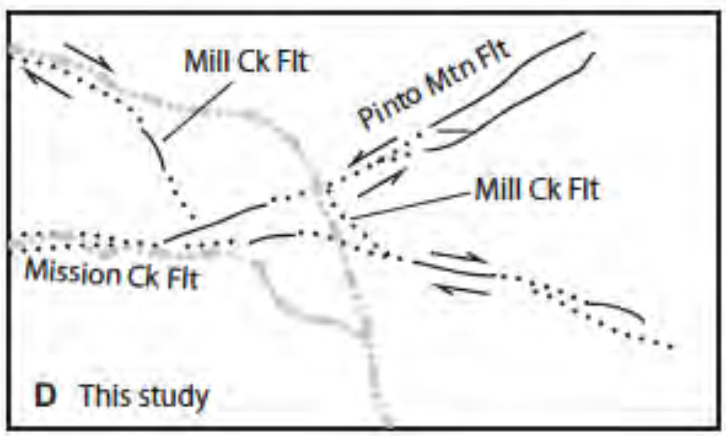
Mill Creek strand

- No offset of Holocene/Latest Pleistocene alluvial deposits at Upper Raywood Flats



(Kendrick et al., JGR. 2015)

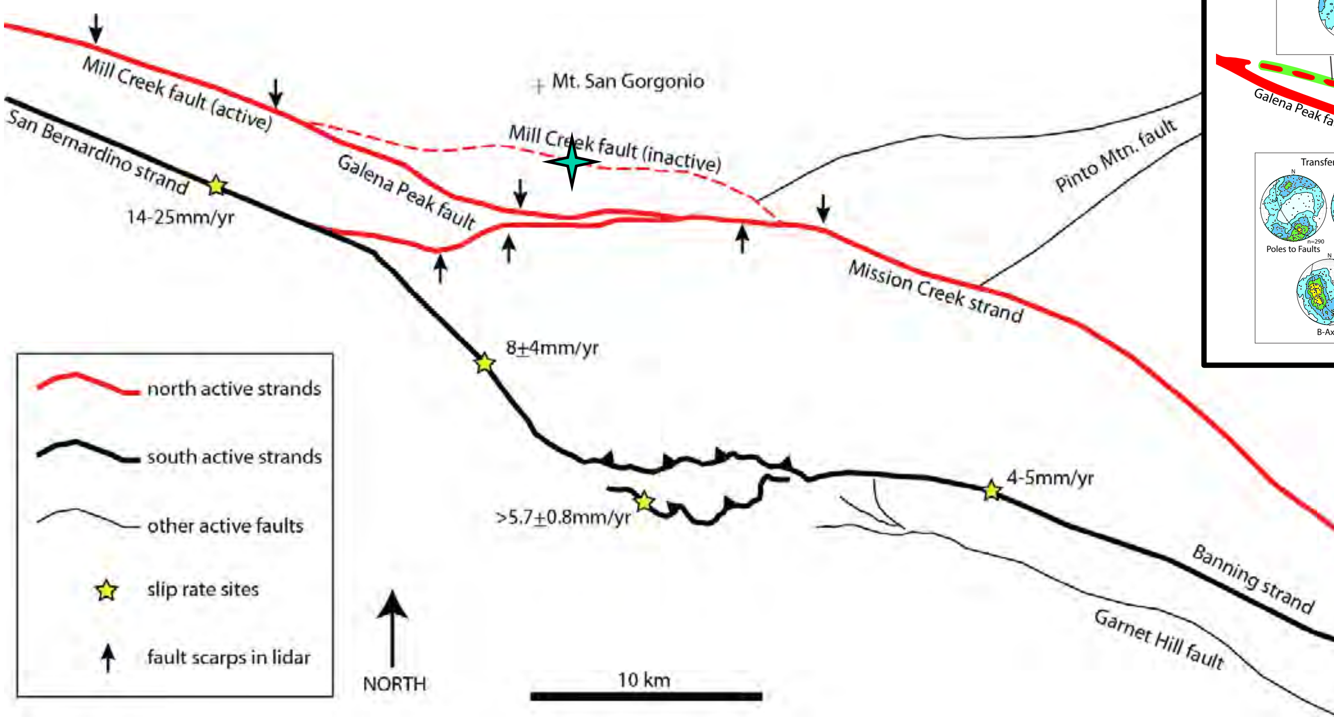
- The Pinto Mountain fault offsets the Mill Creek strand

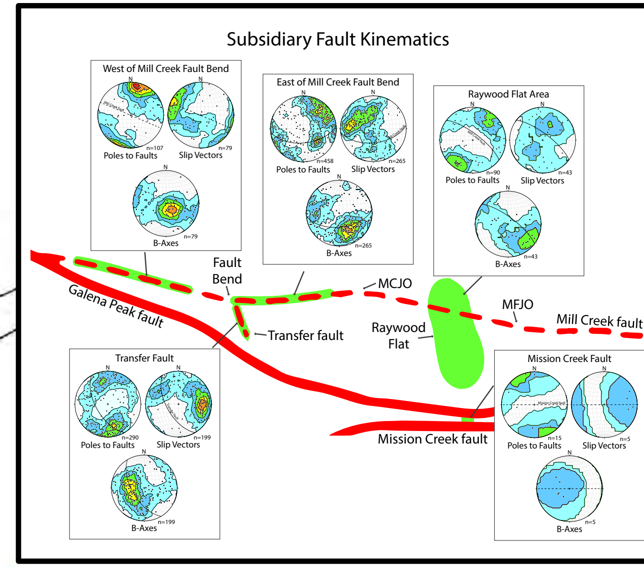


(Kendrick et al., JGR. 2015)

How is slip partitioned? The Mill Creek strand

- Lidar scarp analysis suggests that slip may by-pass upper Raywood flats via the Galena Peak fault.
- Fault kinematics consistent with slip transfer





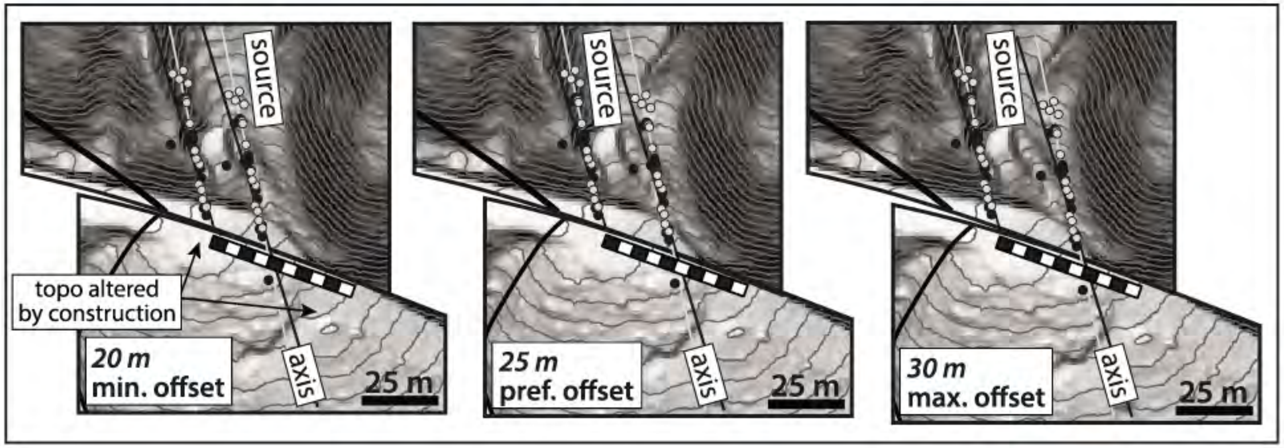
(Morelan, Oskin, Chester and Elizondo, *in prep)*

How is slip partitioned?

The Banning Strand

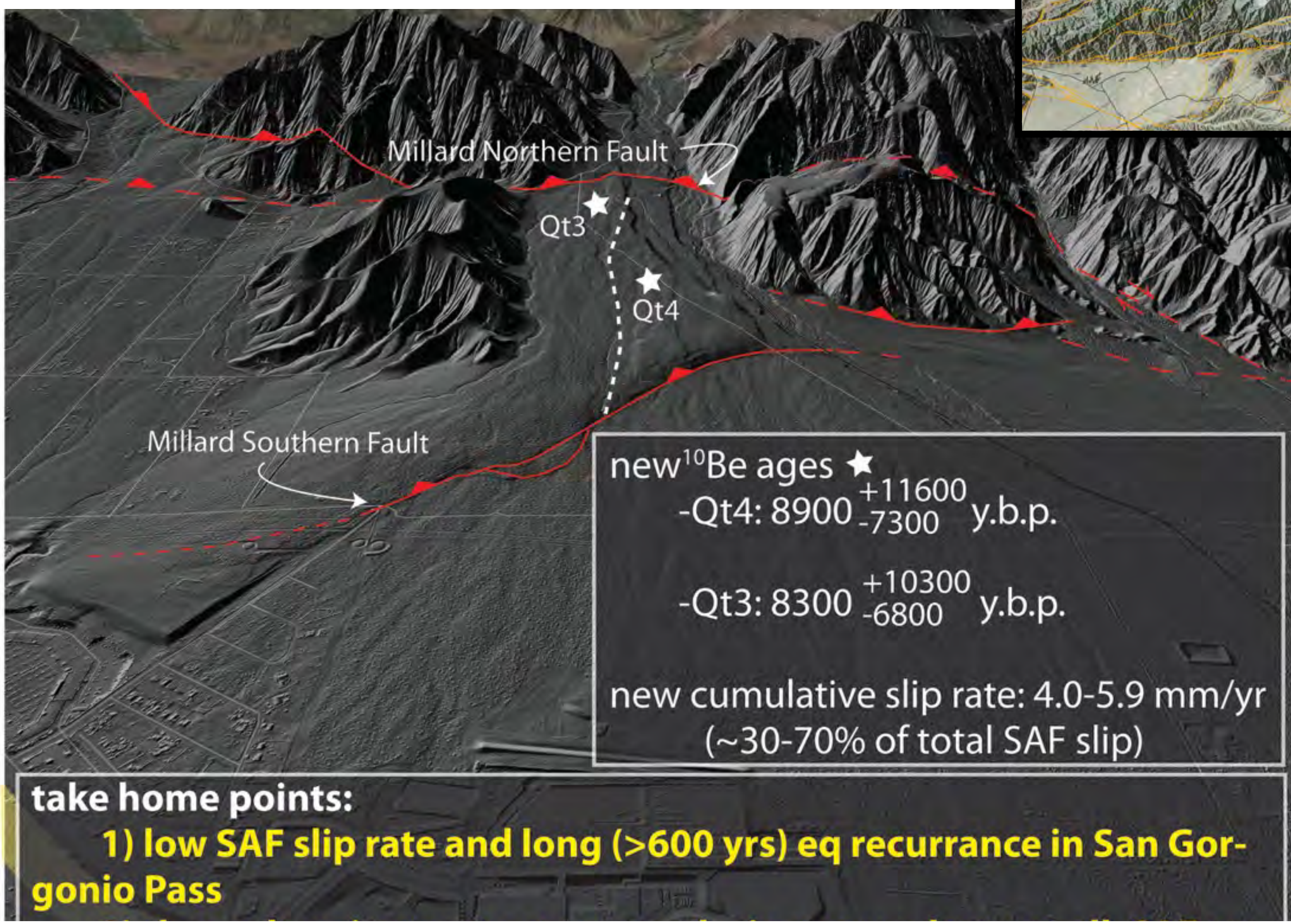
- Offset alluvial fan reveals relatively slow slip rates ~(4-5 mm/yr) along the Banning fault
- Slip rate at SE end of Indio Hills (Scharer) is also 2-6 mm/yr

Holocene rate: 3.9+2.3/-1.6 to 4.9+1.0/-0.9 mm/yr



Gold, Behr et al., JGR 2015

How is slip partitioned?: Banning strand & San Gorgonio Pass thrust



Heermance and Yule, in prep

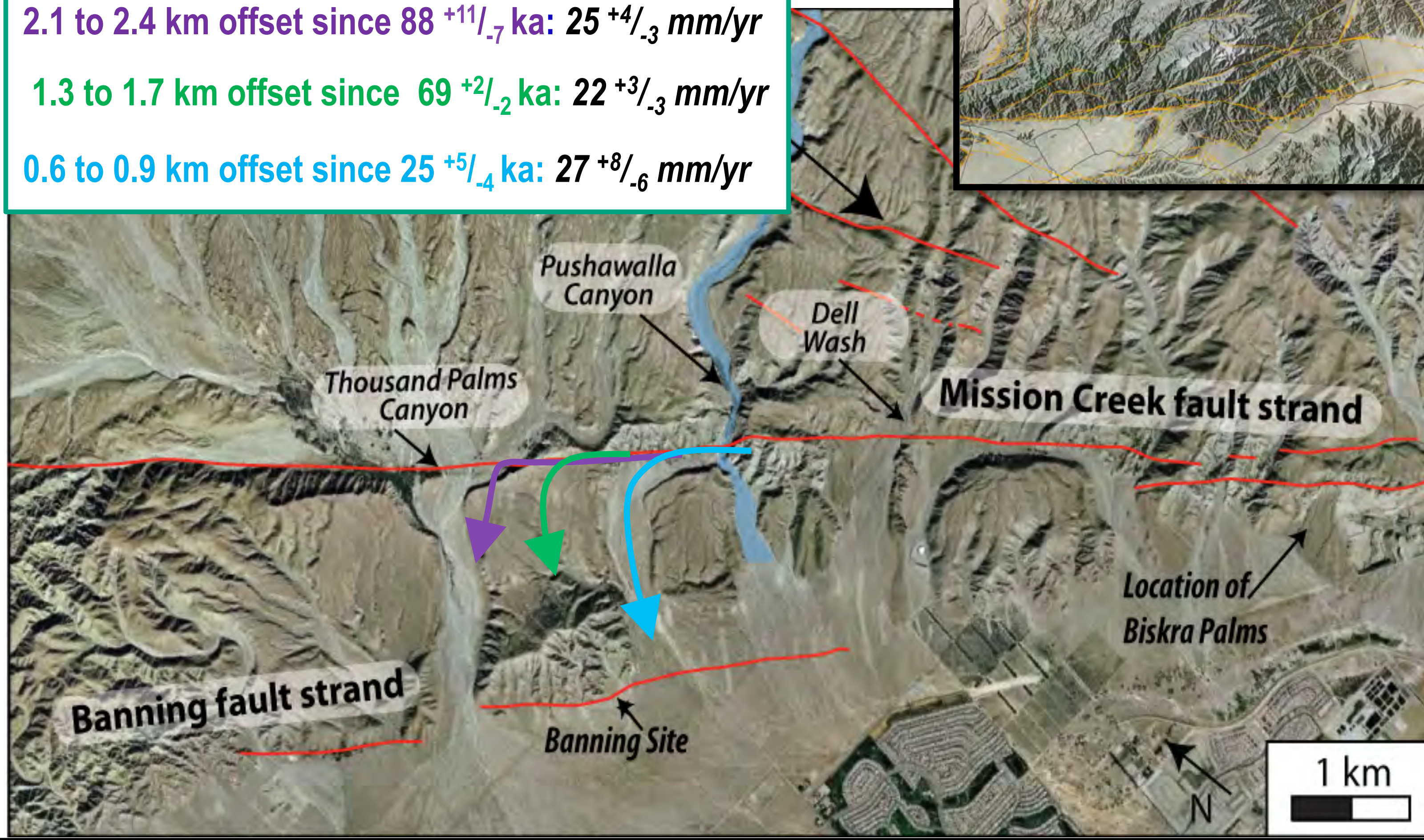
How is slip partitioned?: The Mission Creek strand

Mission Creek strand: 22-25 mm/yr (~90 ka, ~70 ka, & ~25 ka)
Banning strand: 4-6 mm/yr since ~6ka

2.1 to 2.4 km offset since 88 $^{+11}/_{-7}$ ka: 25 $^{+4}/_{-3}$ mm/yr

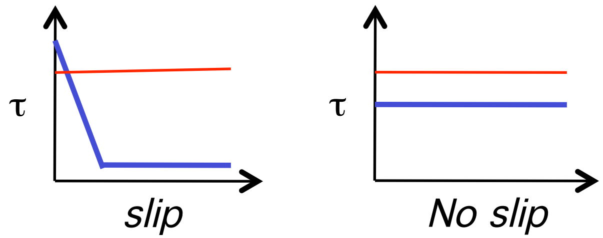
1.3 to 1.7 km offset since 69 $^{+2}/_{-2}$ ka: 22 $^{+3}/_{-3}$ mm/yr

0.6 to 0.9 km offset since 25 $^{+5}/_{-4}$ ka: 27 $^{+8}/_{-6}$ mm/yr

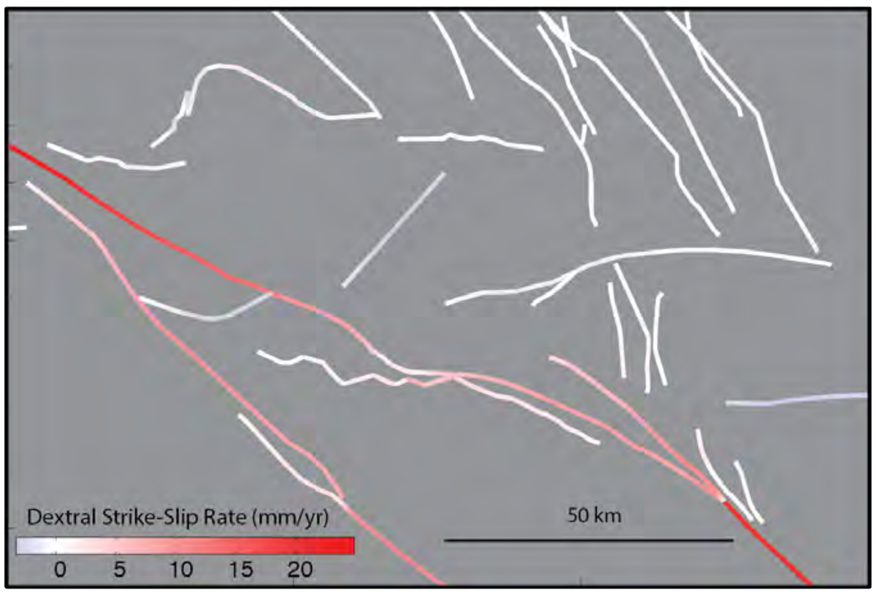


Blisniuk, Scharer, Sharp, Burgmann in prep

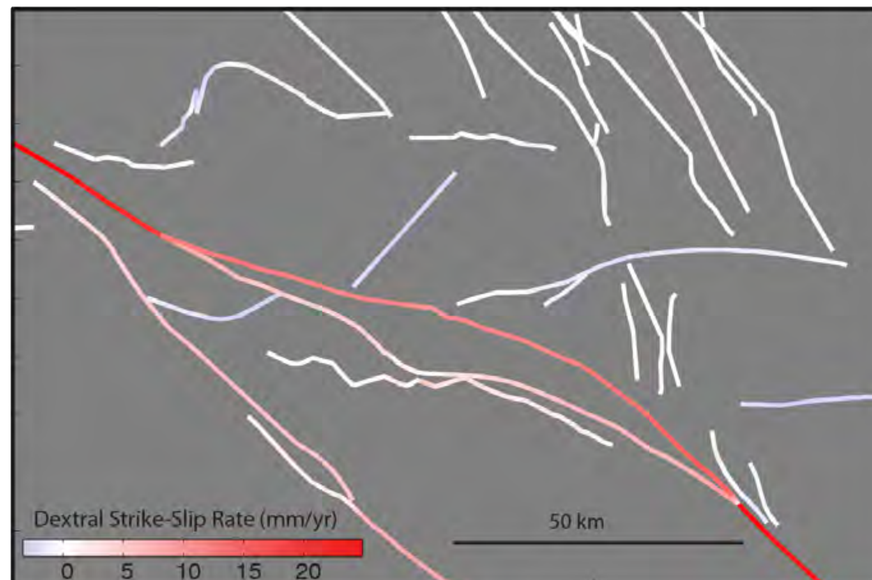
How is slip partitioned? effect of active Mill creek



Mill Creek not in model



Mill Creek slips

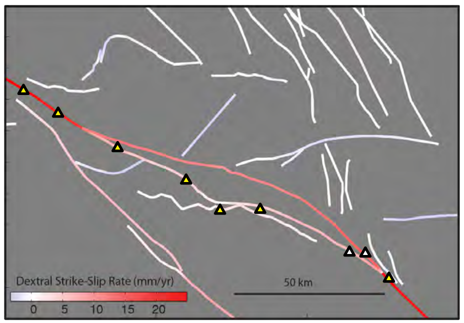


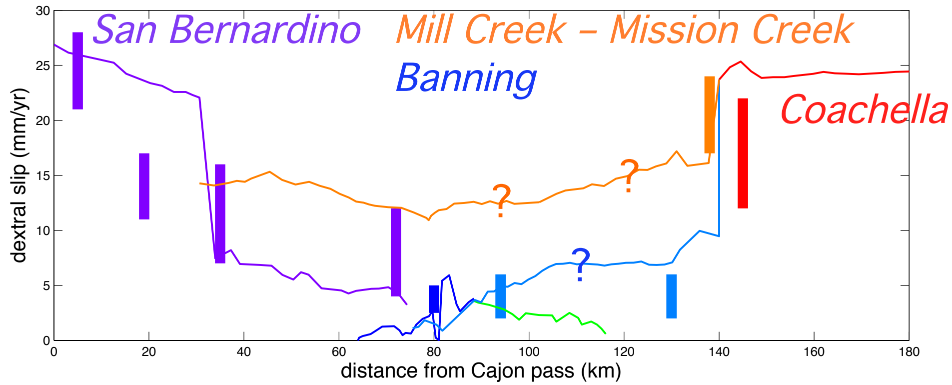
- Strike slip is transferred to the Mill Creek strand.
  - San Jacinto and Banning have slower slip rates

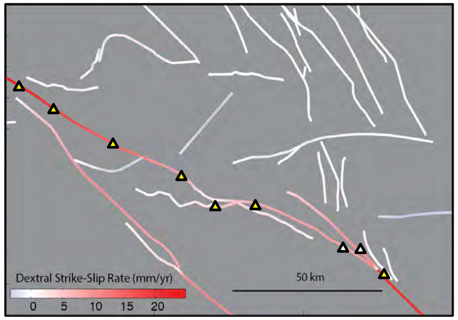
Cooke, in prep.

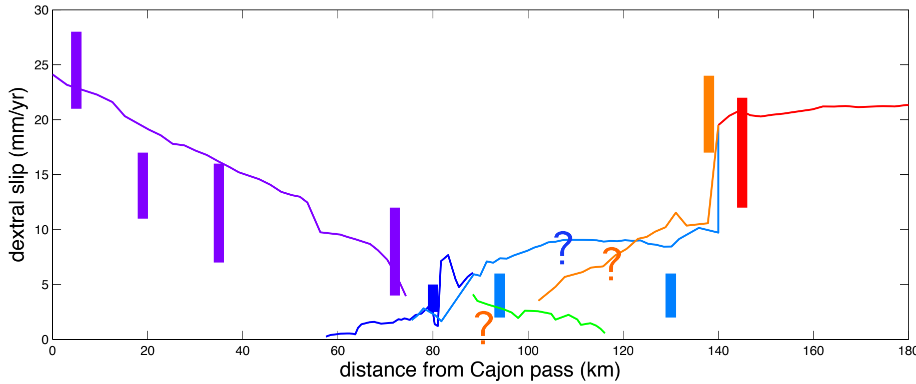
How is slip partitioned? effect of active Mill Creek

Slip partitioning is sensitive to active fault geometry through the pass





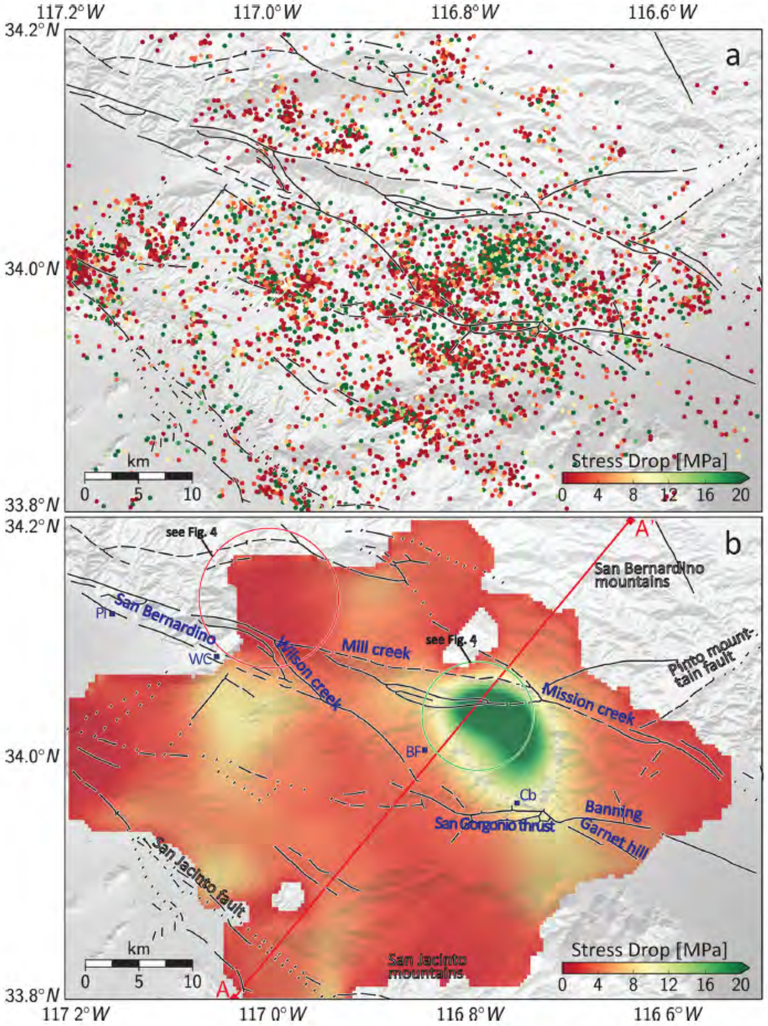




Cooke, in prep.

What is the stress state?

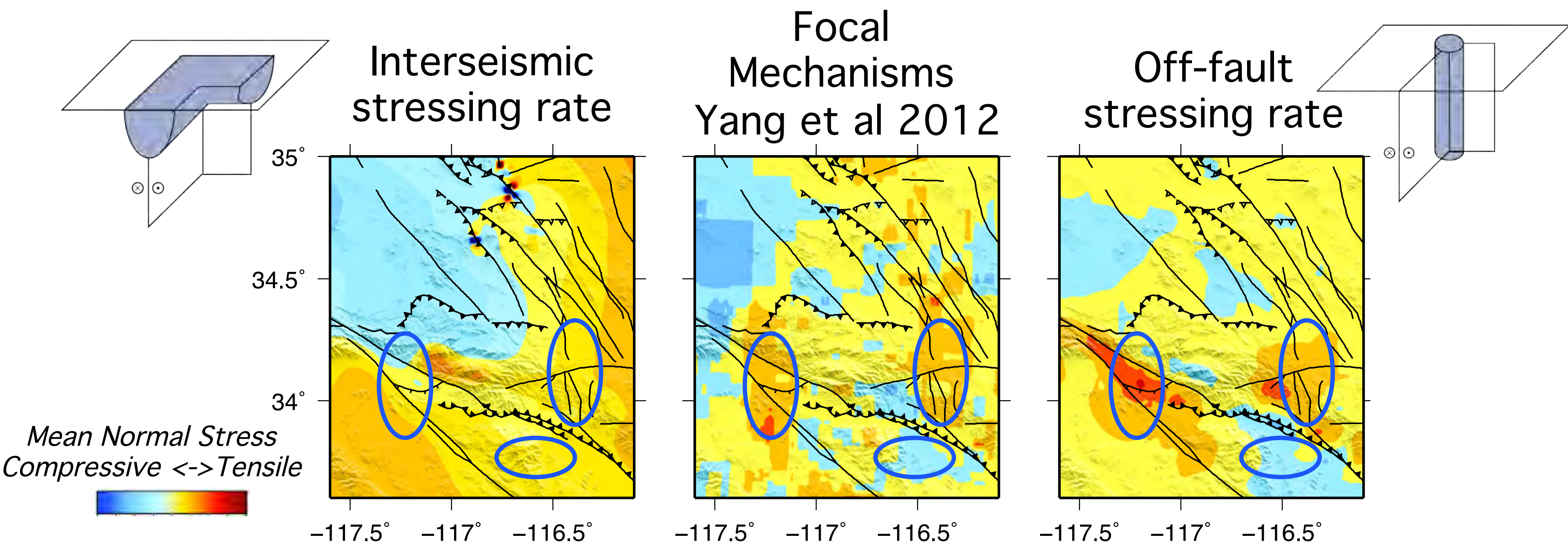
- Insights from microseismicity
  - Large stress drops within the San Gorgonio Pass



Goebel et al., JGR 2015

What is the stress state?

- Insights from crustal deformation models
  - Off-fault deformation matches better the stress inversions from focal mechanisms than interseismic stressing rates

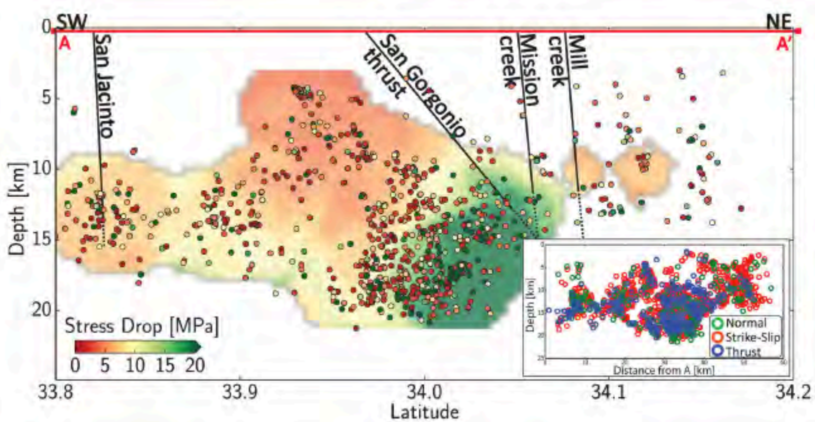


Cooke, in prep.

Correlation to stress drops in SGP

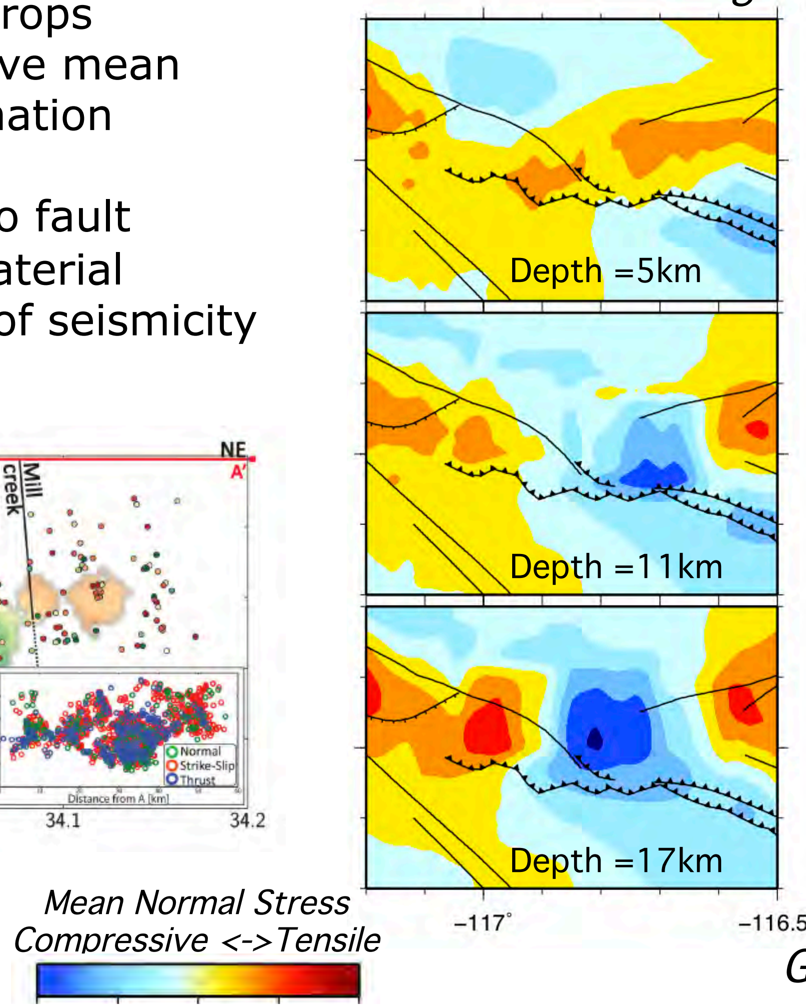
Regions of large stress drops correlate with compressive mean stress of off-fault deformation

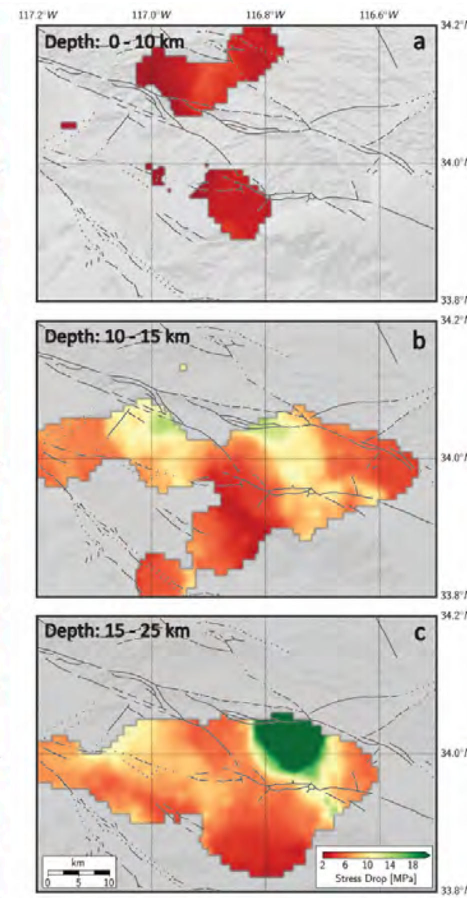
Stress drop may relate to fault geometry rather than material contrast at step in base of seismicity



Goebel et al., JGR 2015

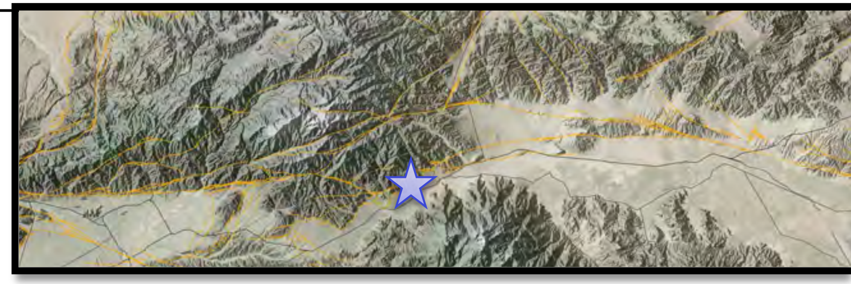
Off-fault stressing



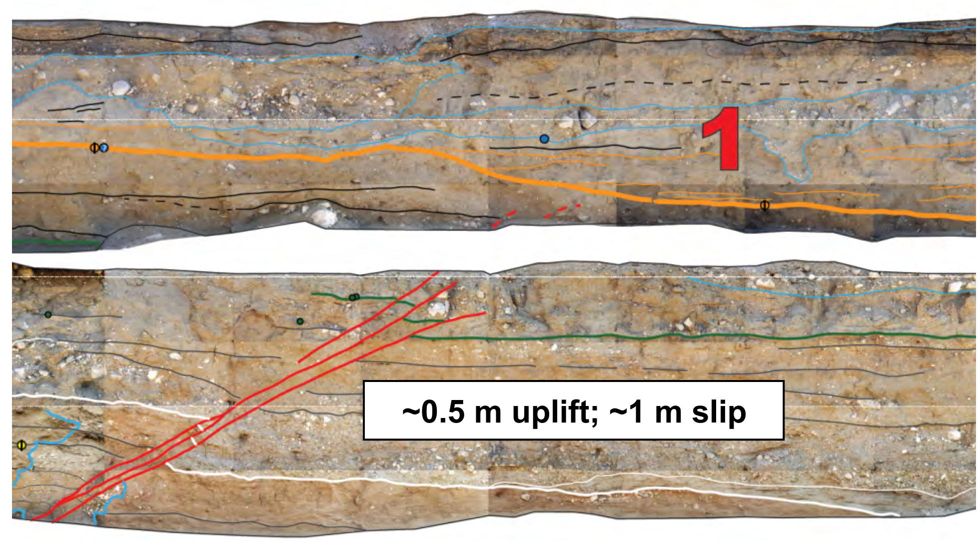


Goebel et al., JGR 2015

Can earthquakes rupture through the Pass? Paleoseismology

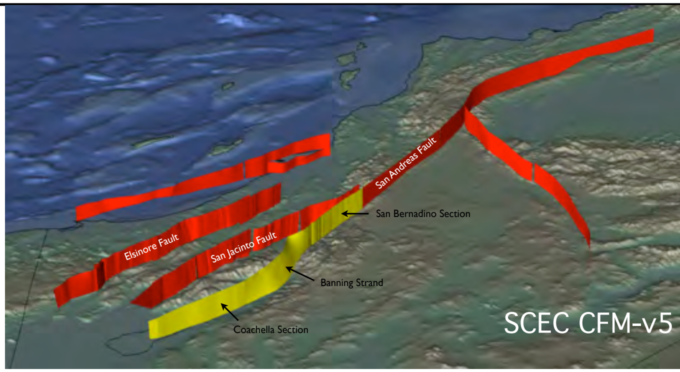


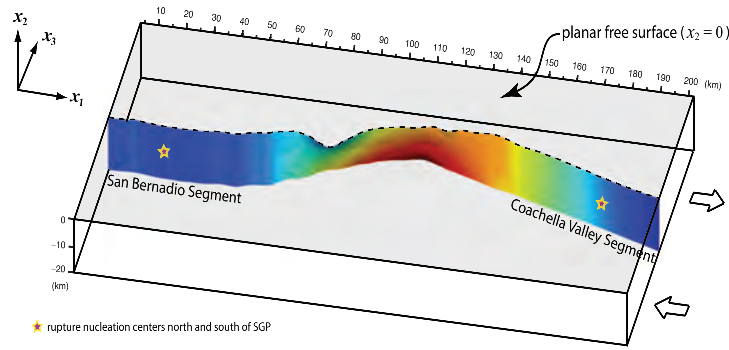
- Only 4 earthquakes in 5500 years
- Complex slip patterns: 0.5 – 2.5 m uplift in single event
- Most recent event was ~1400 A.D.



Yule, Scharer in prep

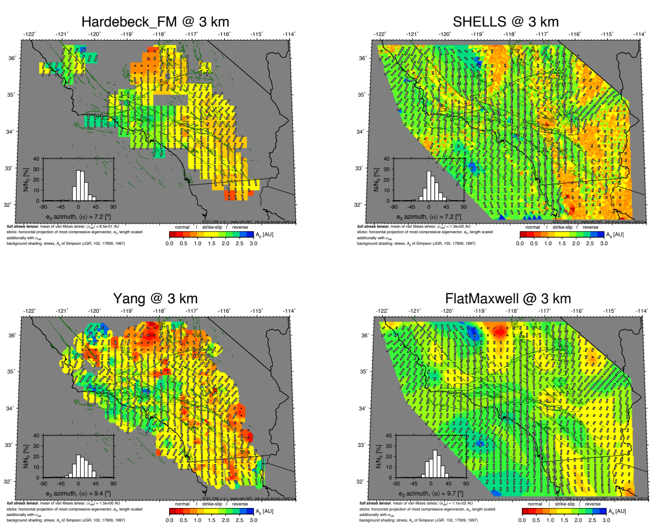
Can earthquakes rupture through the Pass? Dynamic rupture



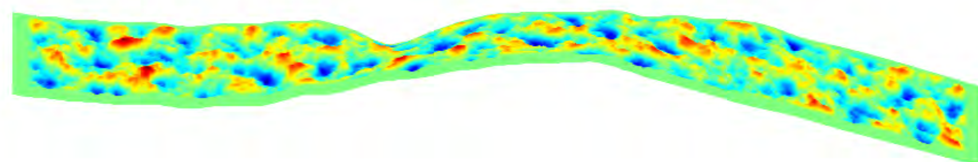


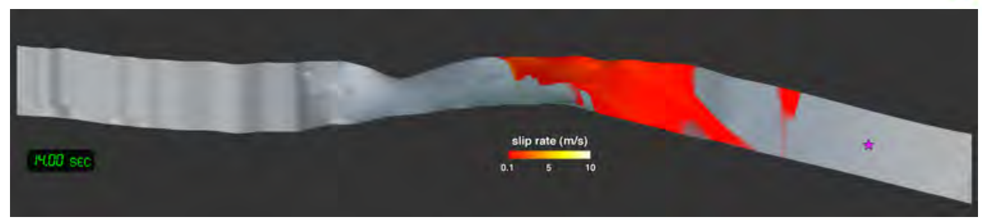
Shi and Day

Candidate SCEC CSMs as Reference of Stress Input



Artificial band-limited roughness superposed on fault



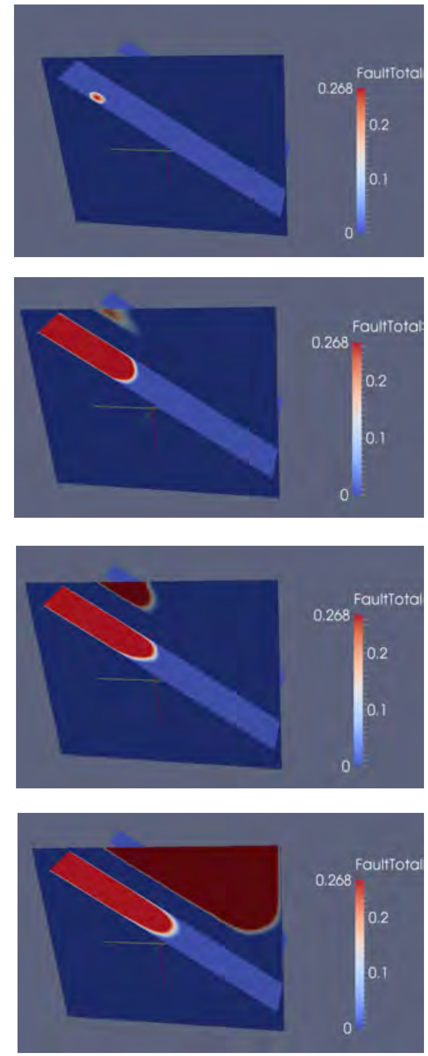


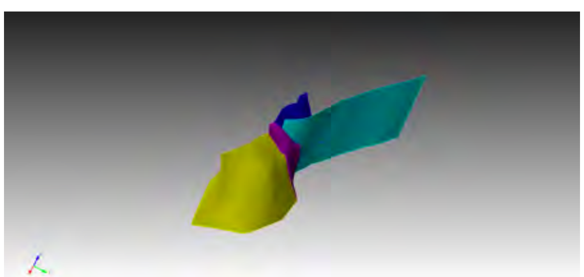
- The initial stress field dominates rupture behavior, compared other factors including small-scale fault geometric complexities.
- Different stress models in their present forms will lead to vastly different rupture scenarios regarding the likelihood of through-going rupture along SGP.

Tarnowski, Kyriakopoulos, and Oglesby

Can earthquakes rupture through the Pass?

- Ruptures starting on the Banning strand can pass to the San Bernardino strand
- Ruptures from the San Bernardino strand are less likely to pass to the Banning.





Tarnowski, Kyriakopoulos, and Oglesby

San Gorgonio Pass SFSA outcomes

- Some but not all ruptures can pass through the SGP as large events.
- The region hosts slow slip rates, low strain rates and unusually high stress drops, which owe to fault geometry.
- Activity distributed among multiple strands rather than along one dominate structure.
- Cross-disciplinary discussions and collaborations
- Leveraging for projects funded by USGS and NSF.

Thank you!

Photo along the Mill Creek strand of the San Andreas fault