Effects of Geology and Seismic Velocity Variations on Spontaneous Rupture Simulations of Large Earthquakes on the Rodgers Creek, Hayward, and Calaveras faults

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with thanks to

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2021 San Francisco Bay Region Unified Structural Representation Workshop

Figure 1
From
Harris
et al.,
JGR,
2021

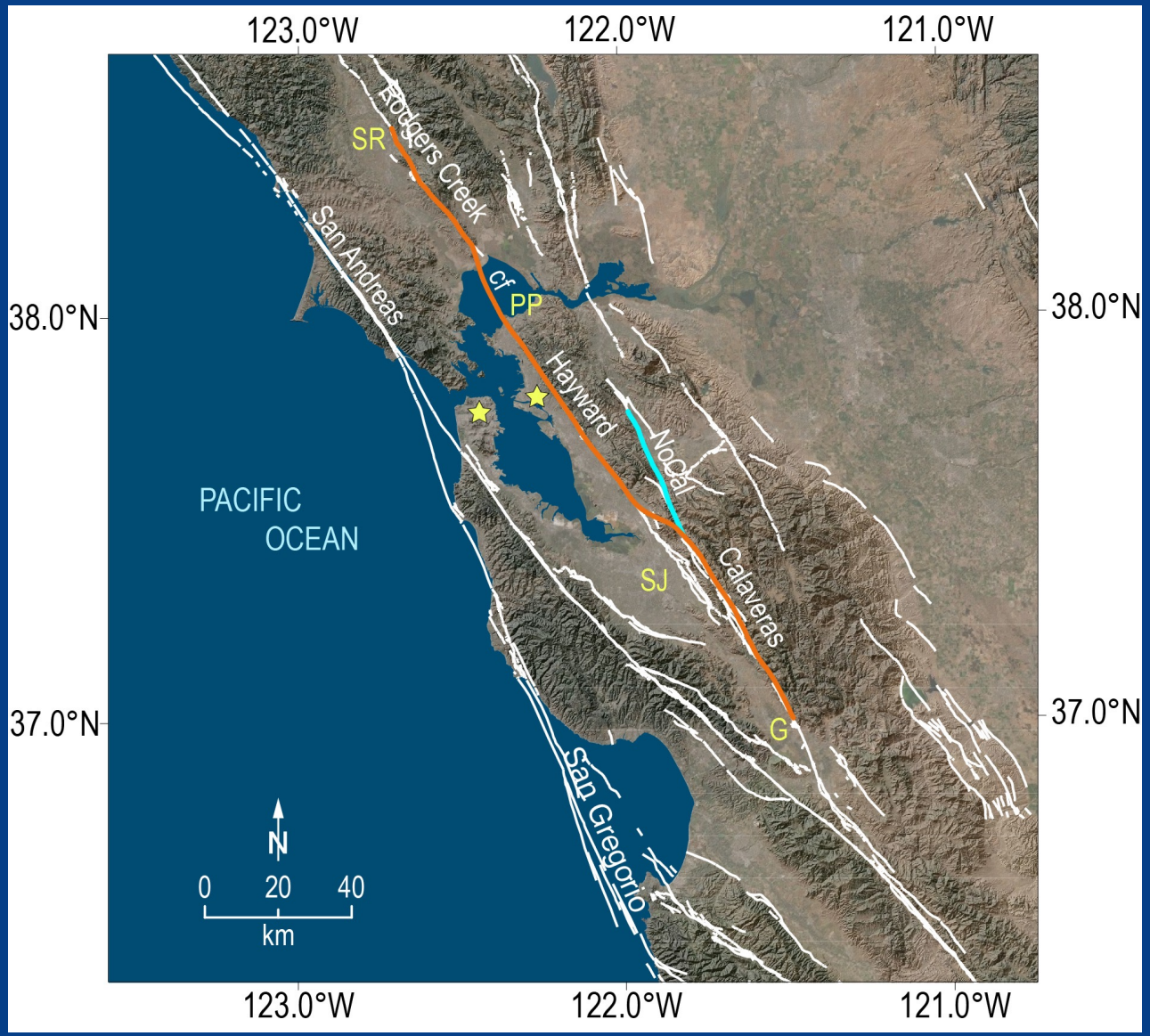
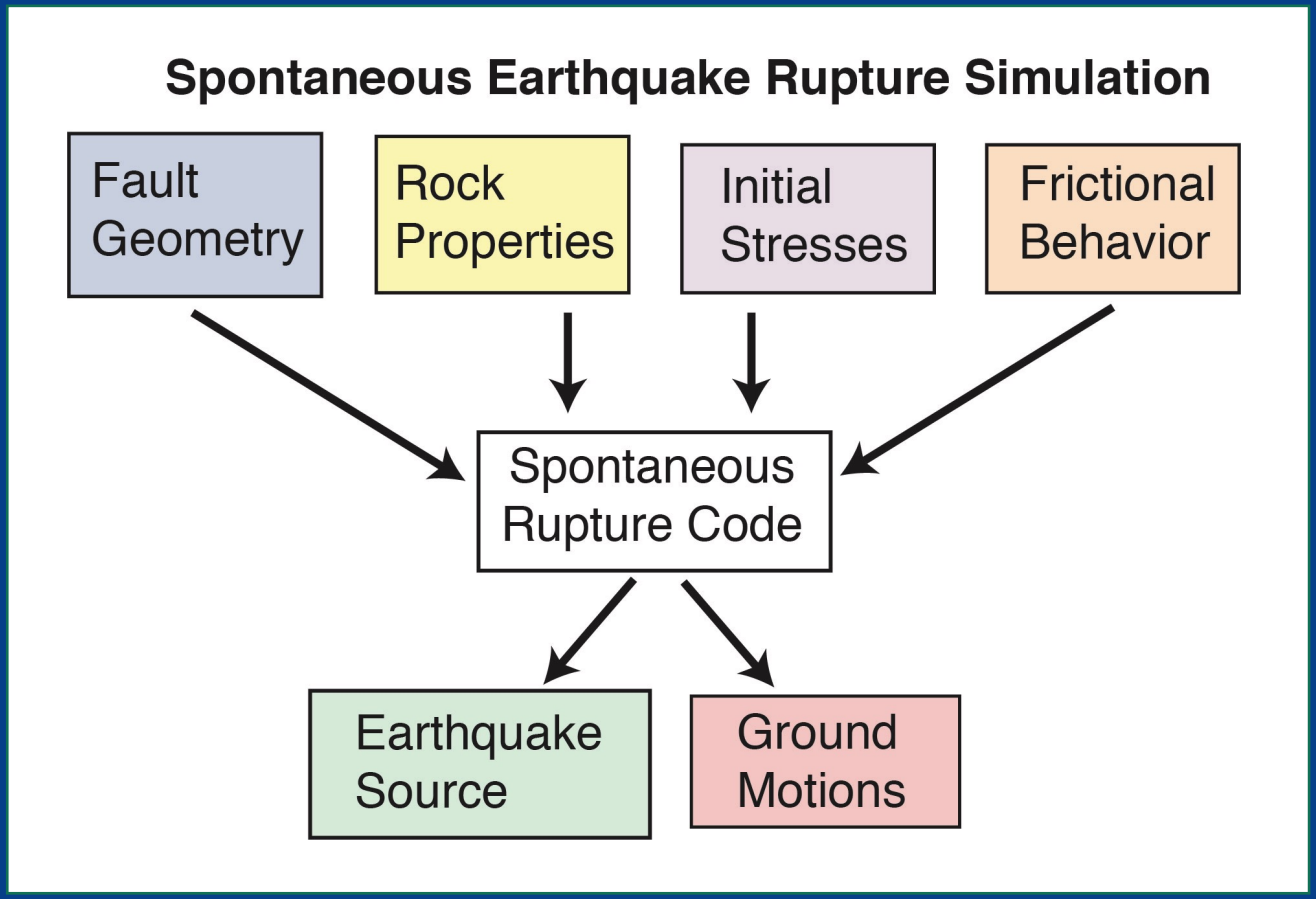


Figure modified from Harris, Reviews of Geophysics, 2017



Fault Geometry

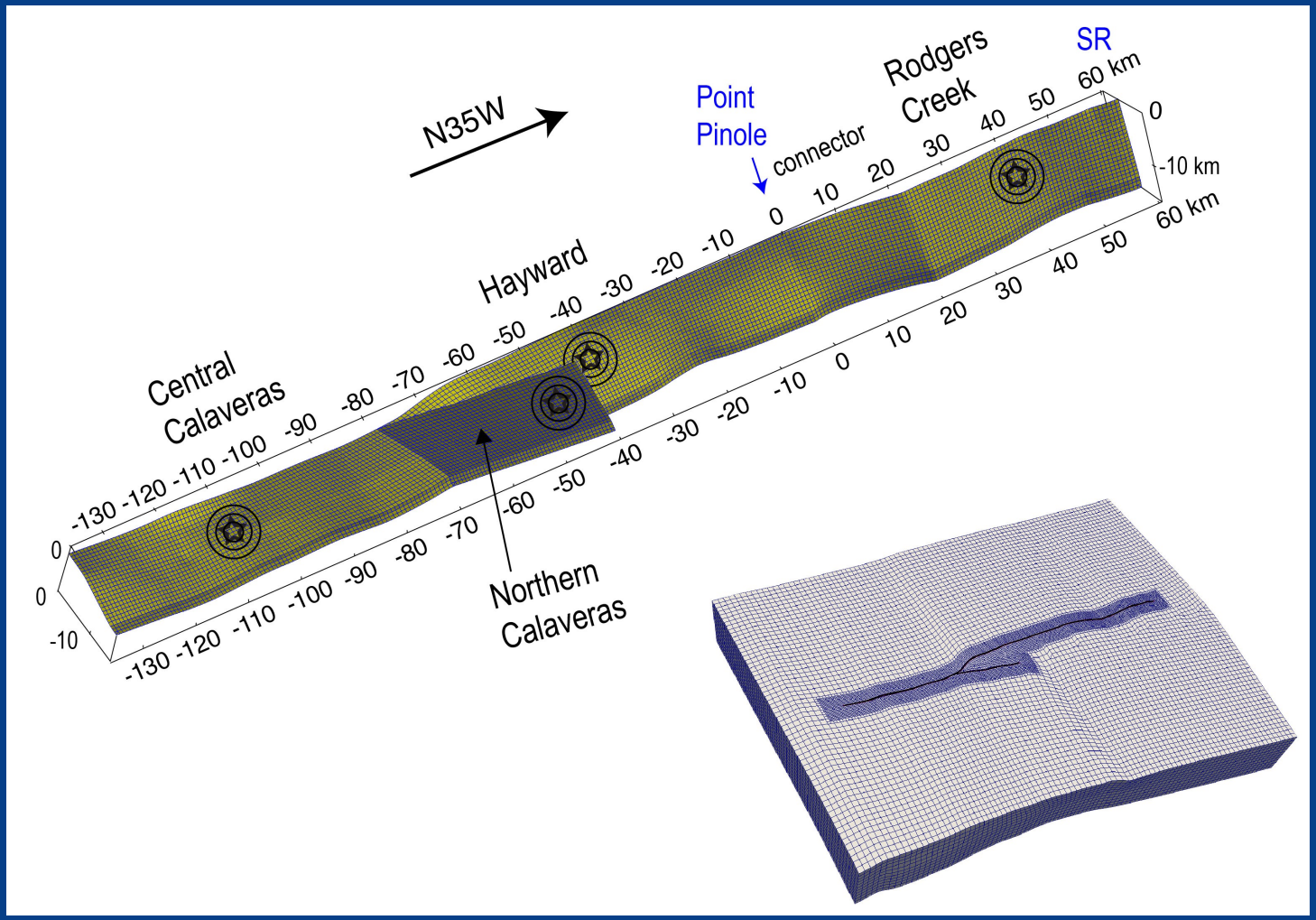
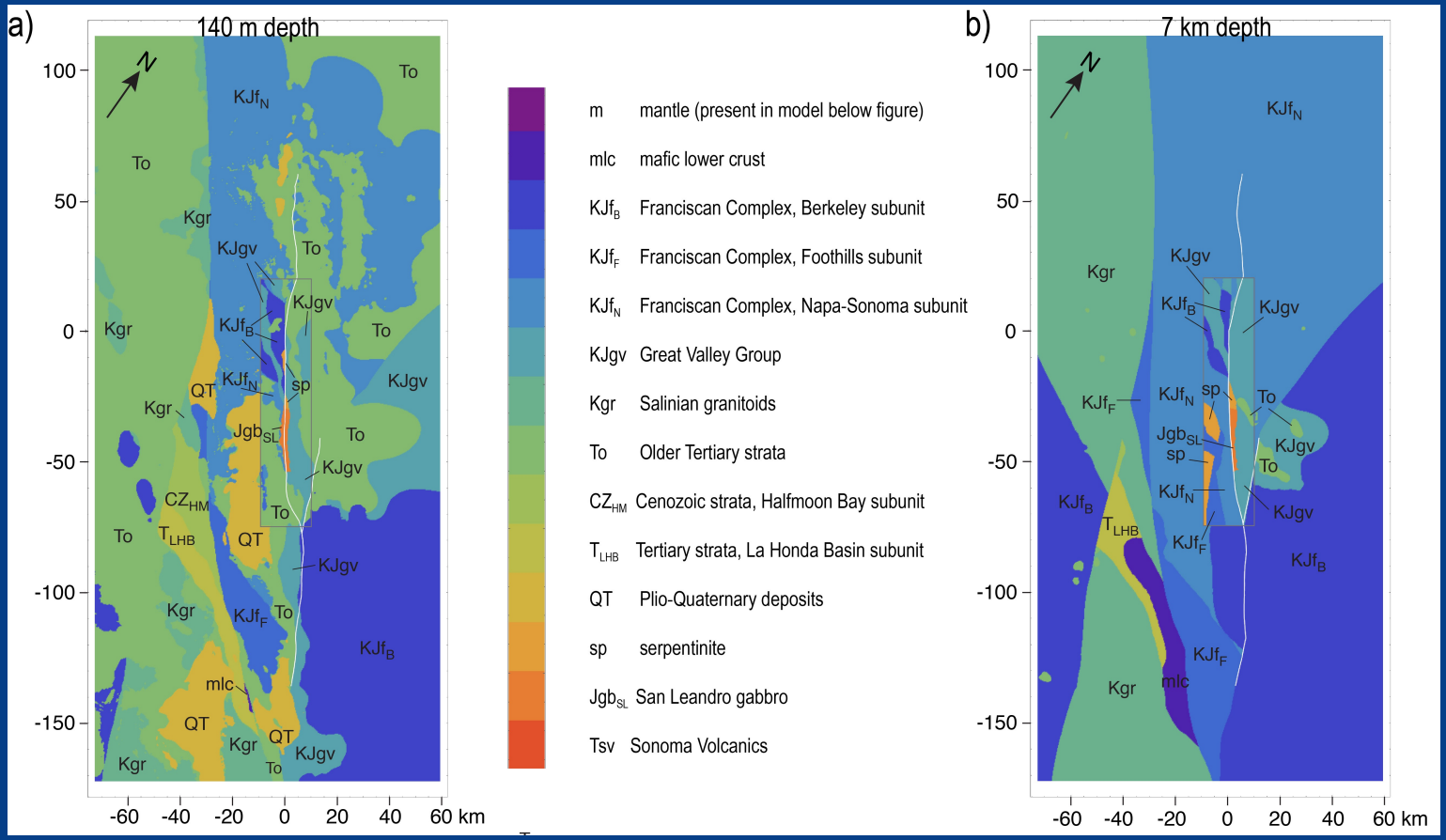


Figure 3 from Harris et al., JGR, 2021

Rock Units (Used to determine our Rock Properties)

view of sample horizontal slices

Figures 4a,b from Harris et al., JGR, 2021



Gray-rectangle region: info. from Graymer et al., 2005 & Phelps et al., 2008
Larger region: info. from Jachens et al., 2006

Rock Units (Used to determine our Rock Properties) - views of the fault surfaces

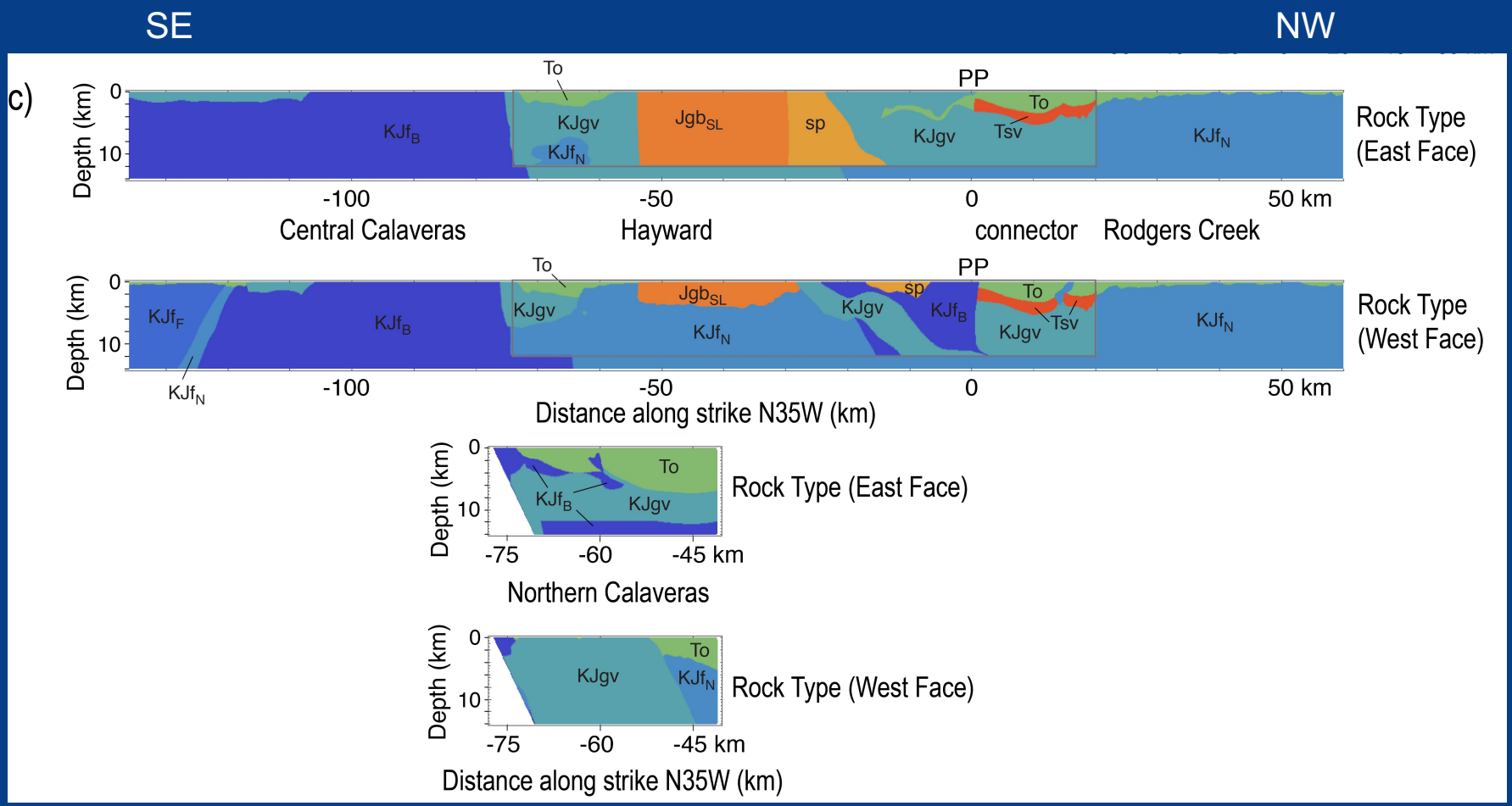
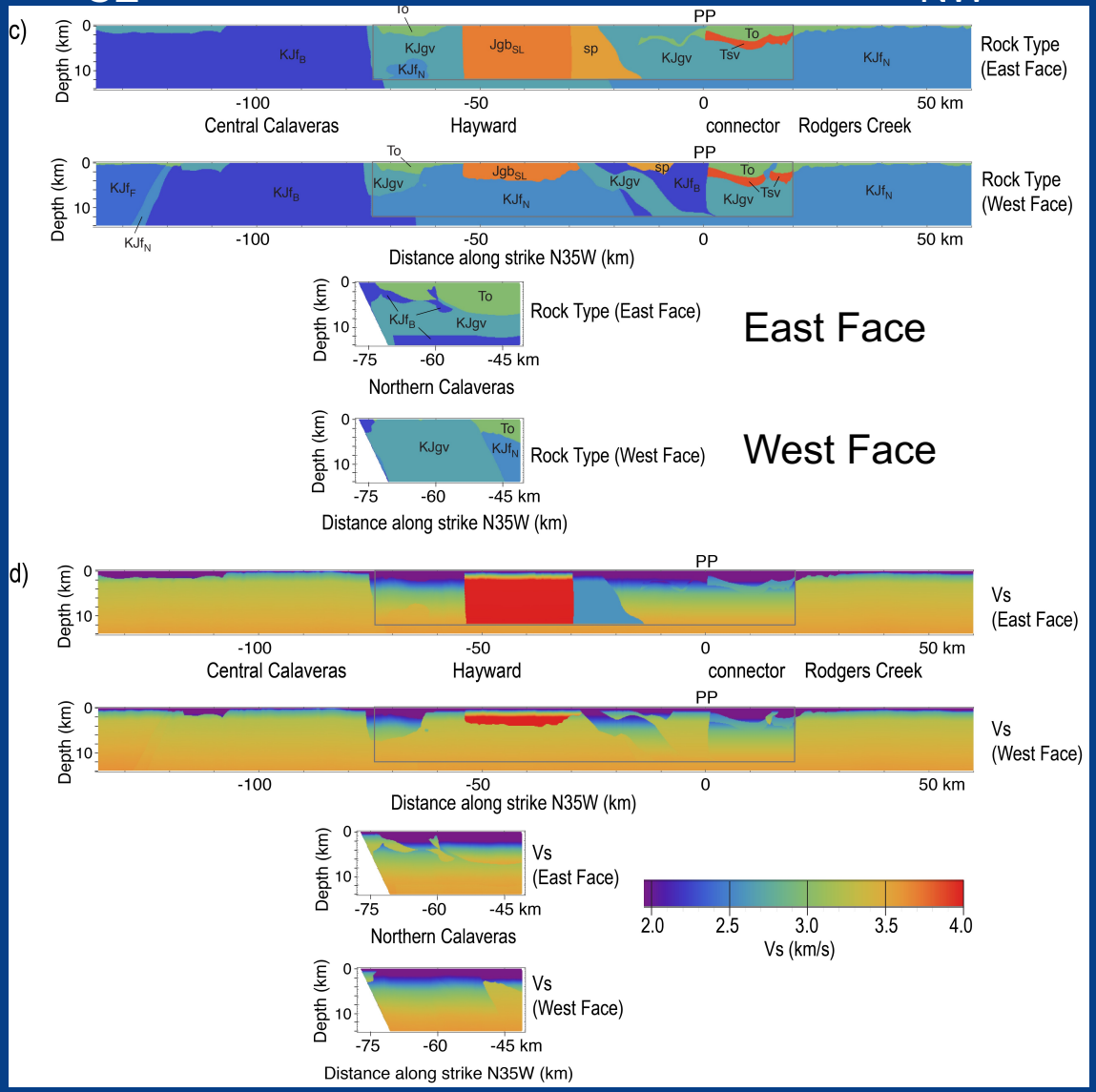


Figure 4c from Harris et al., JGR, 2021

Rock Units (Used to determine our Rock Properties) - views of the fault surfaces

m	mantle (present in model below figure)
mlc	mafic lower crust
KJf_B	Franciscan Complex, Berkeley subunit
KJf_F	Franciscan Complex, Foothills subunit
KJf_N	Franciscan Complex, Napa-Sonoma subunit
KJgv	Great Valley Group
Kgr	Salinian granitoids
To	Older Tertiary strata
CZ_{HM}	Cenozoic strata, Halfmoon Bay subunit
T_{LHB}	Tertiary strata, La Honda Basin subunit
QT	Plio-Quaternary deposits
sp	serpentinite
Jgb_{SL}	San Leandro gabbro
Tsv	Sonoma Volcanics

SE NW



East Face

West Face

Vs East Face

Vs West Face

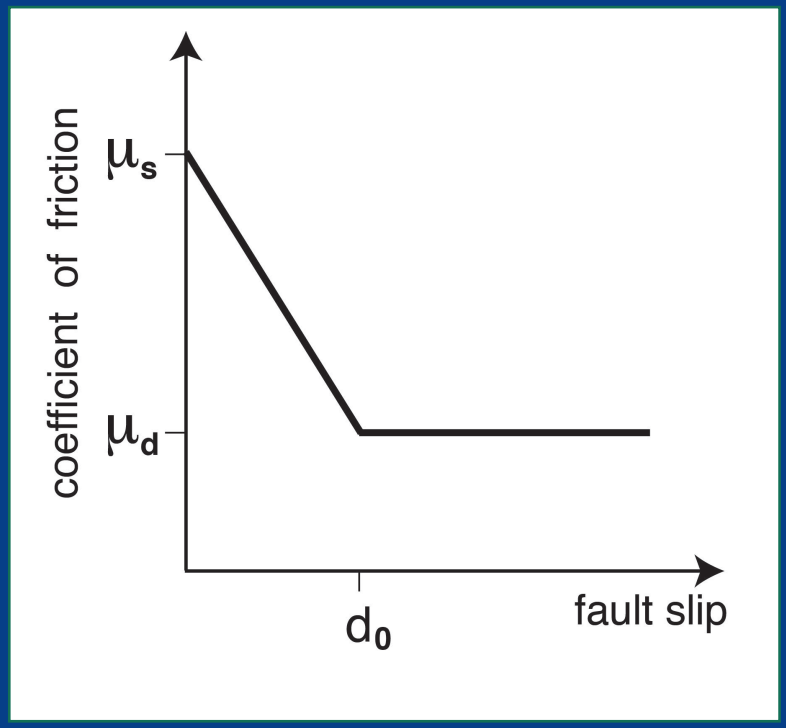
Figures 4c,d from Harris et al., JGR, 2021

Friction Behavior – slip weakening

μ_s = static coefficient of friction

μ_d = dynamic sliding coefficient of friction

d_0 = slip-weakening critical distance



Dynamic coefficients of friction - based on rock type

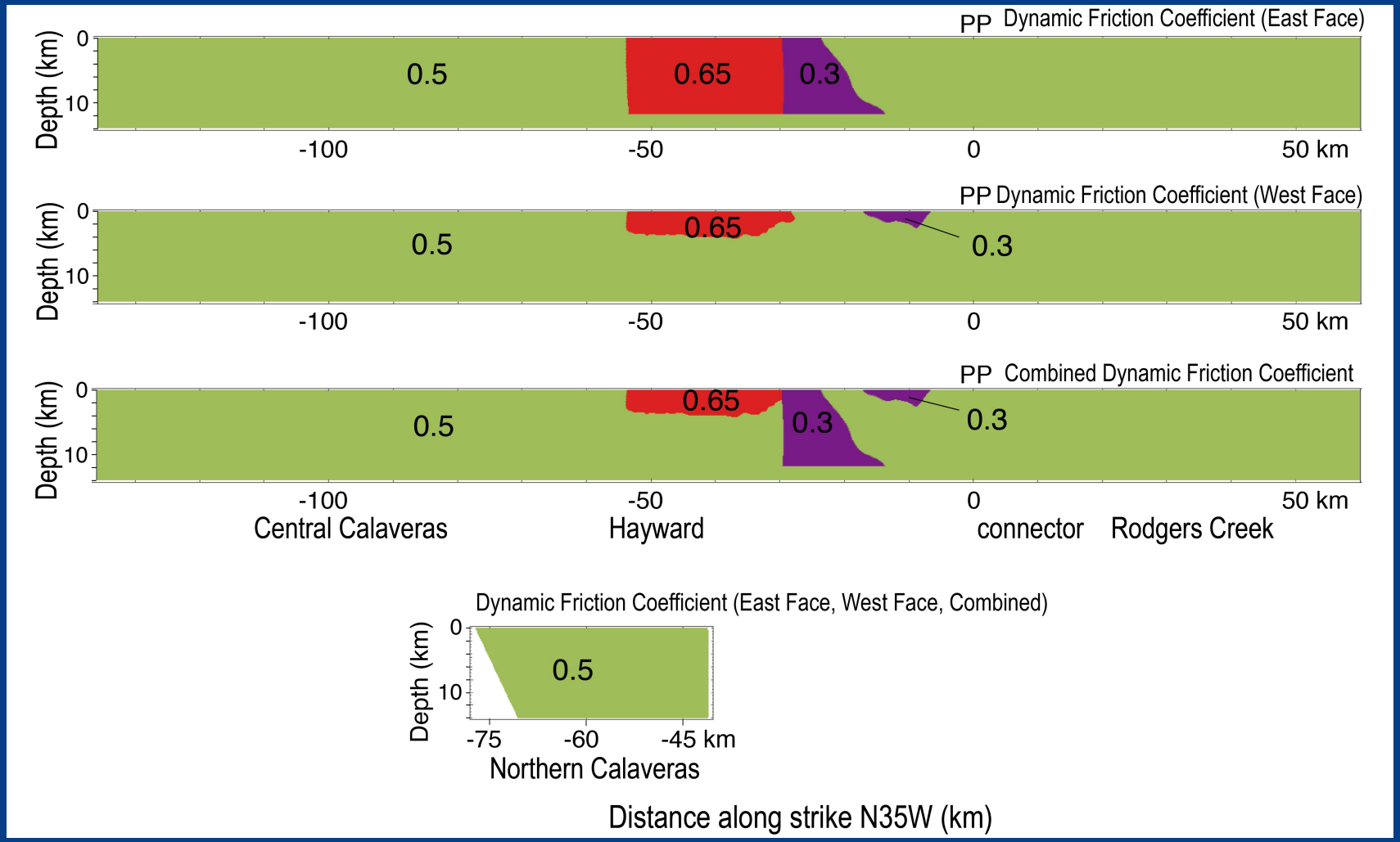


Figure 6 of Harris et al., JGR, 2021

Initial Stresses are inferred from the interseismic slip-rate pattern

For the same rock type:
Higher initial shear stress is assigned to locked patches
Lower initial shear stress is assigned to creeping patches

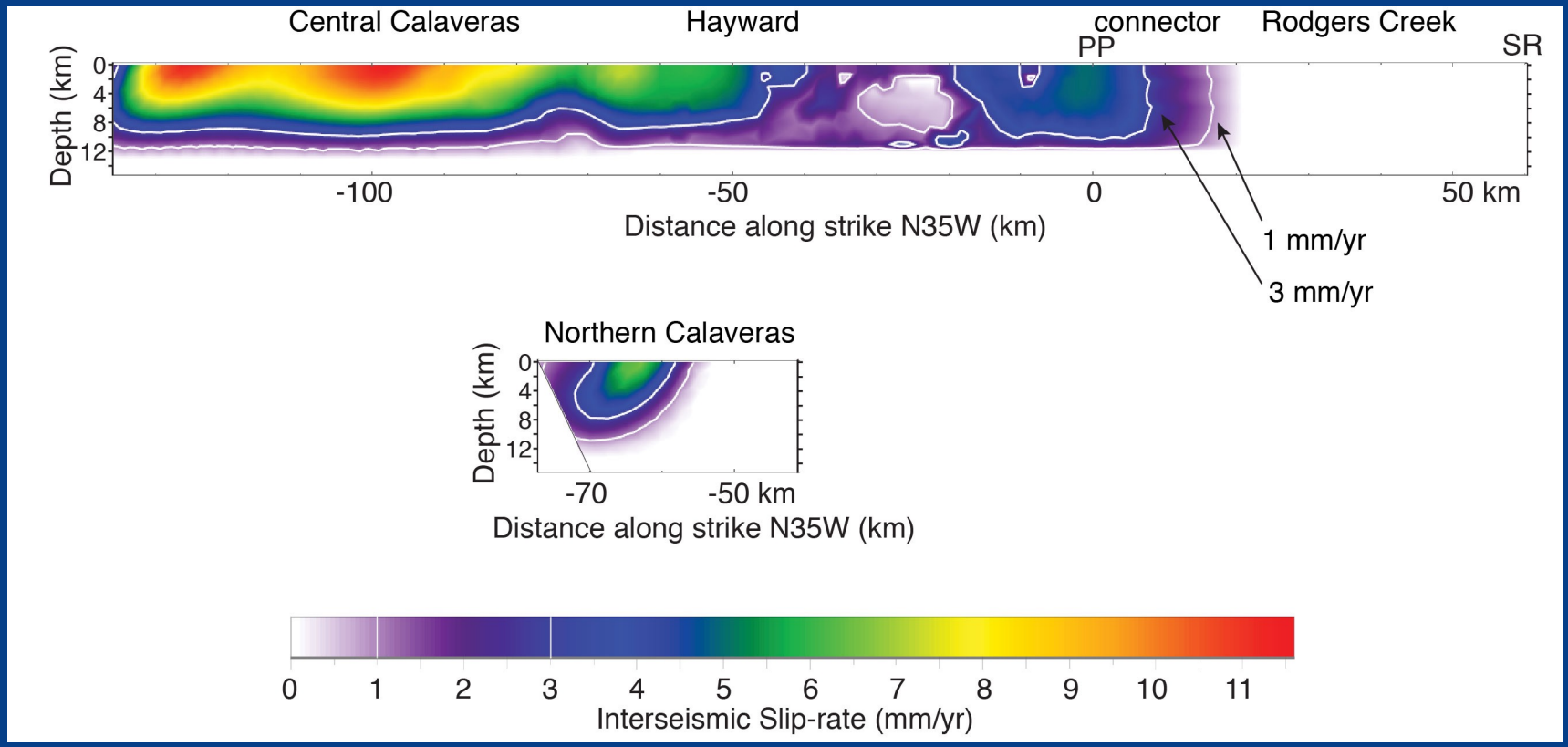
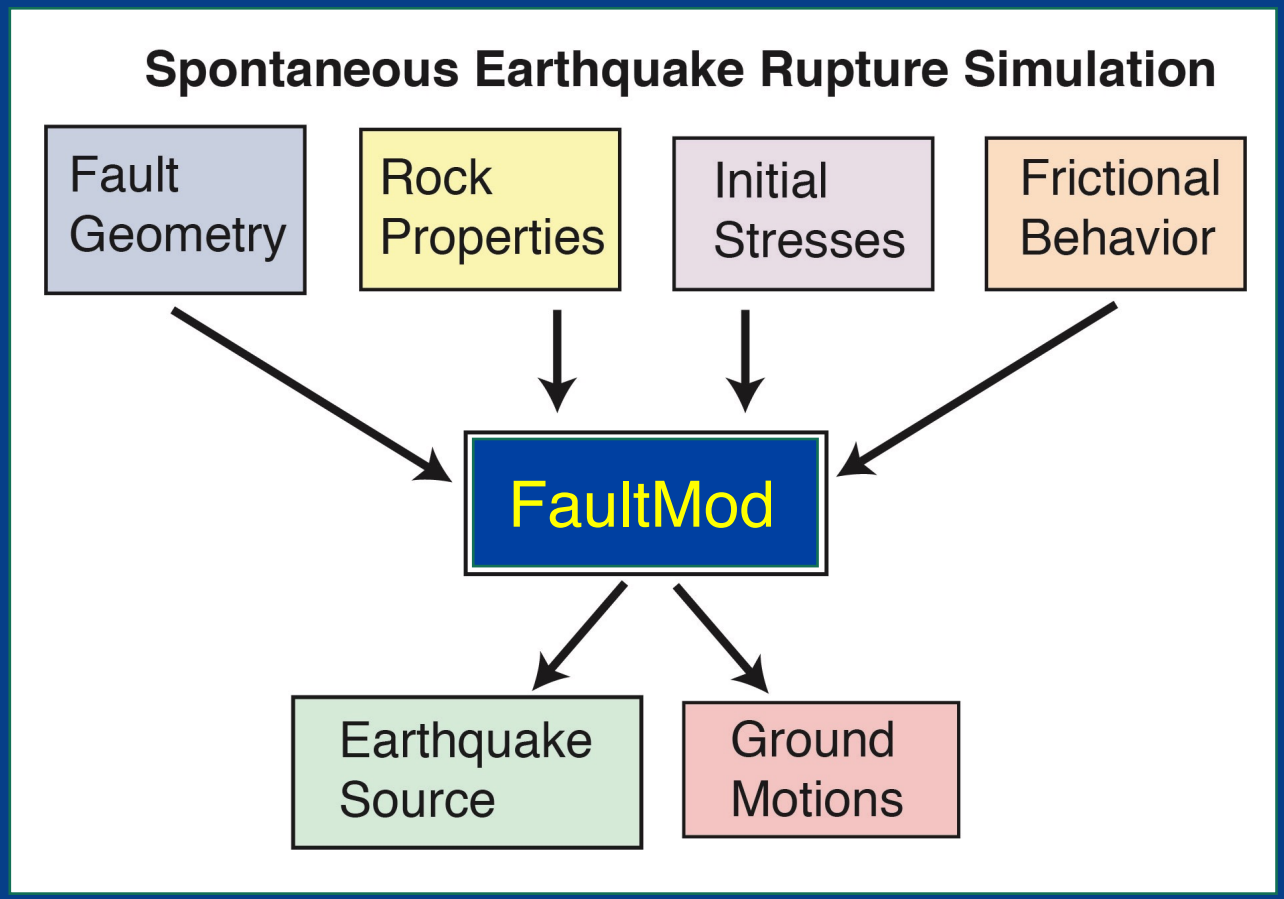


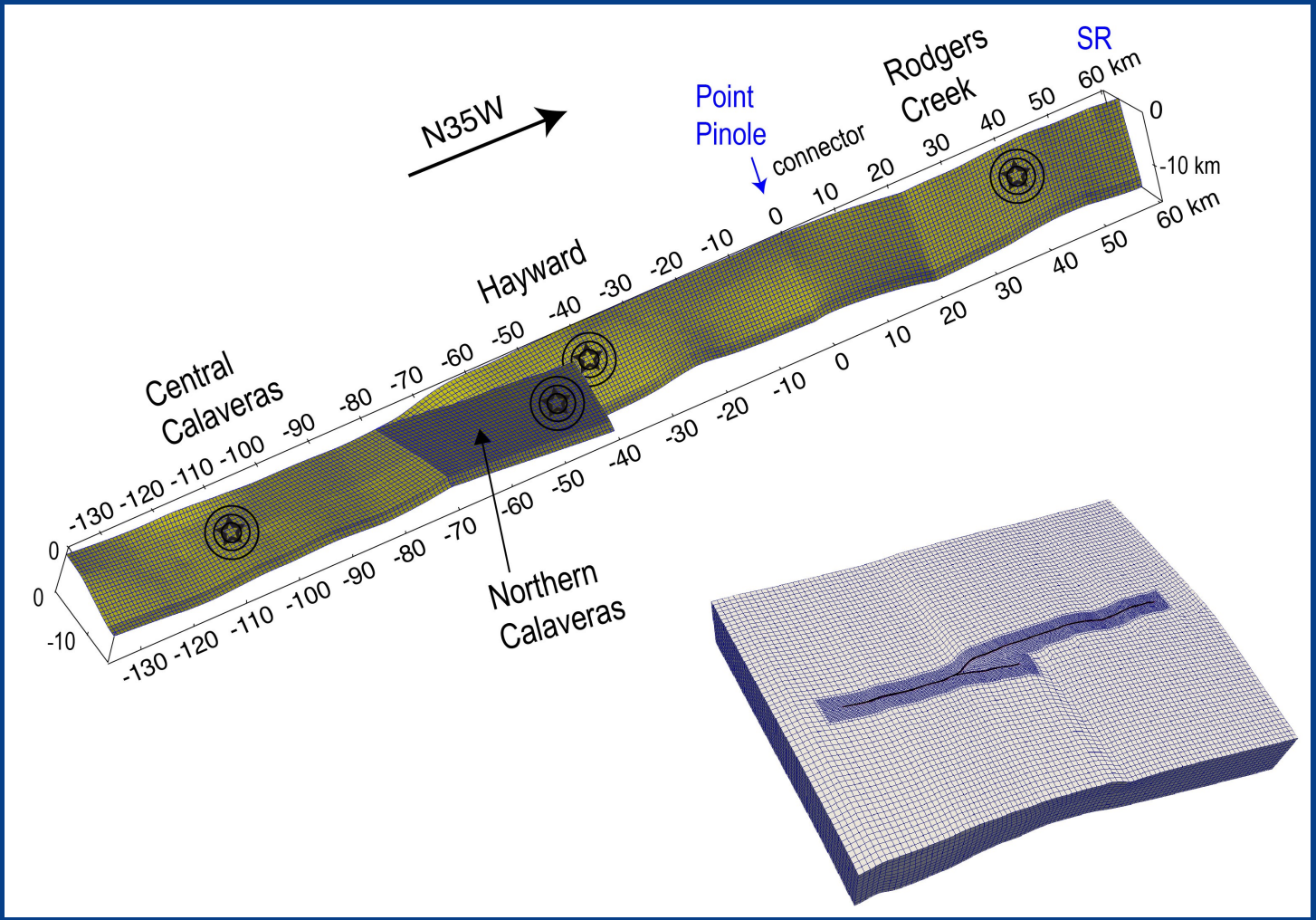
Figure 7 from Harris et al., JGR, 2021


Spontaneous Earthquake Rupture Simulation
Fault Geometry
Rock Properties
Initial Stresses
Frictional Behavior
FaultMod
Earthquake Source
Ground Motions

Results:

Scenario Large Earthquakes

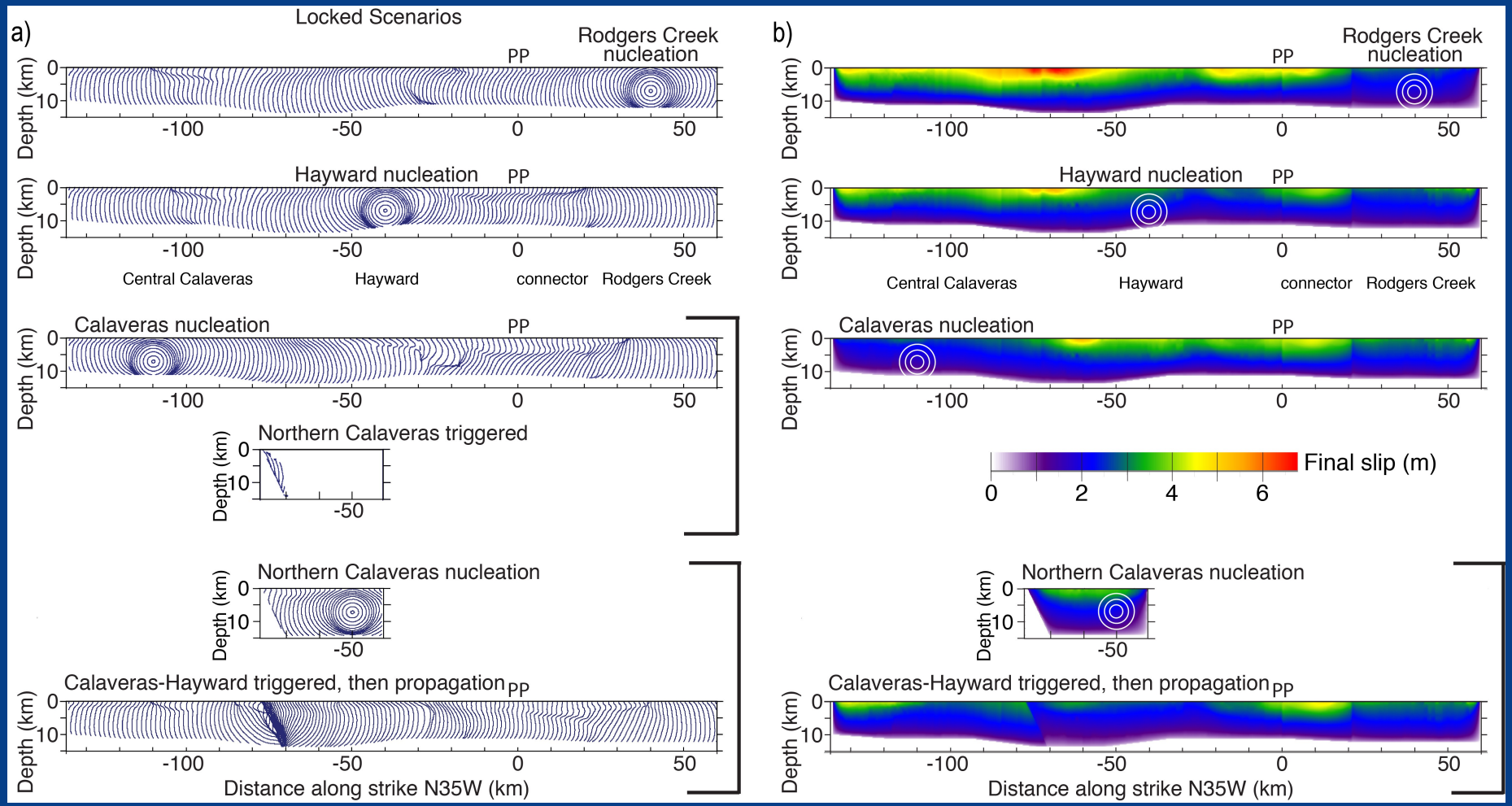
Figure 3 from Harris et al., JGR, 2021



Results: 'Locked' Fault Scenarios (higher initial shear stress)

Rupture Front Contours

Final Slip



Figures 8a, b of Harris et al., JGR, 2021

3 mm/year contour

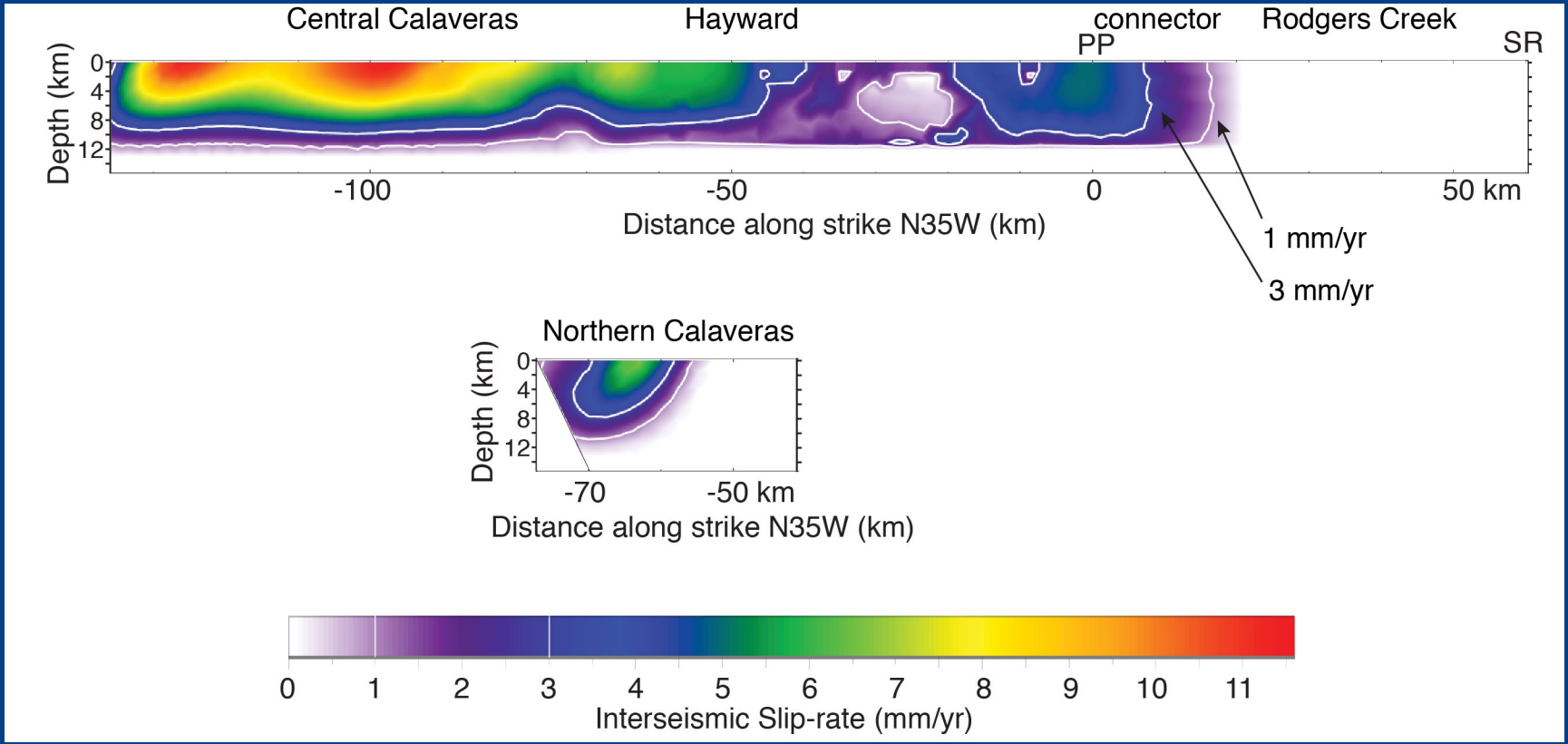
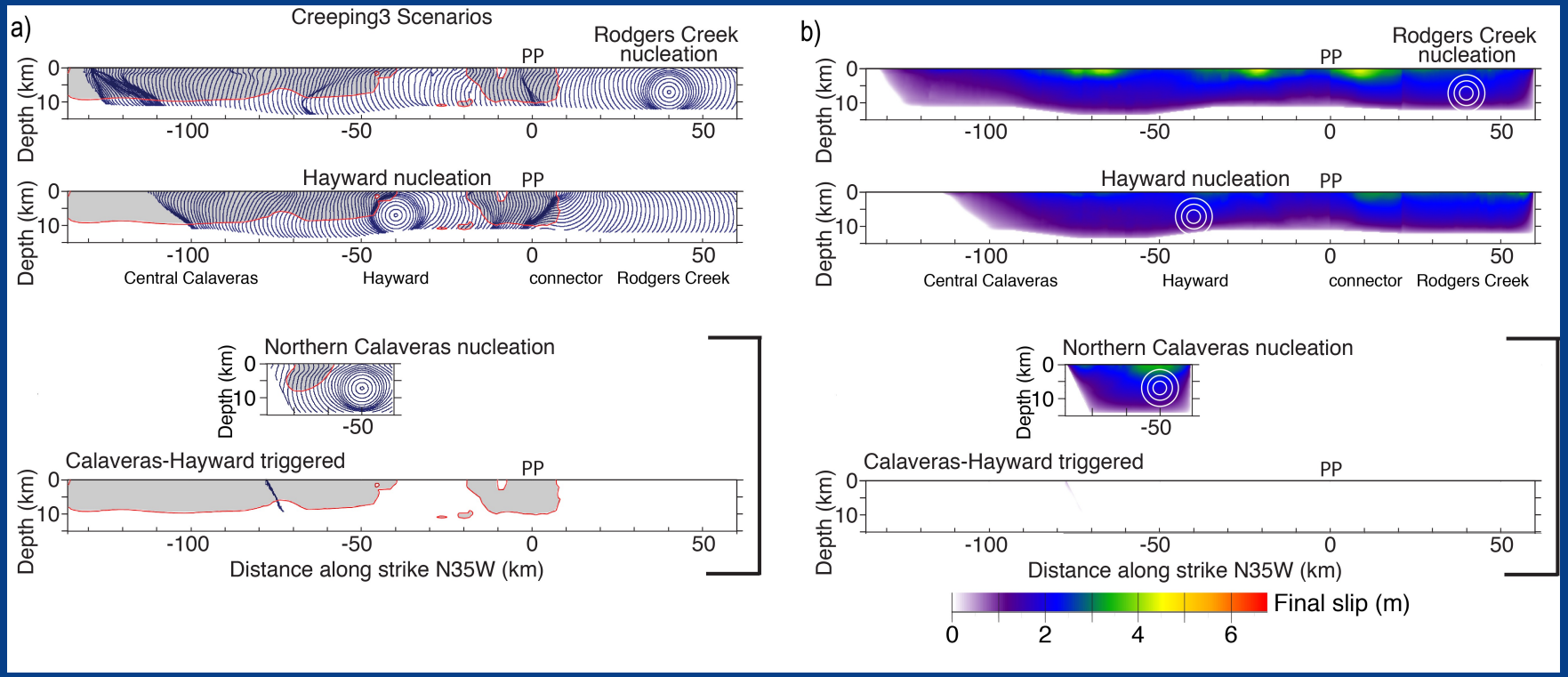


Figure 7 from Harris et al., JGR, 2021

Results: Creeping fault scenarios 3 mm/yr (lower initial shear stress)

Rupture Front Contours

Final Slip



Figures 9a, b of Harris et al., JGR, 2021

1 mm/year contour

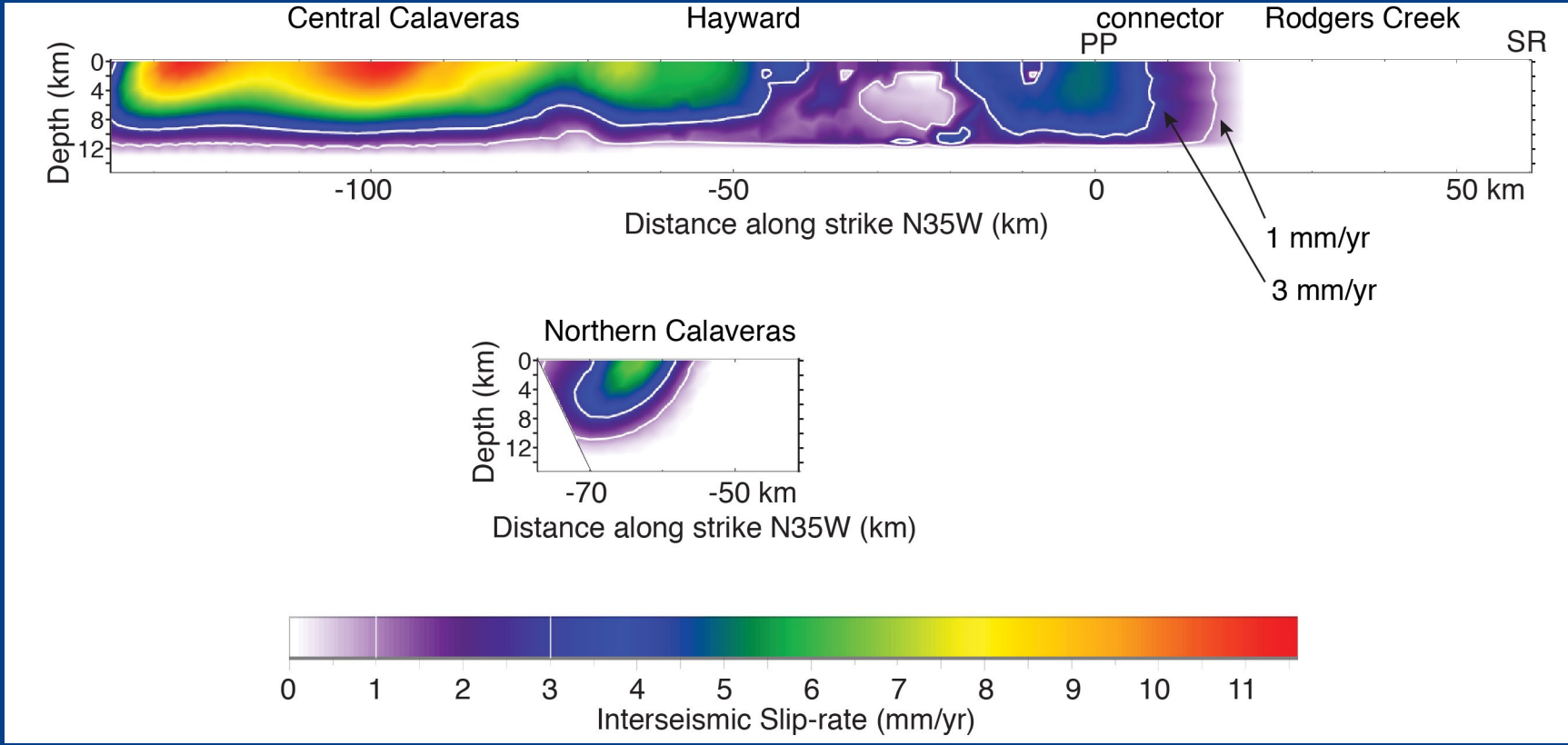
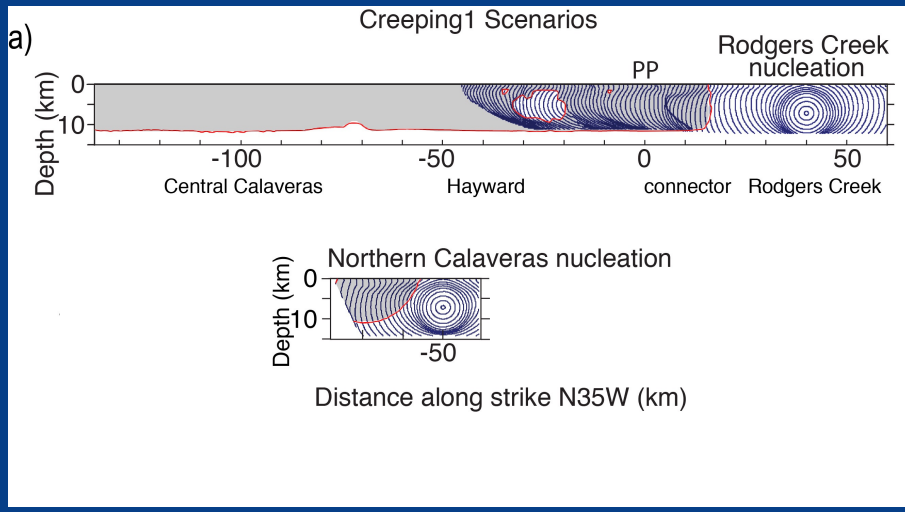


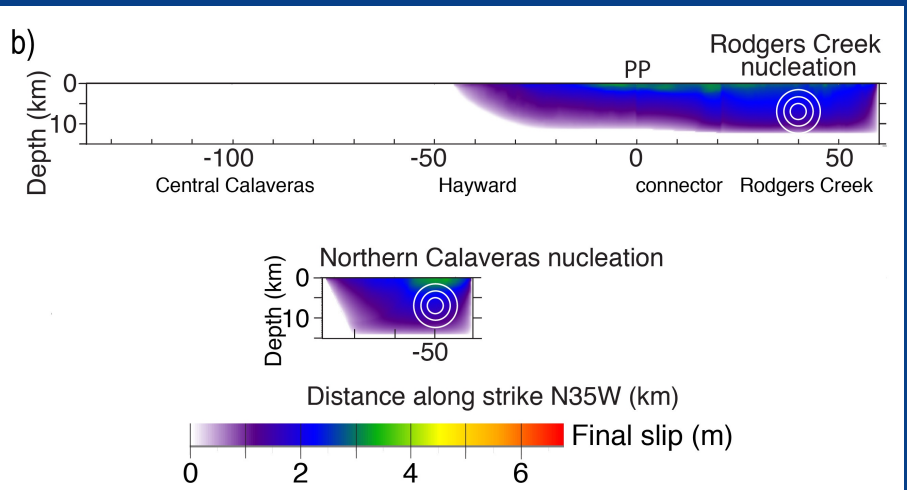
Figure 7 from Harris et al., JGR, 2021

Results: Creeping fault scenarios 1 mm/yr (lower initial shear stress)

Rupture Front Contours

Final Slip





Figures 10a, b of Harris et al., JGR, 2021

Summary (Part 1)

We used the spontaneous (dynamic) rupture method to simulate large earthquakes on the Rodgers Creek – Hayward – Calaveras – Northern Calaveras fault system.

We produced large simulated earthquakes that are stopped by the creeping sections and those that are not stopped, with magnitudes ranging from M6.7 to M7.4.

The most important factors were the nucleation site, the fault geometry, and the pattern of fault creep.

Please see our new published paper: Harris et al., JGR, 2021

But what about the effect of the rock properties structure?

We did look at this.

Please see Figure 12 and related text in our JGR 2021 paper,

and,

the next slide.

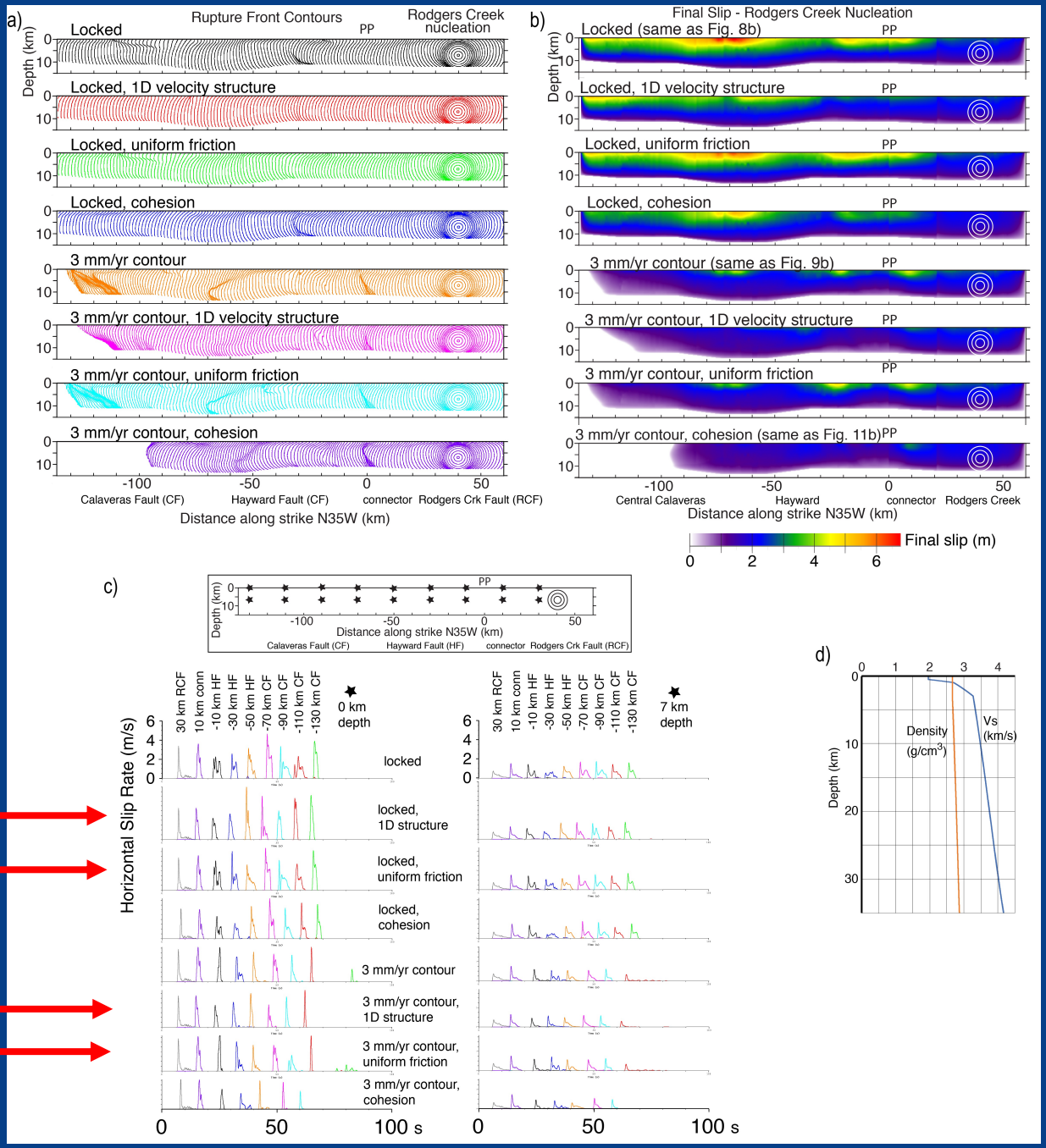


Figure 12 of Harris et al., JGR, 2021

1D structure KJf_N

Acknowledgments

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For More Information:

Harris, R.A., M. Barall, D.A. Lockner, D.E. Moore, D.A. Ponce, R.W. Graymer, G. Funning, C.A. Morrow, C. Kyriakopoulos, & D. Eberhart-Phillips (2021),

A Geology and Geodesy Based Model of Dynamic Earthquake Rupture on the Rodgers Creek-Hayward-Calaveras Fault System, California,

Journal of Geophysical Research: Solid Earth, 126, e2020JB020577.

https://doi.org/10.1029/2020JB020577