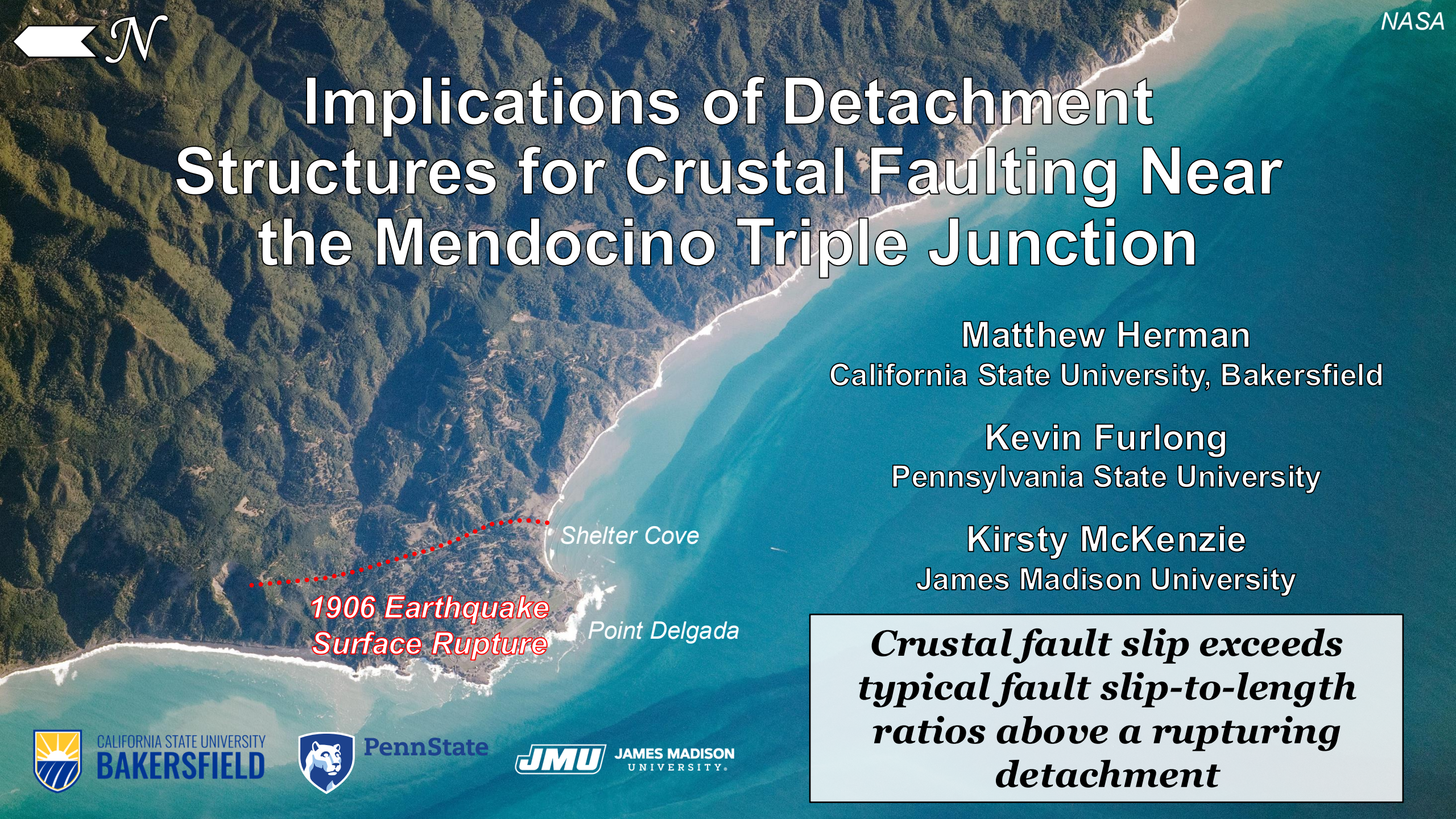


An aerial photograph of a rugged coastline. A red dotted line traces a path along the shore, indicating a surface rupture. The land is covered in dense green forest, and the ocean is a deep blue. The title text is overlaid on the upper part of the image.

Implications of Detachment Structures for Crustal Faulting Near the Mendocino Triple Junction

Matthew Herman
California State University, Bakersfield

Kevin Furlong
Pennsylvania State University

Kirsty McKenzie
James Madison University

***Crustal fault slip exceeds
typical fault slip-to-length
ratios above a rupturing
detachment***



CALIFORNIA STATE UNIVERSITY
BAKERSFIELD

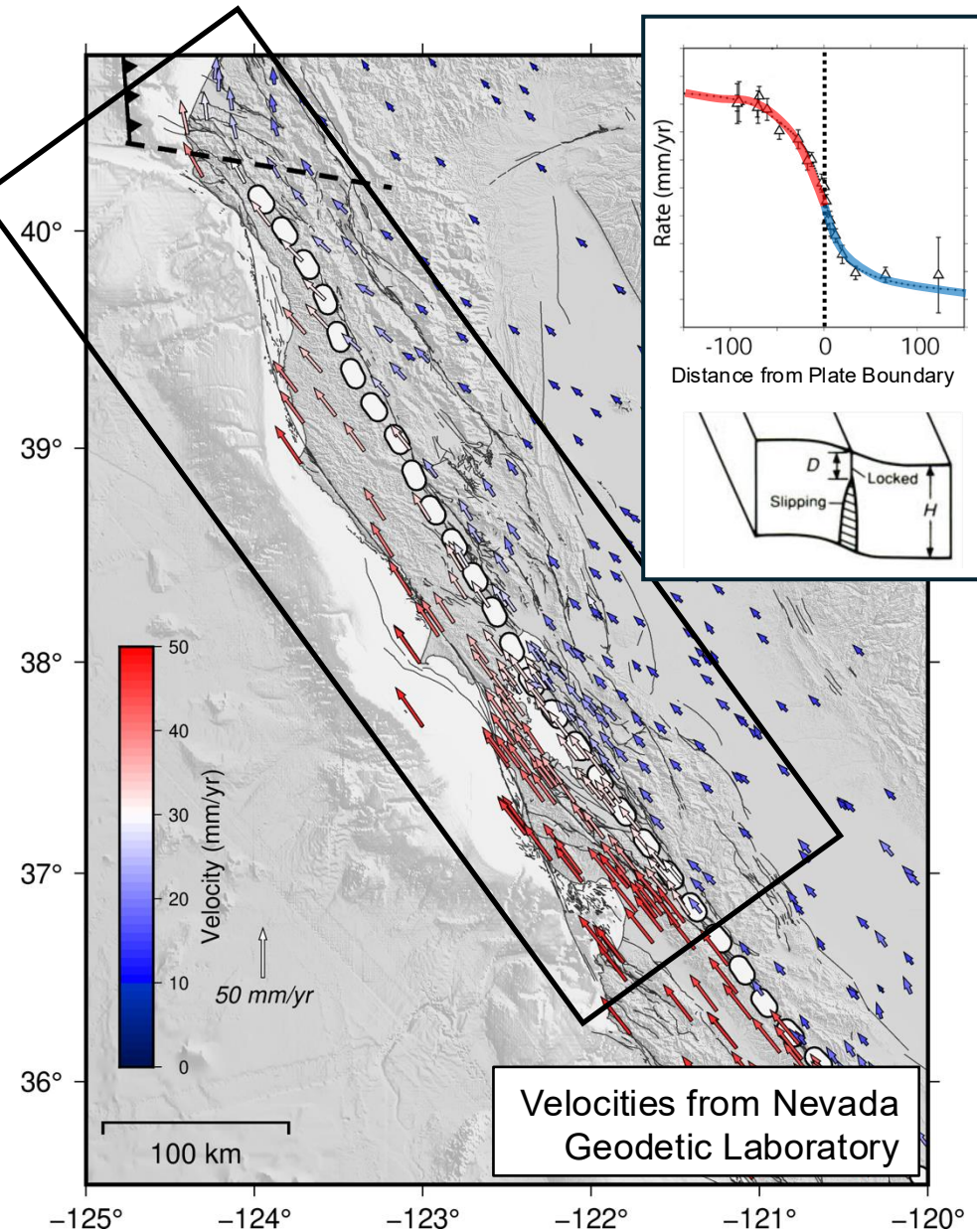


PennState



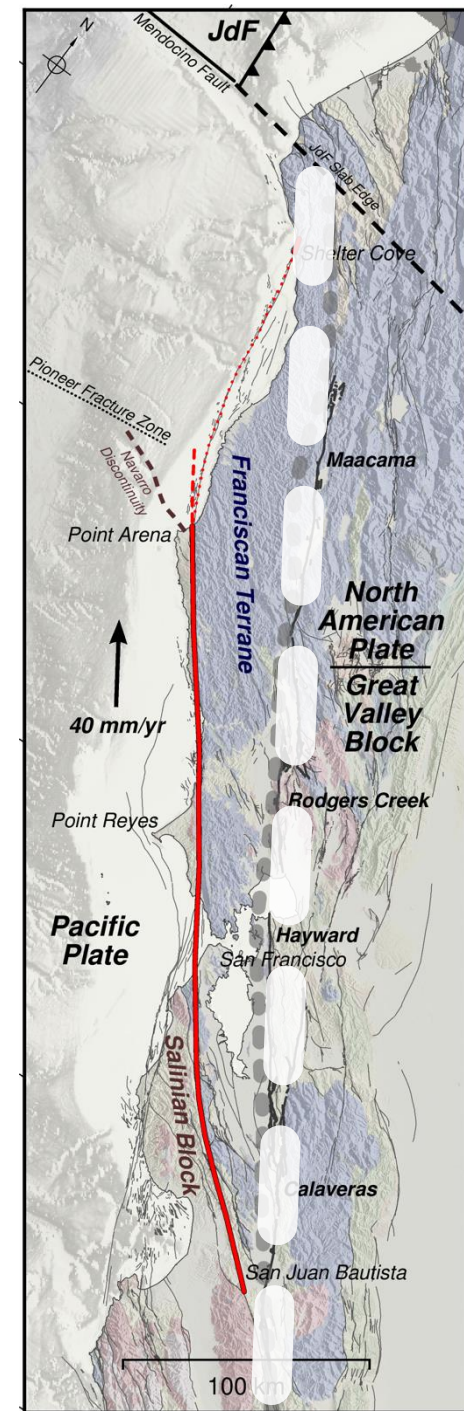
**JAMES MADISON
UNIVERSITY**

MTJ Region Tectonic Structure

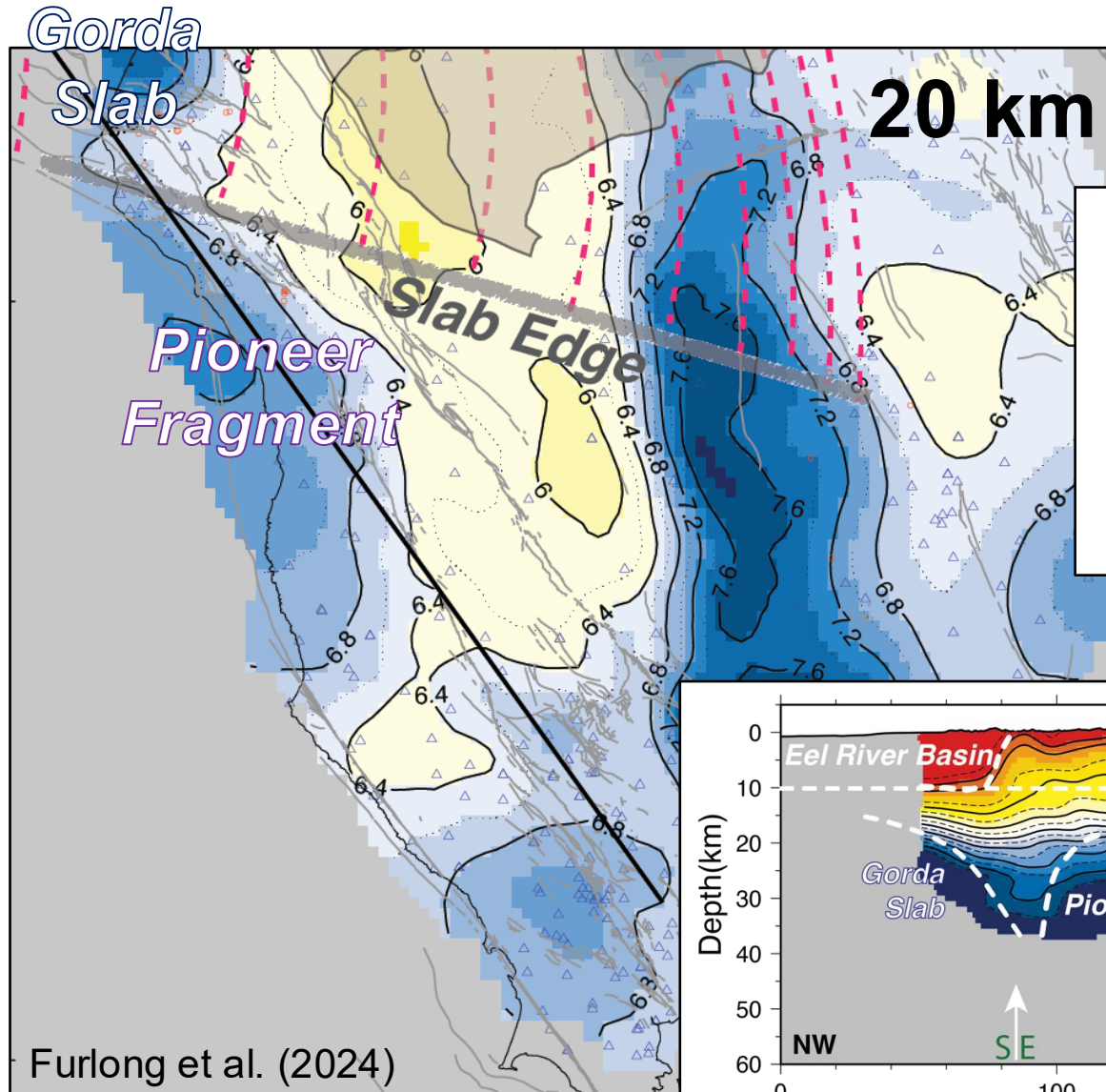


Savage and Burford (1973)

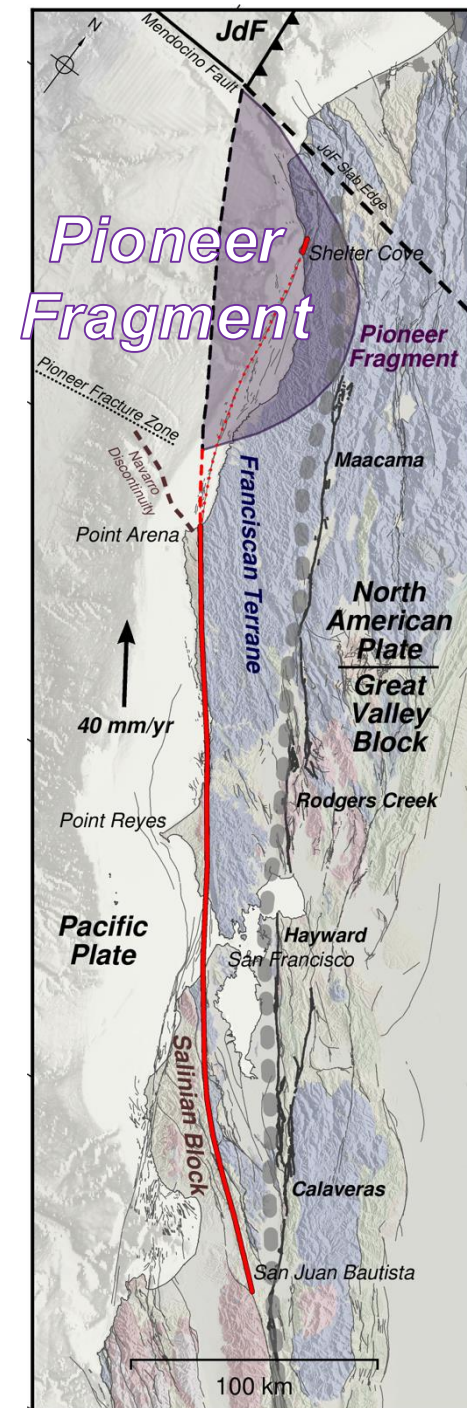
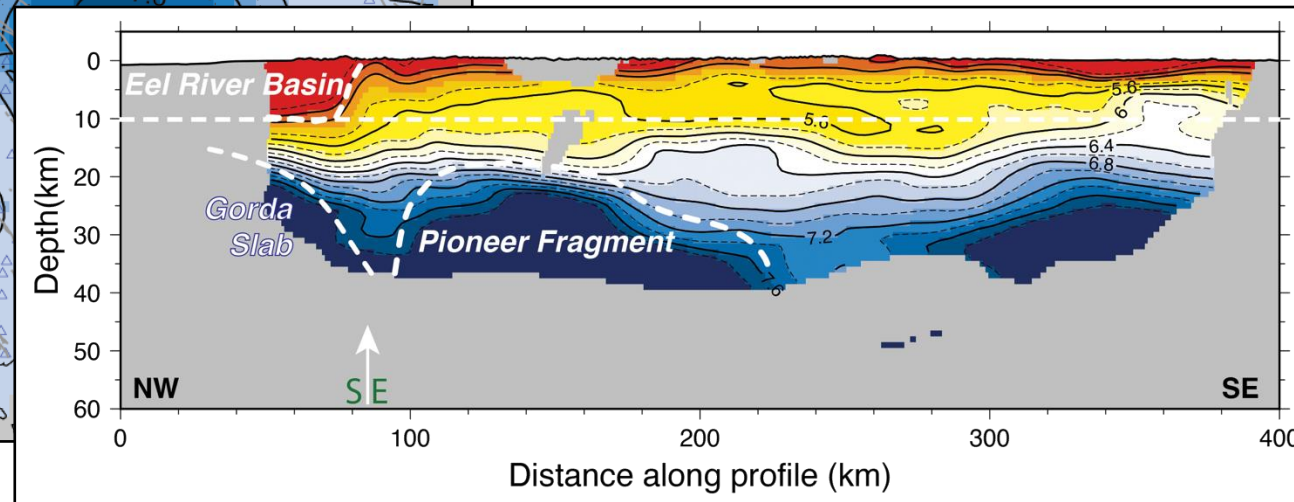
- Transform shear zone lies under center of symmetry in interseismic motions
 - Red: > 30 mm/yr
 - Blue: < 30 mm/yr
- Dashed line: location of transform plate boundary
- Plate boundary under Maacama, Rodgers Creek, Calaveras, Hayward faults
- Coincides with San Andreas Fault south of San Juan Bautista



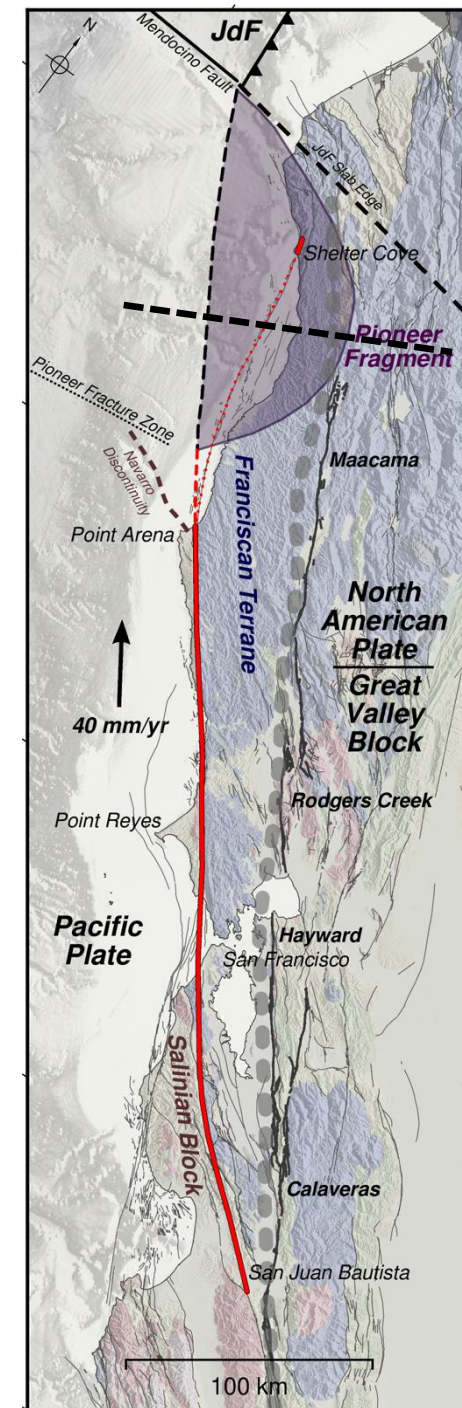
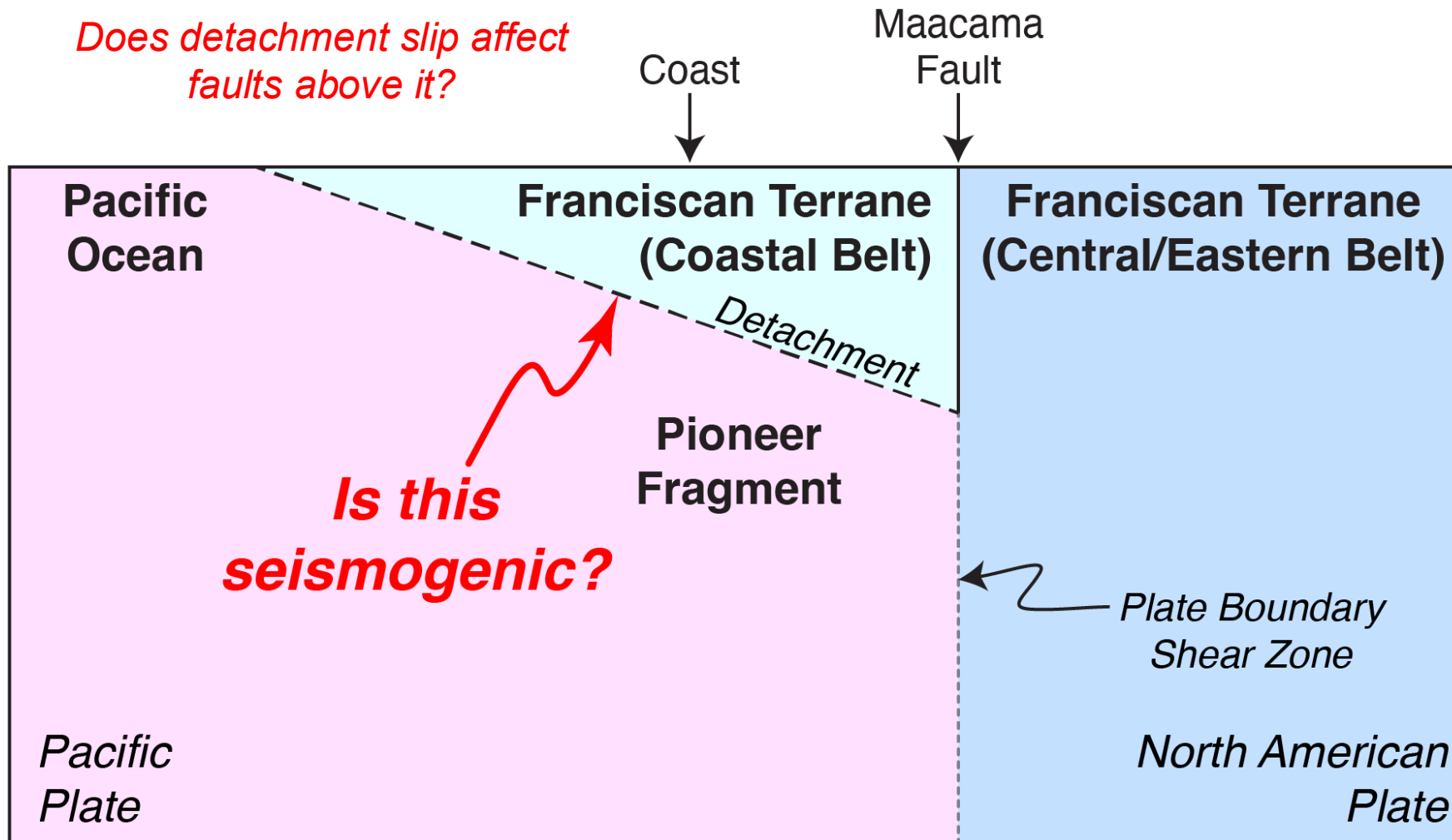
MTJ Region Tectonic Structure



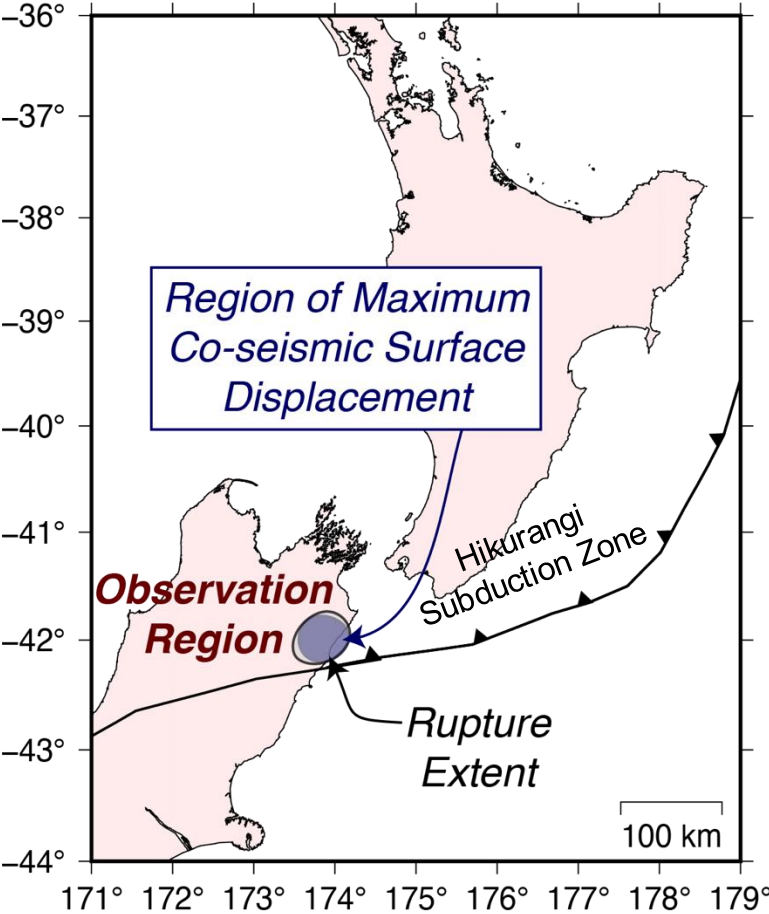
Seismic tomography imaging shows **Pioneer Fragment** connected to Pacific plate extending ~50 km eastward under North America



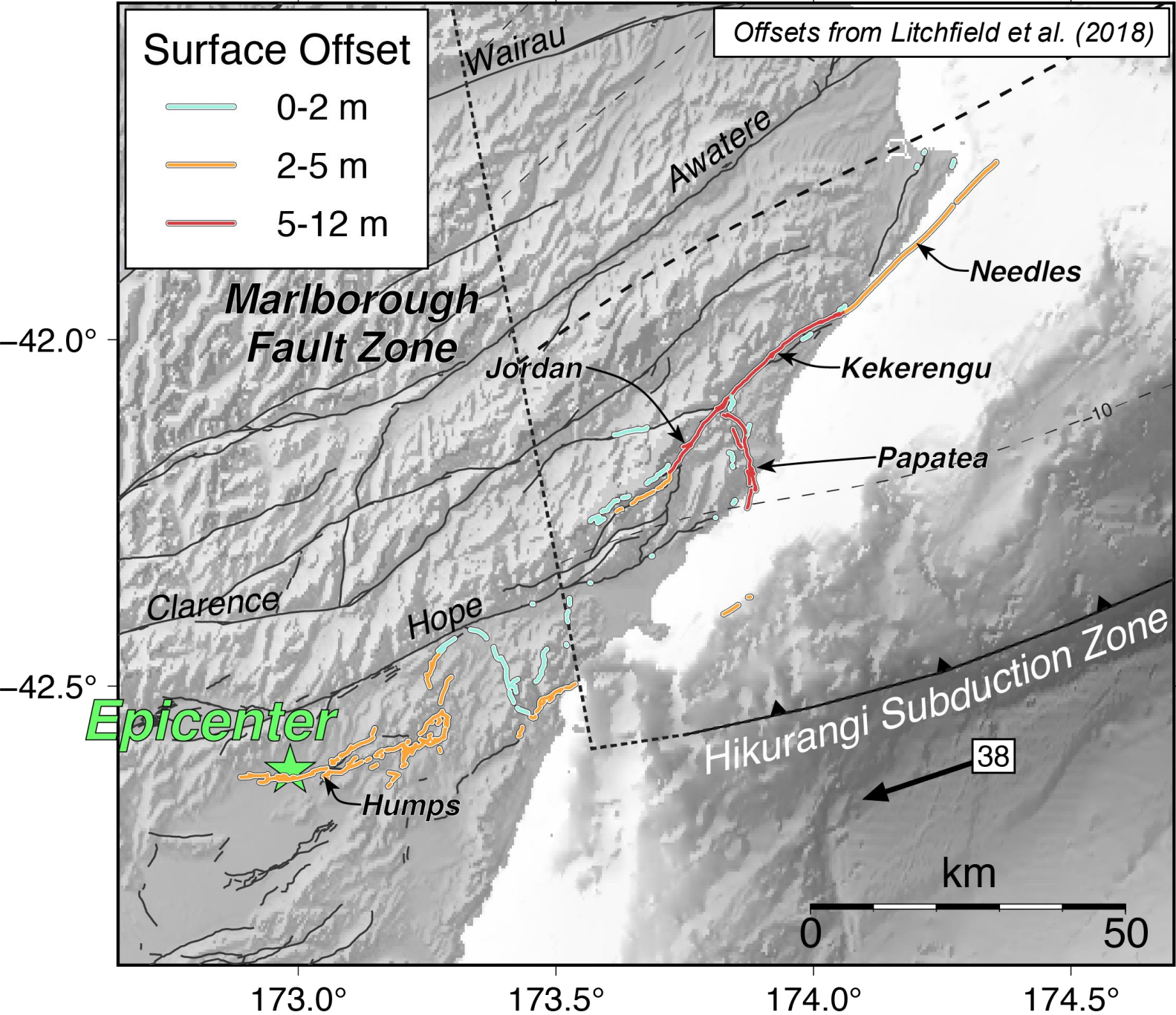
Role of Detachment in Earthquakes?



2016 Mw 7.8 Kaikoura Earthquake

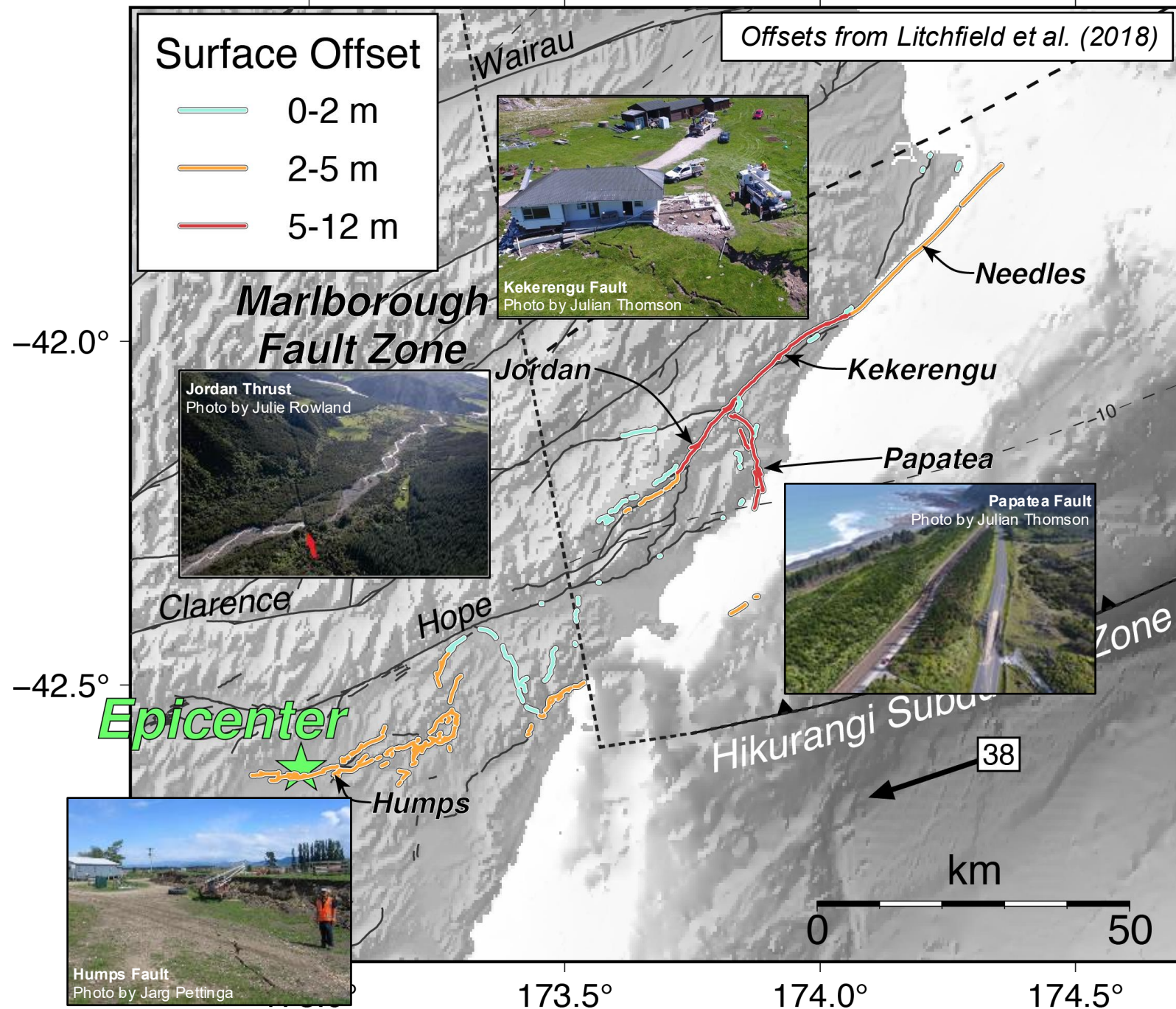


Herman et al., *Tectonics* (2023)



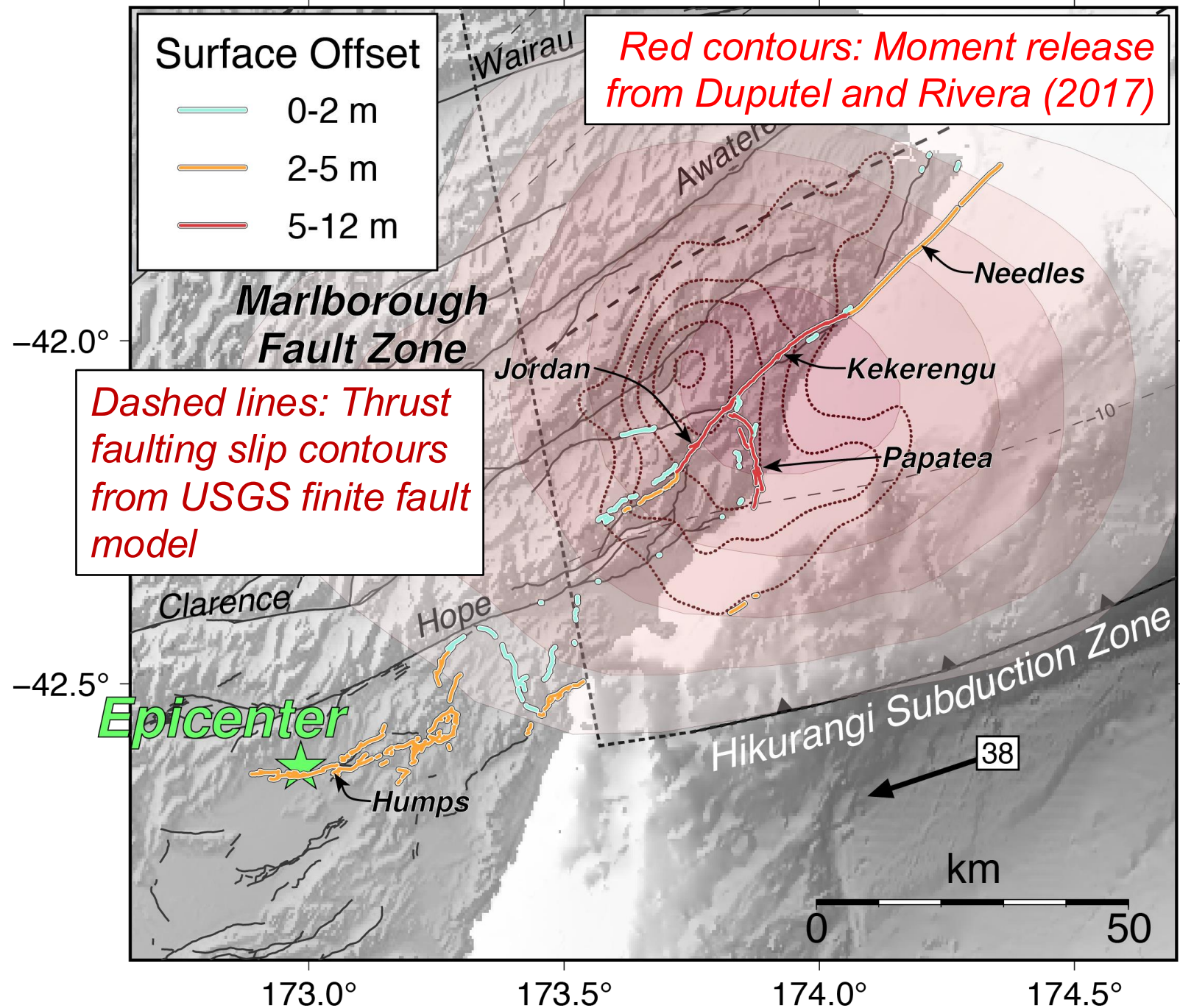
2016 Mw 7.8 Kaikoura Earthquake

- Typical slip (2-5 m) for M ~7+ earthquake on Humps fault
- Extreme slip (up to 12 m) on Papatea, Kekerengu, and Jordan faults
- Typical slip continuing offshore

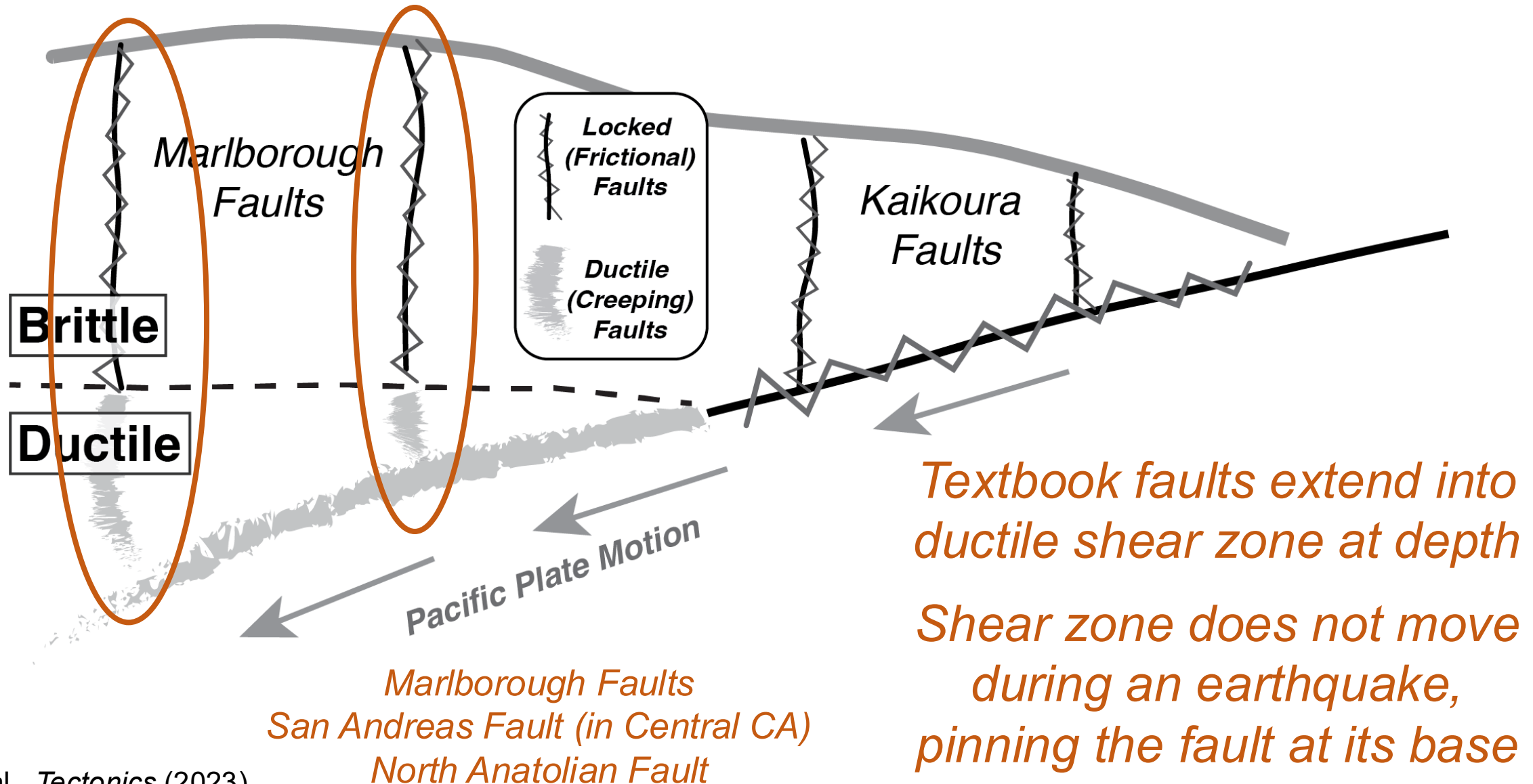


2016 Mw 7.8 Kaikoura Earthquake

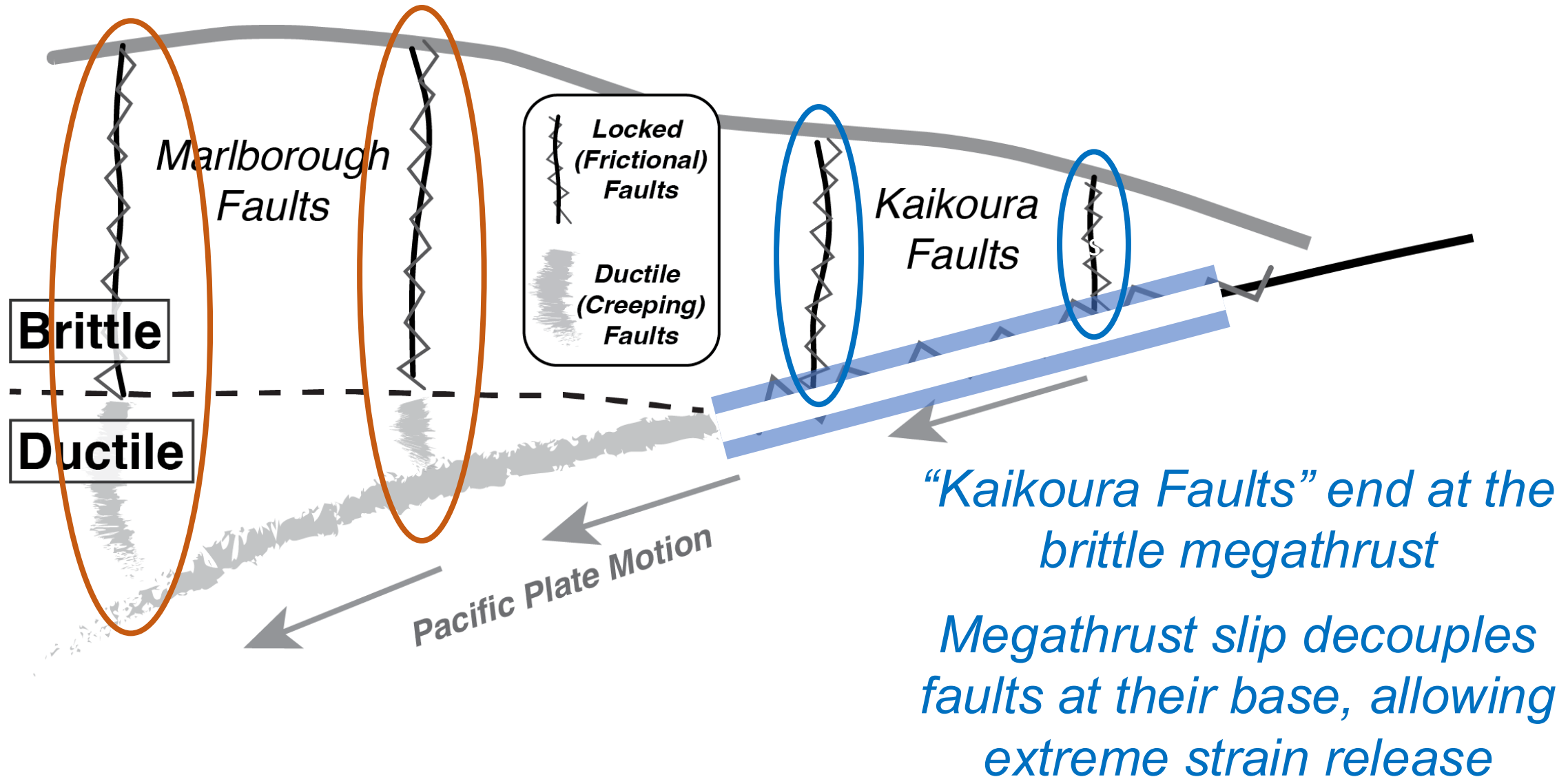
- Simultaneous thrust faulting rupture on subduction interface
- Constrained by teleseismic observations
- Extreme surface faulting occurs only above zone of thrust faulting



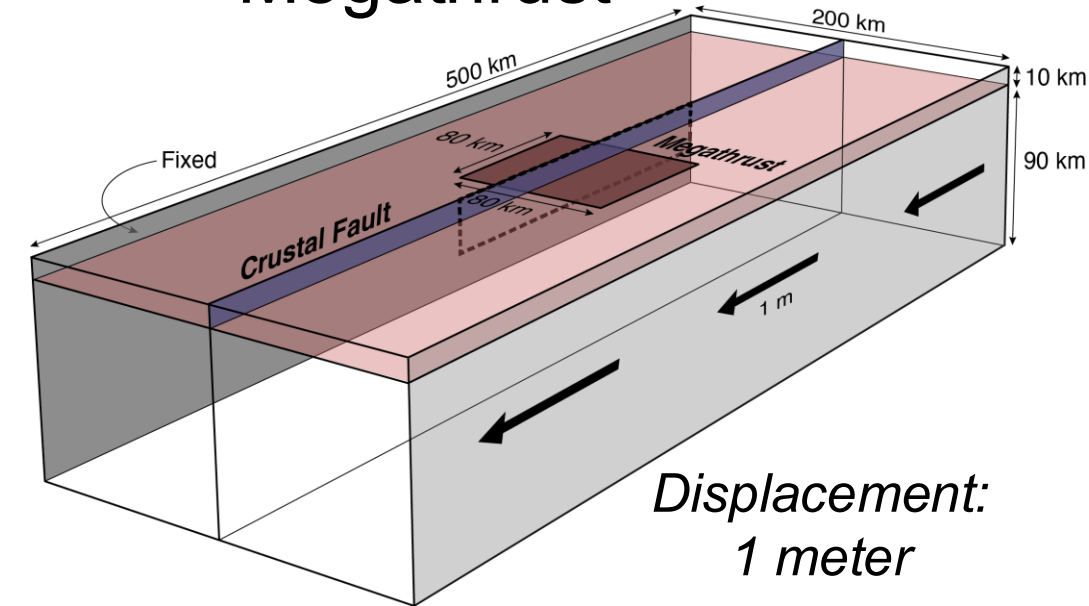
Generating Extreme Crustal Fault Slip



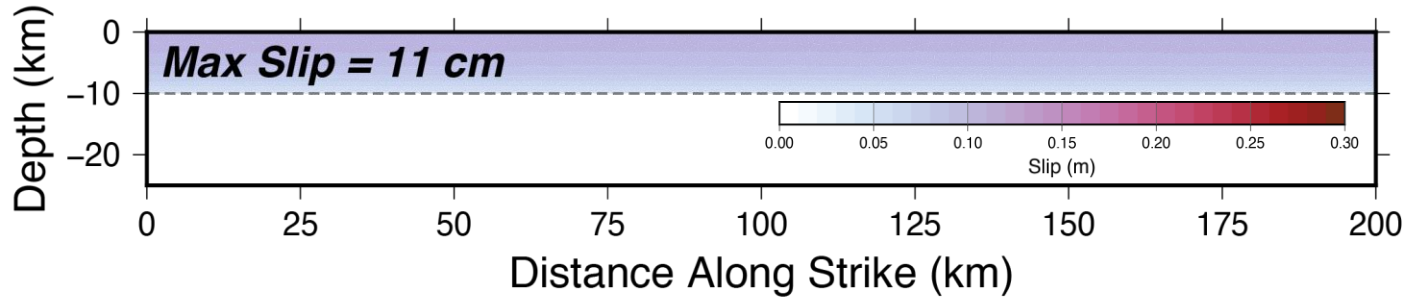
Generating Extreme Crustal Fault Slip



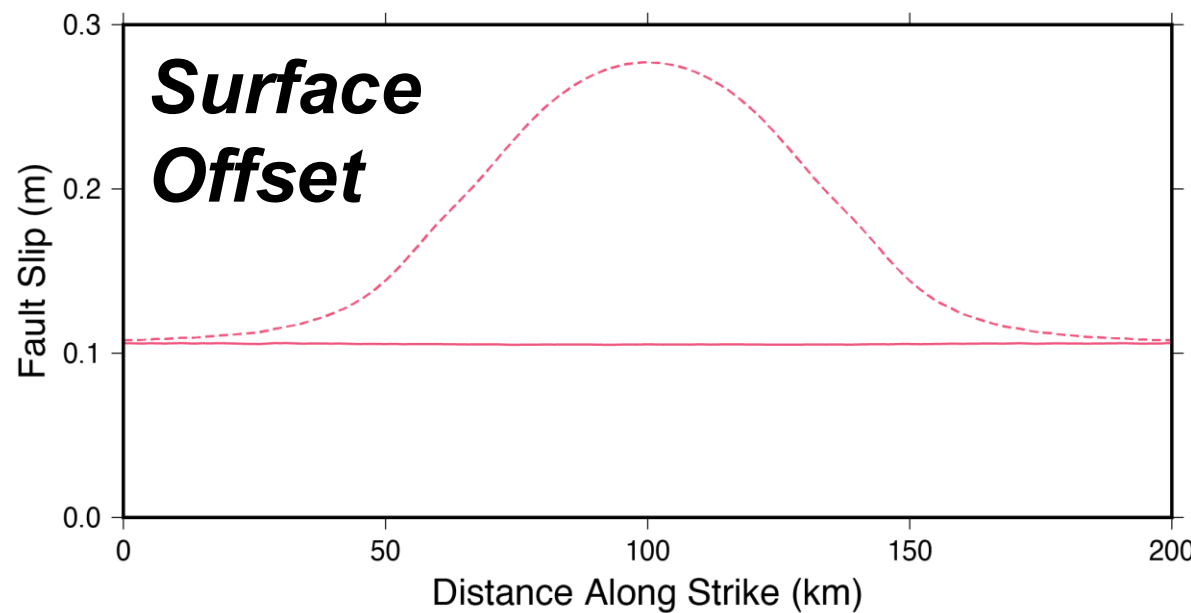
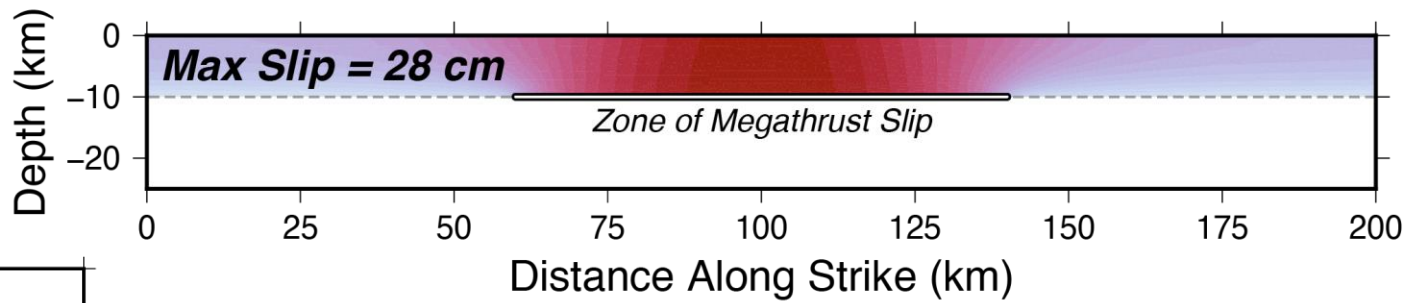
Model of Fault Slip Above Megathrust



Crustal Fault Slip with Coupled Base

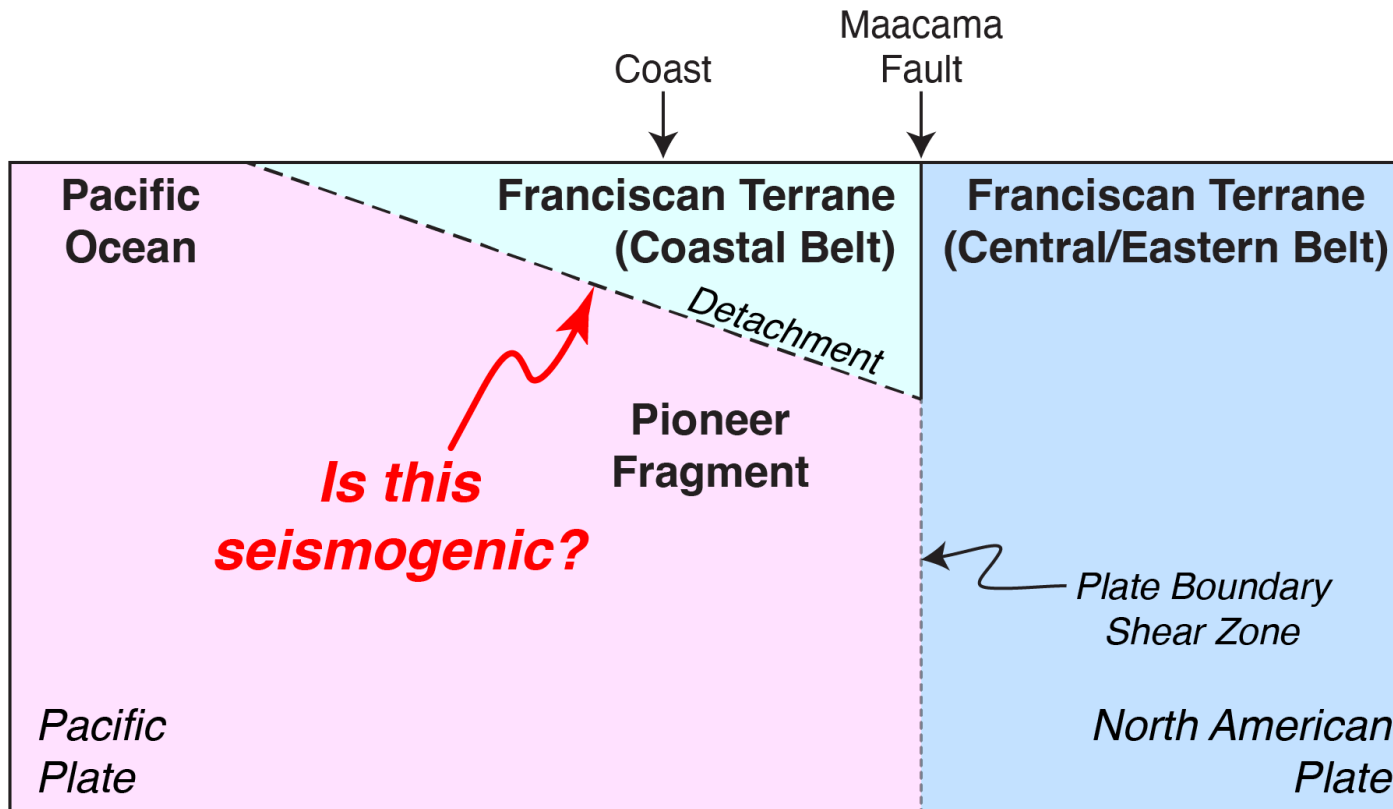
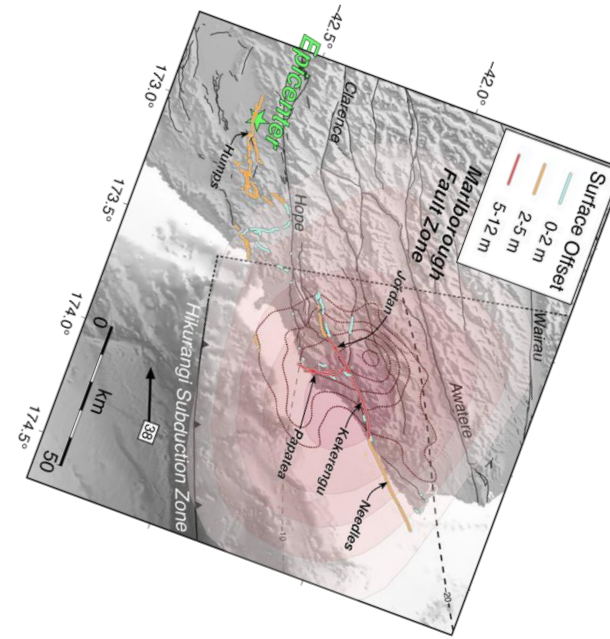


Crustal Fault Slip with Decoupled Base

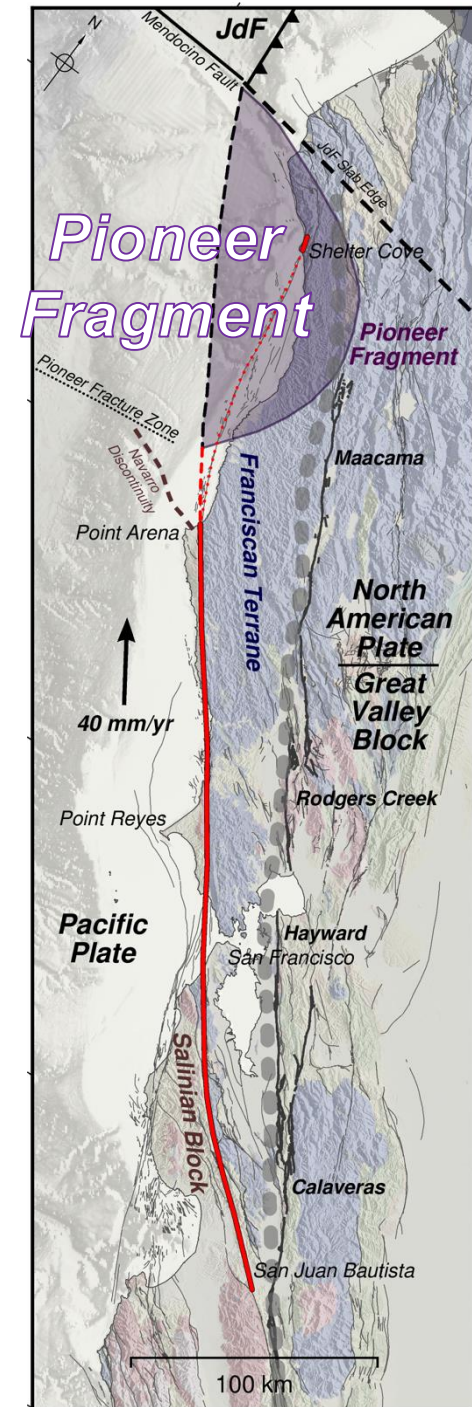


*When decoupled at its base, strike-slip fault slips **28 cm** (3x more) at the surface*

Similar tectonic structure in Kaikoura, Pioneer regions!

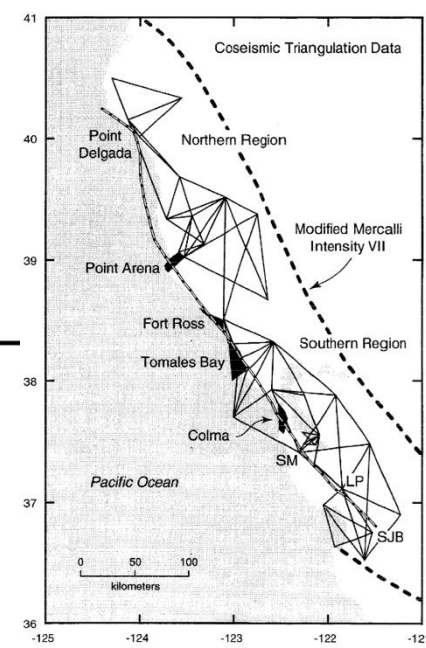
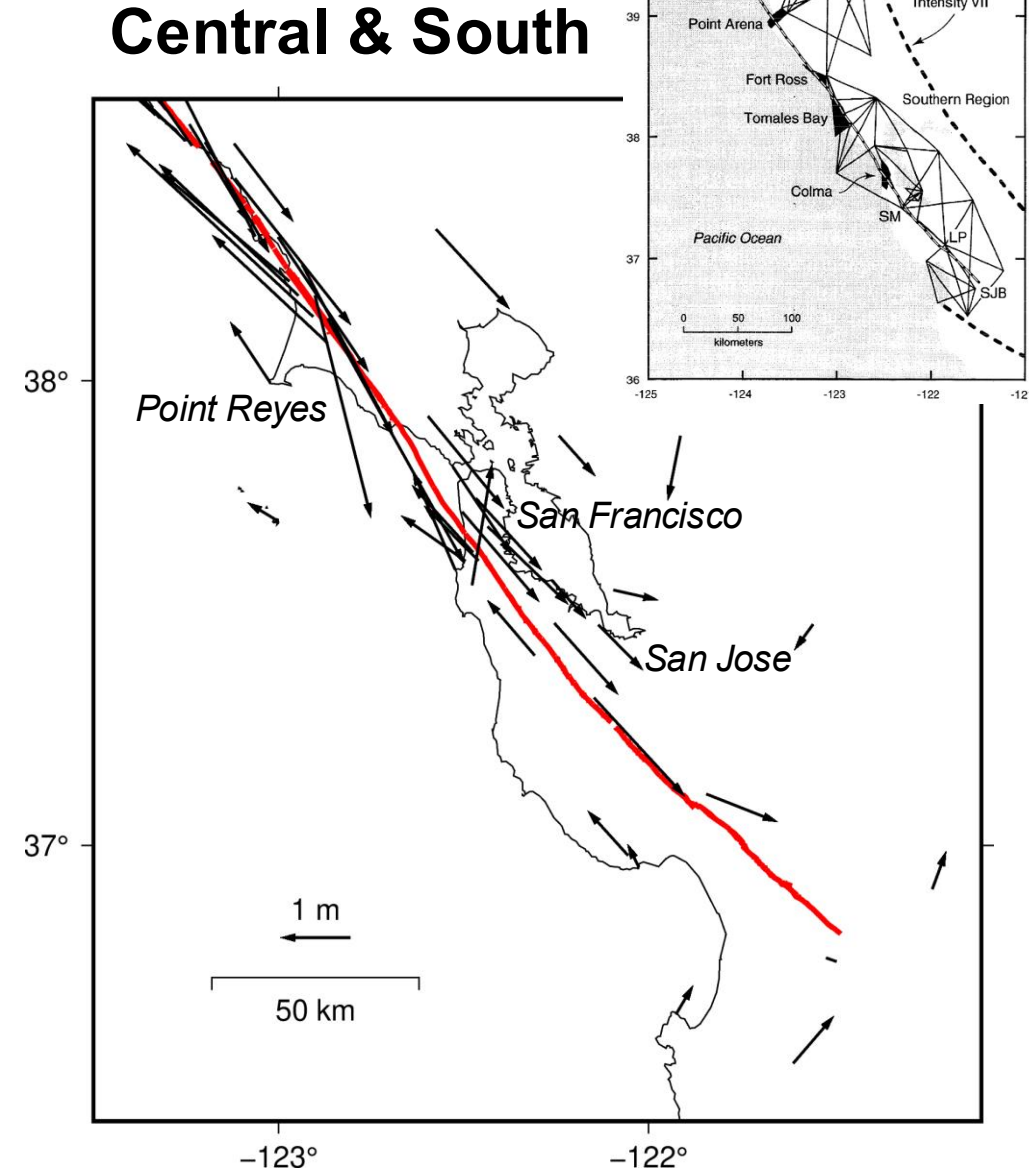
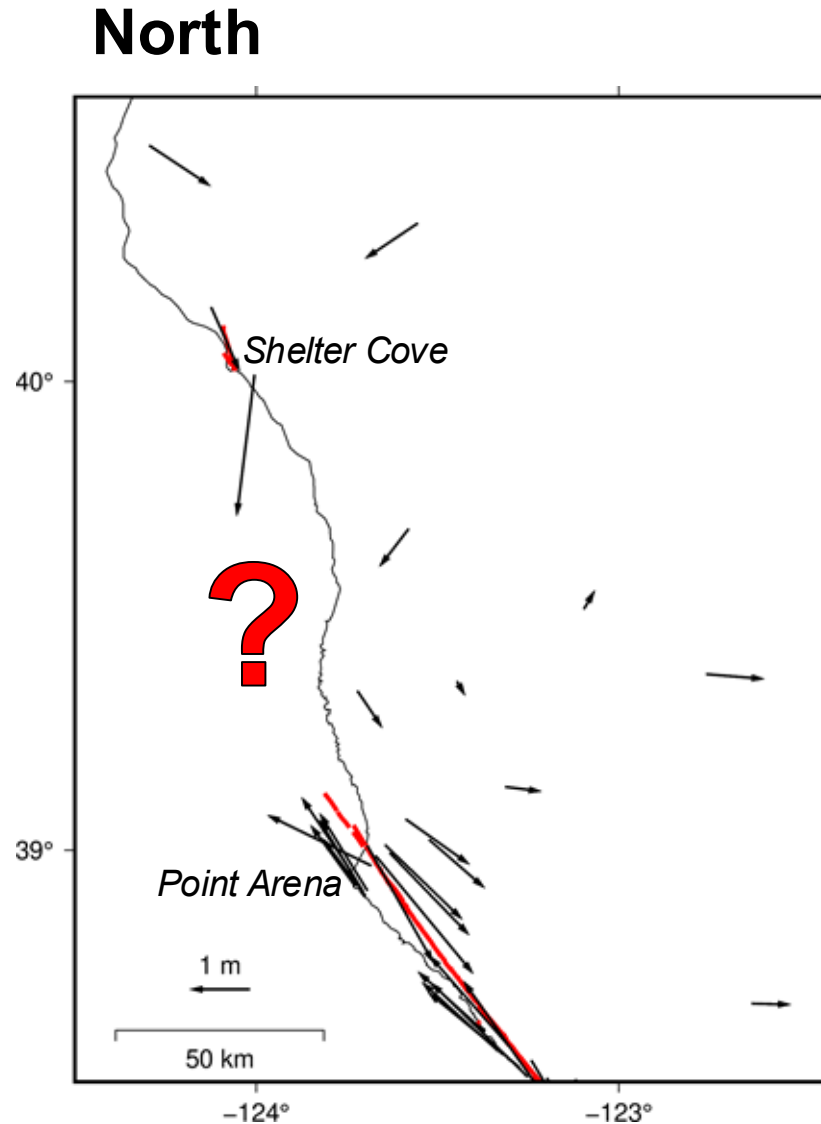


Kaikoura,
New Zealand



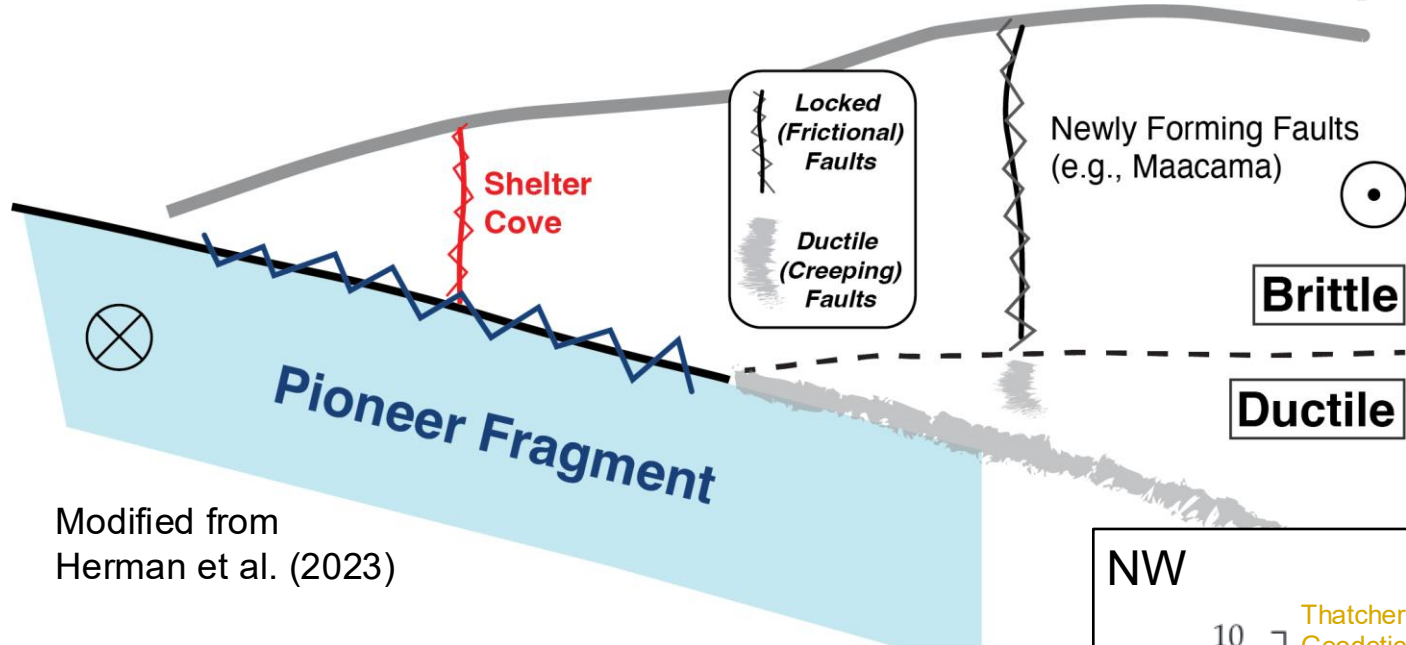
Enhanced Crustal Fault Slip in 1906?

- Triangulation observations (Lawson, 1908)
- Displacements derived from post-earthquake angle changes
- Displacements also indicate northern slip



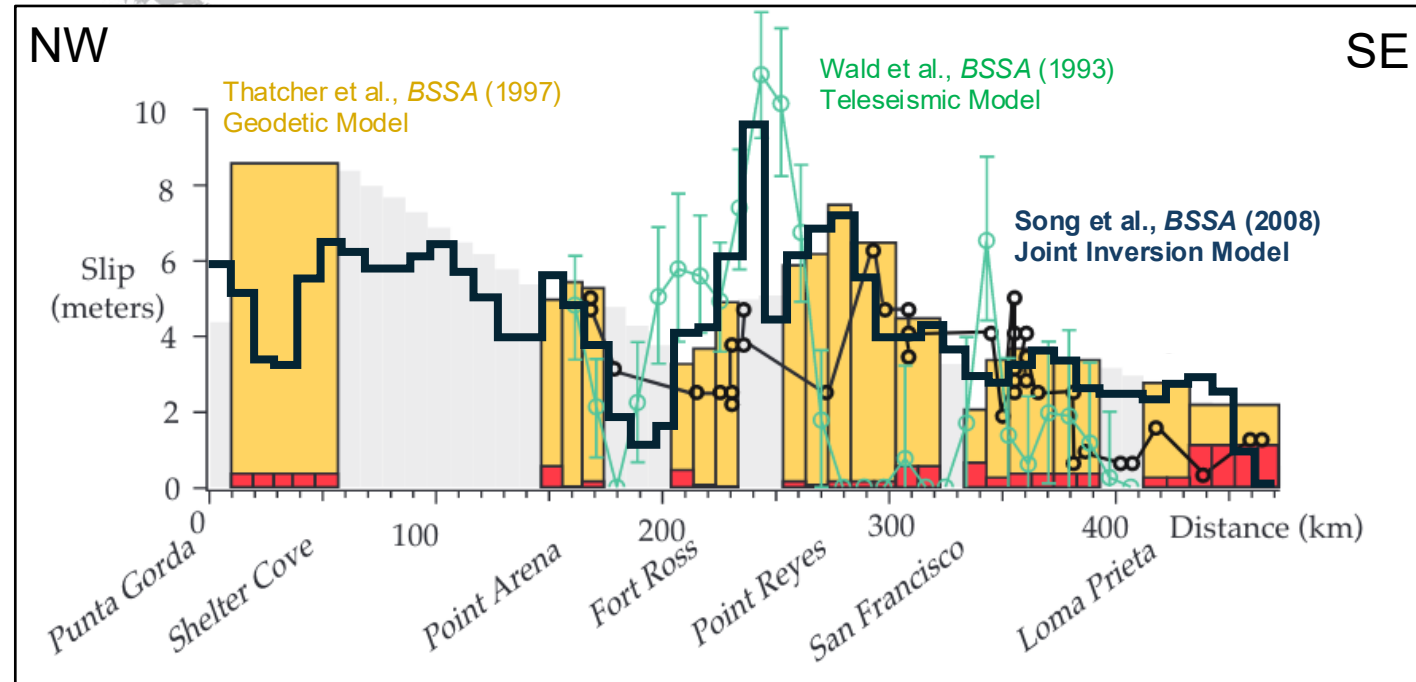
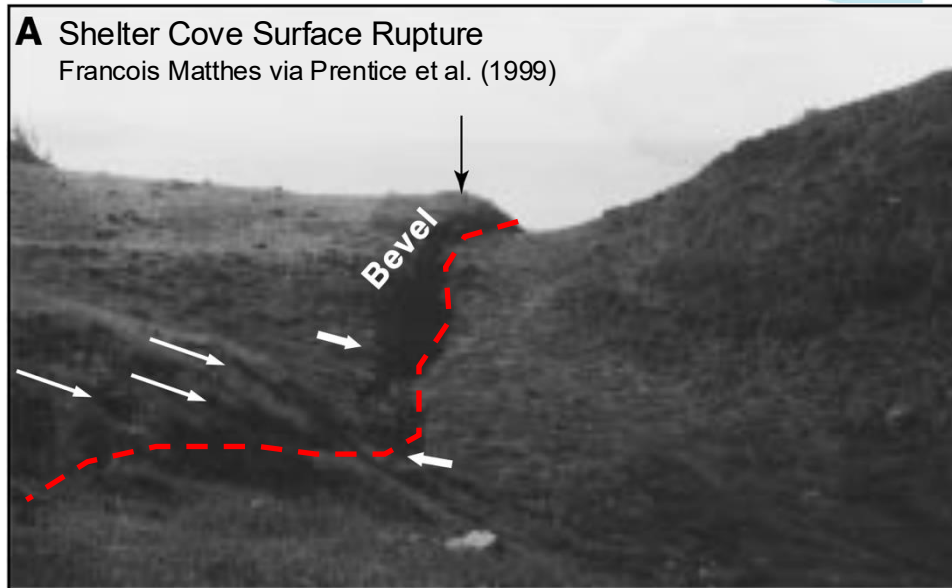
Note: 1-2 m uncertainties!!

Enhanced Crustal Fault Slip in 1906 Earthquake?



Modified from
Herman et al. (2023)

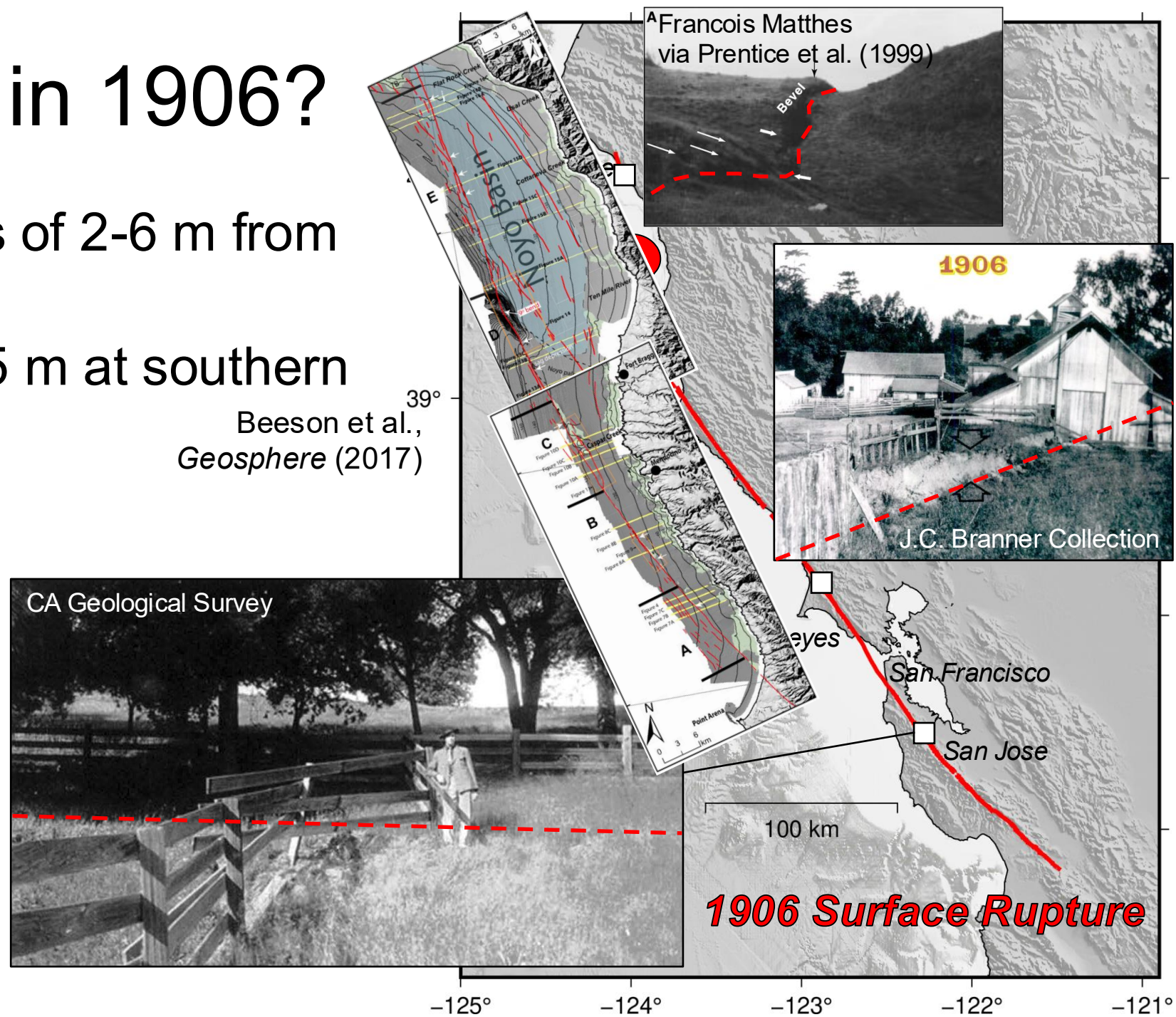
- According to displacement, there was unusually high slip at northern end of rupture
- Typically, slip tapers near fault ends



Zoback, GSA Today (2006)

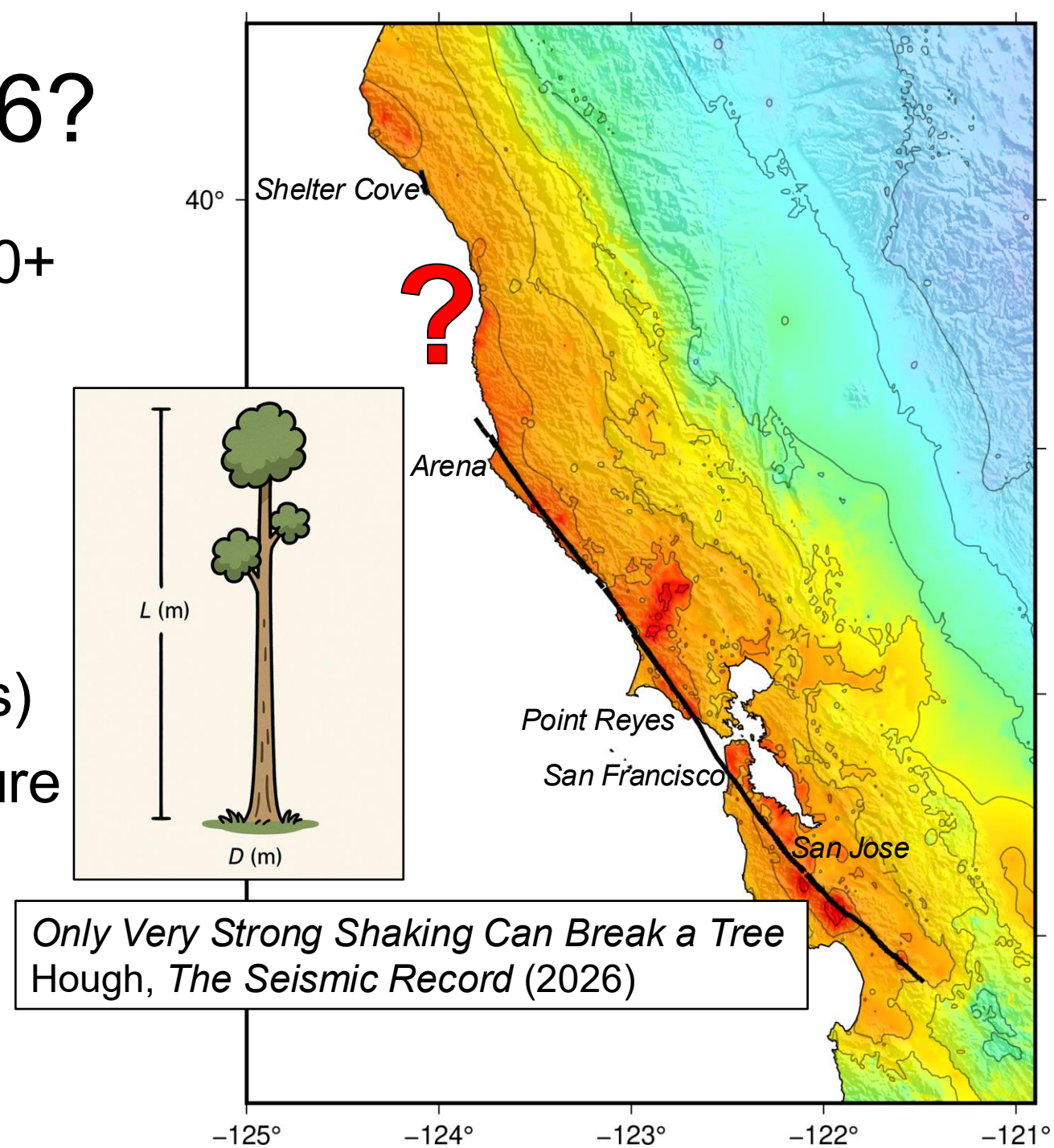
Enhanced Slip in 1906?

- Observed surface offsets of 2-6 m from San Jose to Point Arena
 - Surface offsets of 0.5-1.5 m at southern end of rupture
 - Shelter Cove surface rupture (observed, but unconstrained)
 - No surface rupture data offshore
- Beeson et al. 2000, *Geosphere* (2000)
- 
- A black and white photograph showing a landscape with several trees and a fence in the foreground. The text "CA Geological Survey" is overlaid in the top left corner of the image.

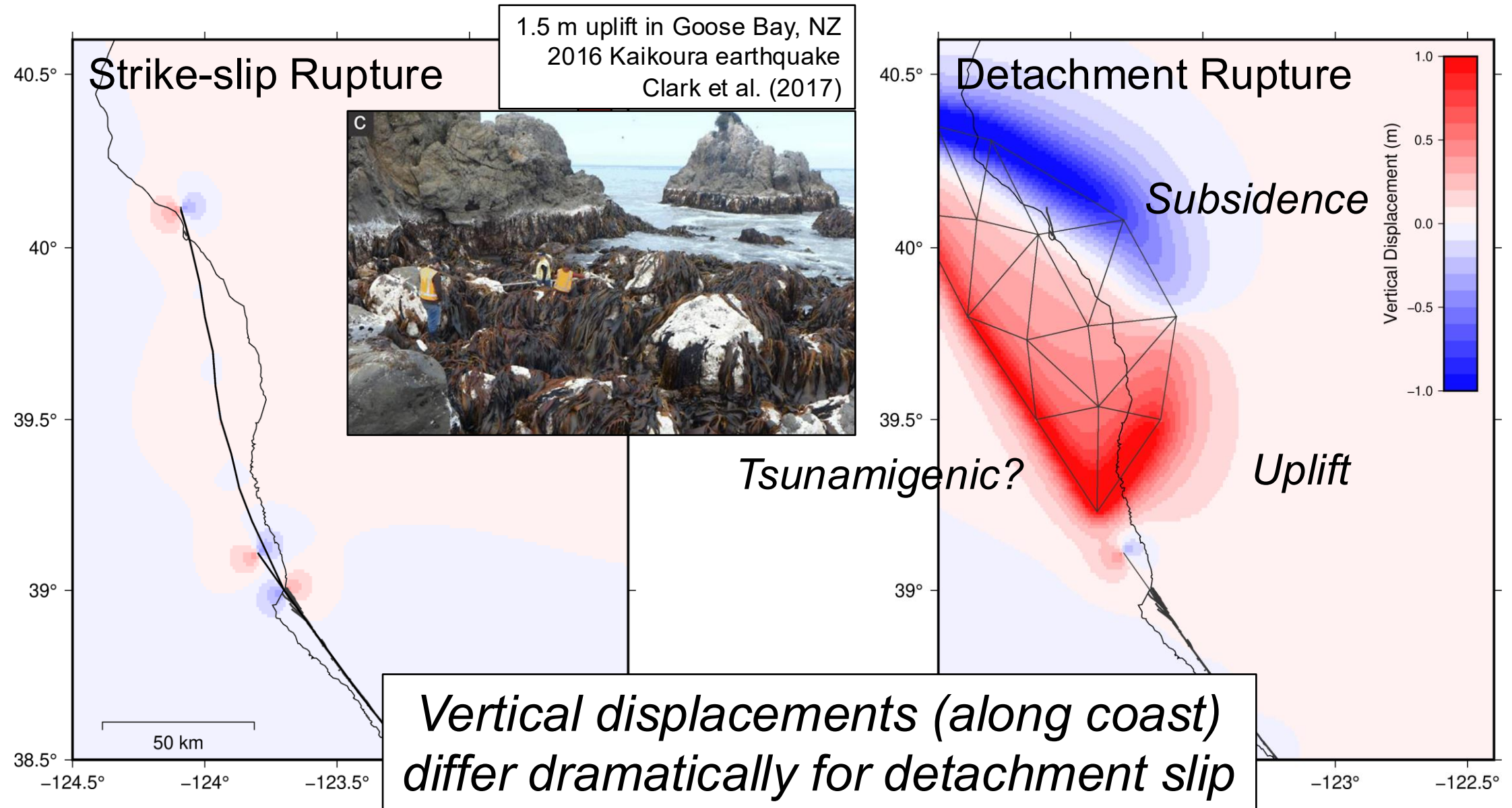


Enhanced Slip in 1906?

- Shaking and damage reports at 600+ sites (Lawson, 1908)
- Additional newspaper and survivor reports and graveyard analyses (Boatwright and Bundock, 2005)
- Greatest shaking intensities near ruptured fault (and in nearby basins)
- Shaking intensity implies fault rupture north of Point Arena



Looking for Detachment Rupture in 1906



Conclusions & Future Work

- Northern San Andreas plate boundary consists of a shallowly dipping detachment along the top of the Pioneer fragment
- Detachment may have participated in the 1906 earthquake rupture, enhancing slip on crustal faults
- Consequences of detachment rupture include:
 - Larger fault slip towards northern end of rupture
 - Broadened region (and different character?) of severe shaking
 - Surface uplift/subsidence and potential coastal impacts (incl. tsunami)