Fault zone evolution along complex plate boundaries: A case study from the Eastern California shear zone

George Pharris[1]; John Naliboff[2]; Veronica Prush[3]
New Mexico Institute of Mining and Technology
[1]george.pharris@student.nmt.edu, [2]john.naliboff@nmt.edu, [3]veronica.prush@nmt.edu

Background & Study Area

The northern Eastern California shear zone (ECSZ) accommodates ~25% of relative Pacific-North America plate motion.

In the ECSZ, dextral shear is accommodated by four fault zones (**Fig. 1**): Northern Death Valley-Furnace Creek (NDVF), Fish Lake Valley (FLV), White Mountains (WMF), and Owens Valley (OVF; Lee et al, 2006).

A northward slip rate decay has been documented in the northern ECSZ (e.g., Frankel et al., 2011).

We seek to model slip decay in the ECSZ using ASPECT modeling to interrogate positive causes of slip loss. We focus on slip transfer from eastern faults (DVFC/FLV) to western structures (WMOV).

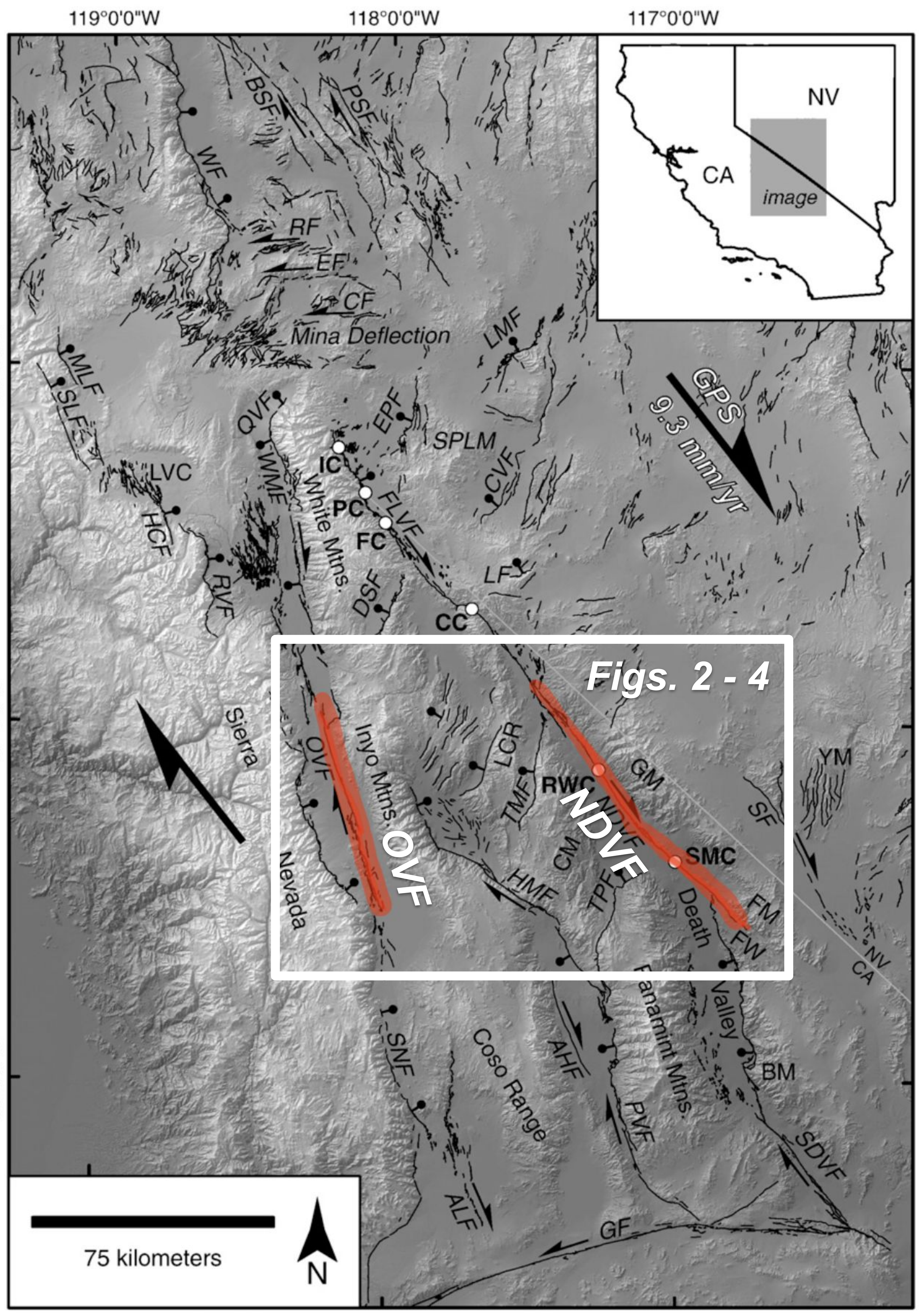

Figure 1: Map of the ECSZ study area (Frankel et al., 2011). The modeled faults are highlighted in red. White box indicates this study area.

Forward Modeling of Fault Slip Rates

The Southern California Earthquake Center (SCEC) Community Fault Model (CFM) includes 3D triangular representations of all southern California faults, including fault trace and data on average strike, dip, and fault plane area.

We use fault trace data and average dip to create a 3D model of selected faults within the Geodynamic World Builder (GWB) software package (Fraters et al., 2019).

The GWB fault representation is used as an initial condition in models of instantaneous, boundary-driven deformation run with the mantle convection and lithospheric dynamics code ASPECT (Heister et al., 2017; Naliboff et al., 2020)

Faults (2 km wide) are embedded in a visco-plastic model and have reduced friction angle and cohesion to localize deformation.

The model of the OVF and NDVF span 200x125x20 km. We apply a right-lateral velocity of 10 mm/yr.

For additional details, please contact us via email!

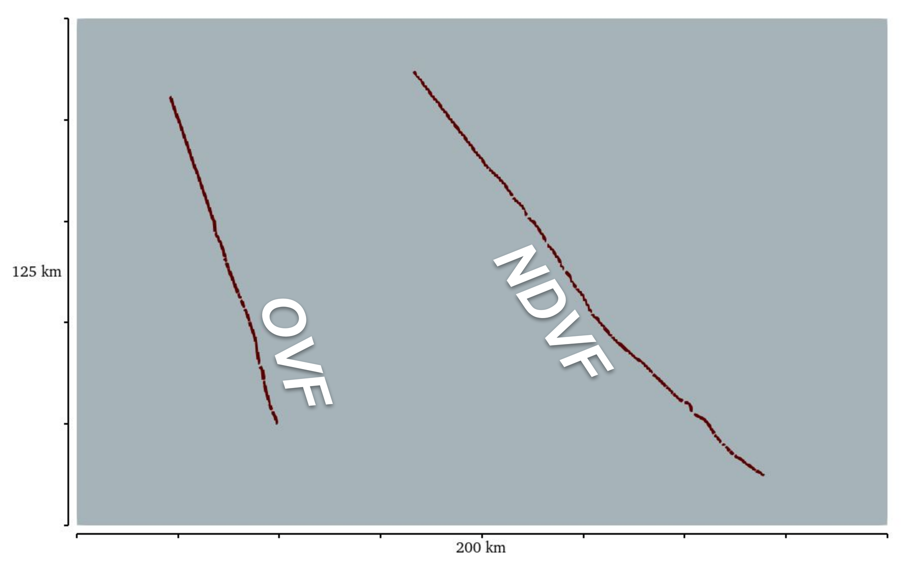

Figure 2: Surficial geometry (map view) of the OVF (left) and the NDVF (right) as modeled in ASPECT.

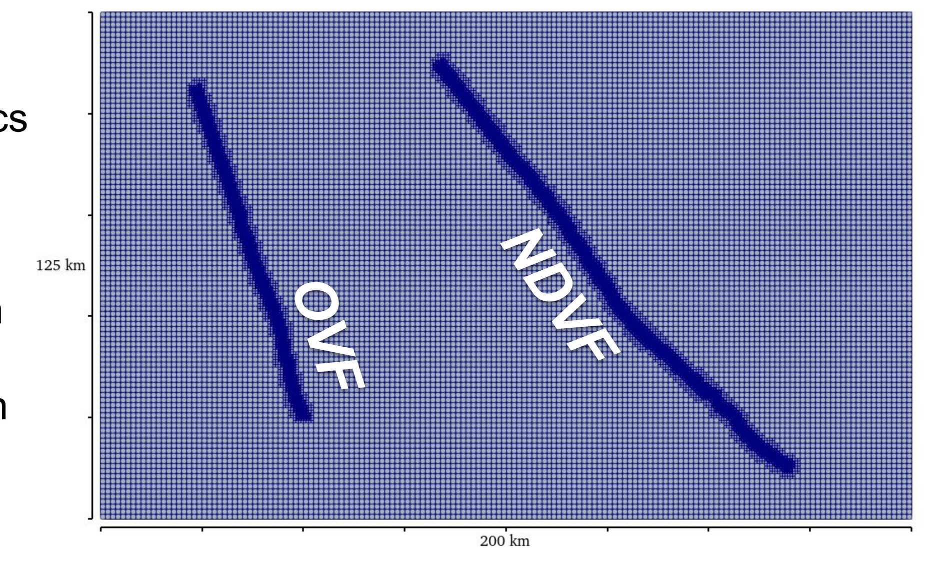

Figure 3: Surface mesh view, with areas of refinement near and within fault zones. The maximum resolution is ~312.5 meters.

Modeled Fault Slip Rate Distributions

- **The OVF slip rate is significantly higher than that of the NDVF due to its more optimal alignment with the imposed strike-slip boundary conditions.**
- Consistent with observations, the NDVF undergoes a decrease in slip rate from south to north as slip is transferred onto the OVF.

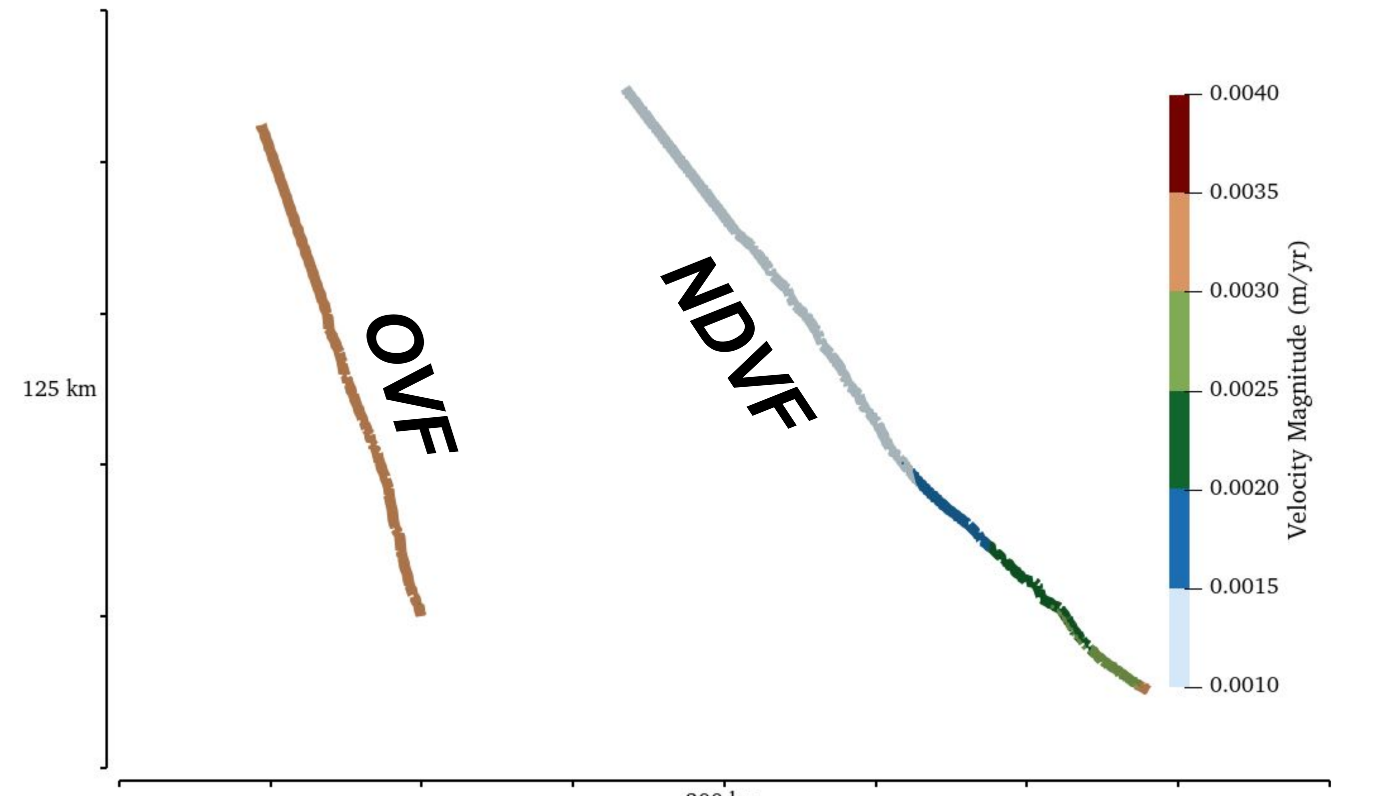

Figure 4: Magnitude of slip velocity across both faults in meters/year.

Potential future use of ASPECT in Southern California: San Andreas Big Bend

Given the success of ASPECT modeling for reproducing slip decay along targets in the ECSZ, we anticipate similar success may be had on larger, more complex regions. **Future work will focus on modeling the "Big Bend" of the San Andreas fault.**

Due to the Big Bend's complex geometry, partitioning of deformation amongst both mapped and unmapped faults, and deformation in the deeper ductile regime, many aspects of the Big Bend remain only partially constrained.

We've created a preliminary conceptual model of the bend using its surface trace geometry. For now, we disregard along-strike dip variations.

Our current ASPECT model demonstrates a variable slip velocity magnitude (**Fig. 5**), with higher values on the edges of the bend and lower values concentrated in the middle of the bend, as predicted given its geometry.

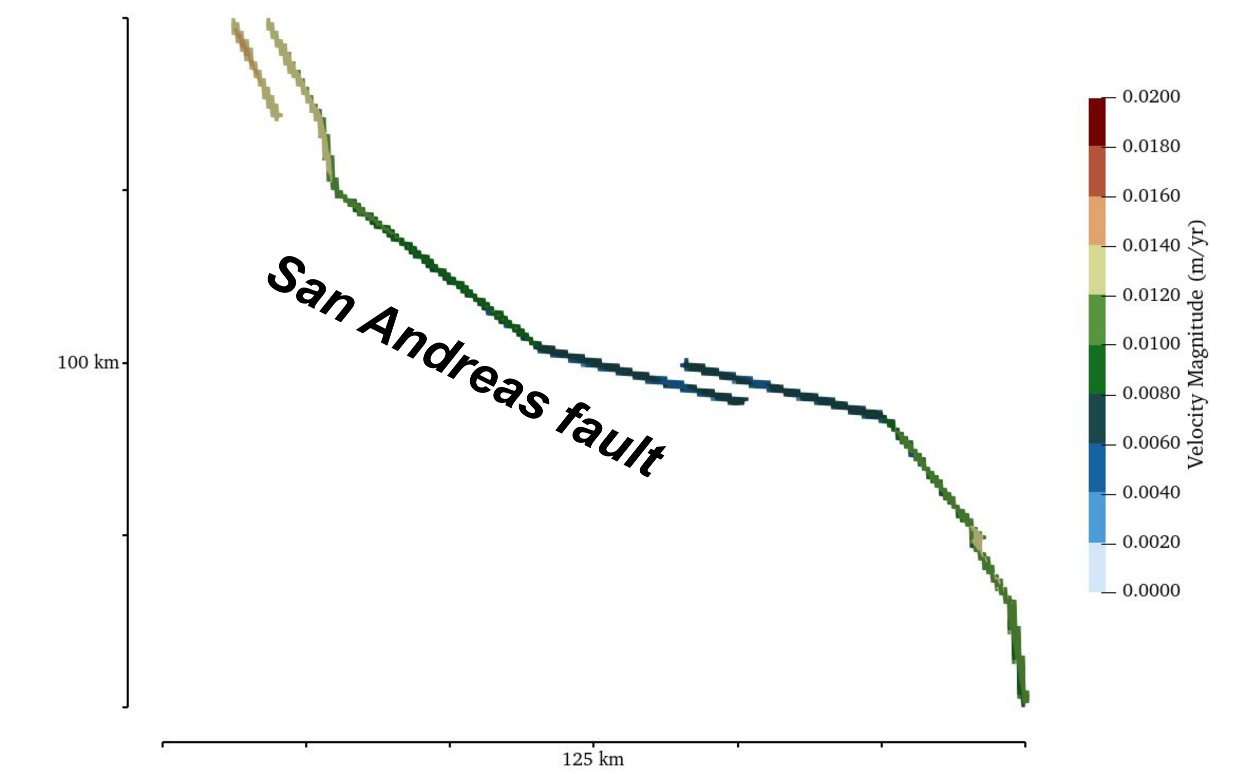

Figure 5: Slip velocity across a conceptualized model of the San Andreas Big Bend.

Summary & Conclusions

- We use the SCEC CFM, Geodynamic World Builder, and ASPECT to investigate how active deformation is distributed among faults within the ECSZ and the Big Bend of the San Andreas fault.
- Our preliminary results reveal an observed northward slip-rate decrease on the NDVF, reflecting the known slip decay along this fault. Our suggests slip transfer between northern ECSZ is significant here.
- Future work will include: adding further complexity to the ECSZ simulations, including additional fault strands to the North, a conductive geothermal profile, and variations in crustal structure.
- We will also explore (1) the role of fault strength and width on long-term slip rates and (2) ECSZ interactions with the Garlock and San Andreas fault systems.

References

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