Updated mapping of active fault traces along the Calaveras Fault from high resolution 3DEP topography

Celina Driver[1,2]; Madeline Schwarz[3]; Malinda Zuckerman[3]; J Ramon Arrowsmith[3]; Chelsea Scott[3]; Austin Elliott[4]

[1]Oregon State University, [2]Statewide California Earthquake Center, [3]Arizona State University, [4]U.S. Geological Survey

Introduction

The Calaveras Fault (CF) is a source of seismic hazard for the southern San Francisco Bay Area, exhibiting active distributed faulting that includes both aseismic creep and the potential for moderate to large earthquakes. Previous fault maps have provided foundational insights but lacked precision. With the recent acquisition of high resolution topographic data, we can now refine these maps. The updated fault traces leverage the enhanced topographic detail to improve our understanding of the fault's structure and behavior, ultimately leading to more accurate seismic hazard evaluations for the region.

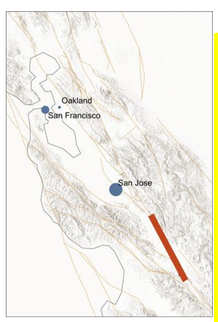
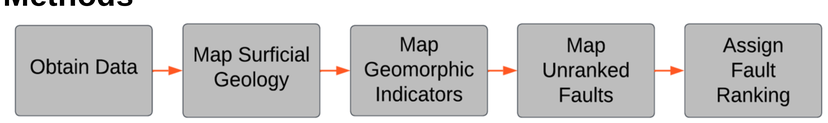


Figure 1: Location of study area

Methods



We used a systematic, geomorphology-based approach to desktop fault mapping.
Satellite imagery from Sentinel-2 and existing geological maps were referenced in addition to lidar-derived topographic derivative layers. We used available high resolution 1m topography from the USGS. We compared line work from QFaults and Dibblee geological maps.

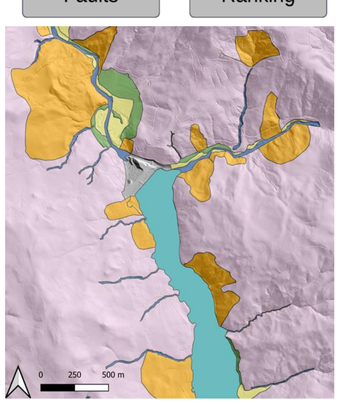


Figure 2: Surficial geologic mapping.

Results

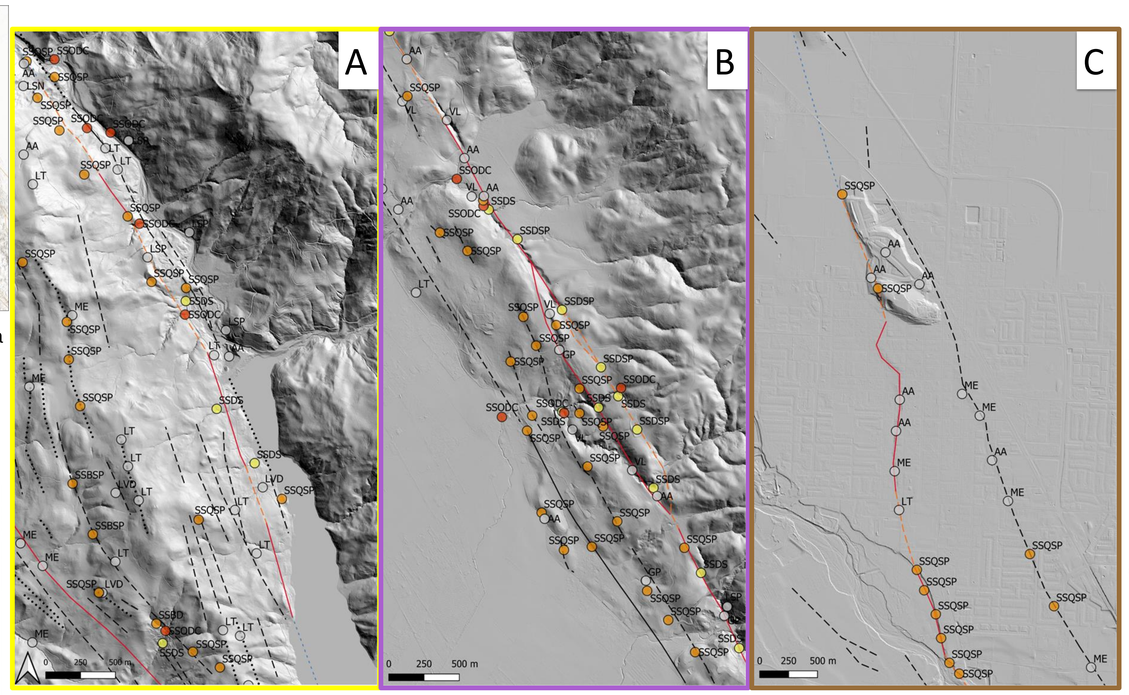


Figure 3: Map of the study area showing ranked mapped faults and geomorphic indicators. (A) Northwest of Coyote Lake, (B) a complex section east of Gilroy, and (C) fault through Hollister.

The fault zone exhibits high geometric complexity. (A) Landsliding and fluvial modification (Figure 2) makes it difficult to identity exact fault location and whether or not linear features are tectonic in origin. (B) The primary fault splits into two strands. More obvious scarps and deflected streams on the western strand result in a higher confidence ranking. (C) Here, the primary fault has high confidence due to strong tectonic indicators along the pressure ridge and river channel. The secondary strand has fewer and weaker indicators, thus its confidence ranking is low.

Fault Rankings
- Strong & Primary
- Distinct & Primary
- Weak & Primary
- Uncertain & Primary
- Strong & Secondary
- Distinct & Secondary
- Weak & Secondary
- Uncertain & Secondary

Surficial Geology
- Qy - Young Quaternary Alluvium
- Qi - Intermediate Quaternary Alluvium
- Qo - Older Quaternary Alluvium
- Qls - Quaternary Landslides
- Br - Bedrock
- L - Lake

Indicator Points
- SSODC - Strike-Slip Offset Drainage Channel
- SSQSP - Strike-Slip Quaternary Scarp
- SSBD - Strike-Slip Beheaded Drainage
- SSDS - Strike-Slip Deflected Stream
- SSDSP - Strike-Slip Depression/Sag Pond
- SSBN - Strike-Slip Bench
- ALMT - Alignment
- AA - Anthropogenic Alteration
- GP - General Pond
- LSN - Landslide (Negative)
- LSP - Landslide (Positive)
- LT - Lineation in Topography
- LVD - Linear Valley/Drainage
- ME - Morphologic Element
- VL - Vegetation Lineament

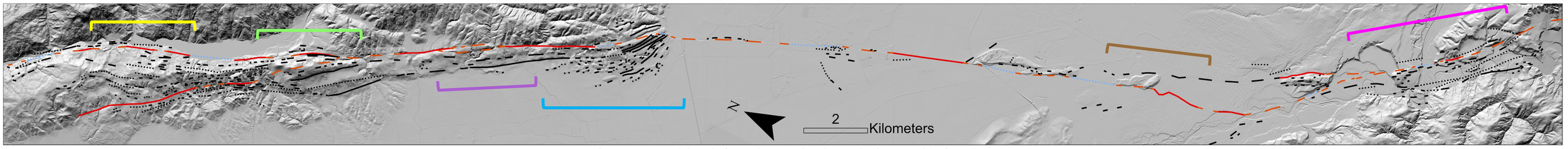


Figure 4: Map of the whole study area showing ranked mapped faults.

Discussion

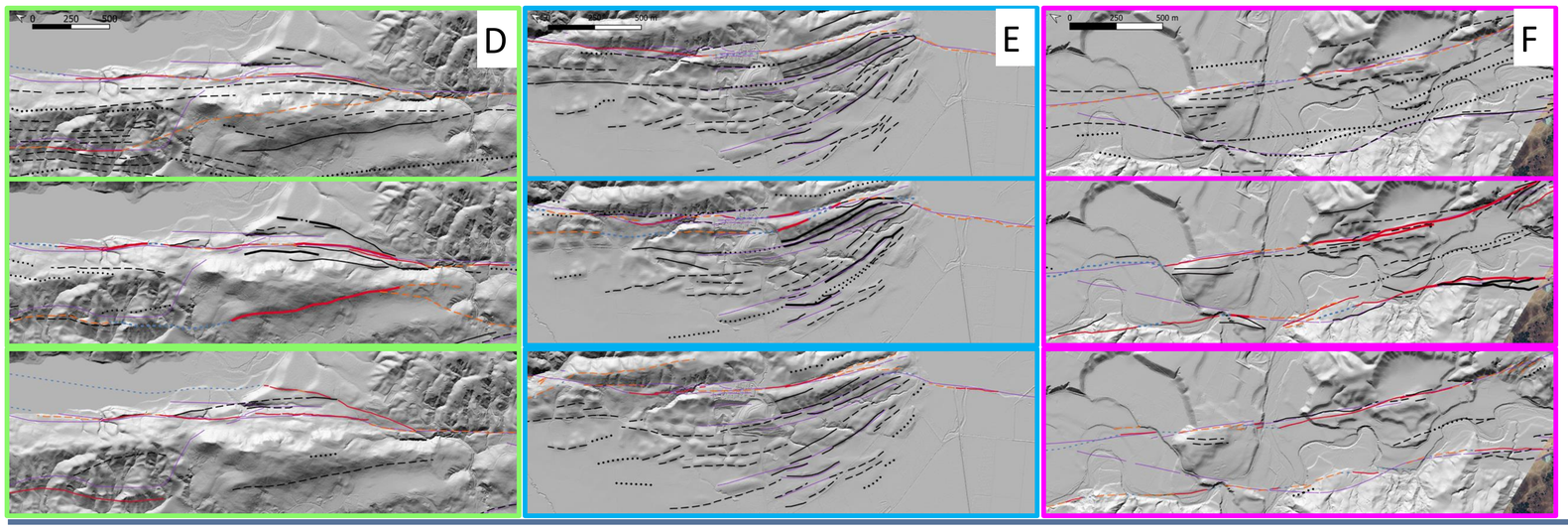


Figure 5: Compared line work showing the difference in experience. QFaults in purple. (Top row) Senior undergraduate, (Middle and bottom row) Graduate student. (D) Lower Coyote lake, (E) Landfill (F) Lower Hollister

Conclusion

We completed two 50 km maps of the Calaveras fault zone from Coyote Lake to Paicines, CA. Results from applying our geomorphic mapping approach demonstrate that mapping styles vary with geomorphic interpretation. Our resulting maps show greater fault discontinuity and geometric complexity along the fault zone compared to fault traces linework from QFaults and existing geological maps. These updated maps may provide valuable resources for earthquake geology researchers and professionals, aiding in fault displacement hazard analysis and the study of landscape evolution in this active fault zone.

References

Adam, R., 2023, Evaluation of remote mapping of active fault traces [Master's thesis]: Arizona State University, 60p.

Scott, C., Adam, R., Arrowsmith, R., Ma dugo, C., Powell, J., Ford, J., Gray, B., Koehler, R., Thompson, S., Sarmiento, A., Dawson, T., Kottke, A., Young, E., Williams, A., Kozaci, O., Oskin, M., Burgette, R., Streig, A., Seitz, G., Page, W., Badin, C., Carnes, L., Giblin, J., McNeil, J., Graham, J., Chupik, D., and Ingersoll, S., 2023, Evaluating how well active fault mapping predicts earthquake surface-rupture loca tions: Geosphere, v. 19, no. 4, p. 1128–1156, https:// doi.org/10.1130/GES02611.1.

Dibblee, T.W. and Minch, J.A., 2005, Geologic map of the Gilroy quadrangle, Santa Clara County, California, Dibblee Geological Foundation, Dibblee Foundation Map DF-169, 1:24,000

U.S. Geological Survey (2021). United States Geological Survey 3D Elevation Program 1 meter Digital Elevation Model. Distributed by OpenTopography. https://urldefense.com/v3/__https://doi.org/10.5069/G98K778D__;!!IKRxdwAv5BmarQ!Y08nqAX77EJ3dym366ngPN-kPlyWyFFZYc7YFUYmSyrERNlH8sSn515K0l3cyNIS-oD2ddPaxCPShBVU4UTLN9M$. Accessed: 2024-06-24

U.S. Geological Survey and California Geological Survey, Quaternary fault and fold database for the United States, accessed June 24, 2024, at: https://www.usgs.gov/natural-hazards/earthquake-hazards/faults.

Acknowledgements

This project is supported by the Statewide California Earthquake Center under the SURE Internship program.

Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government