Active Faulting in the Klamath Mountains Revealed by Lidar Data

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Introduction

The Klamath Mountains province (KMP) in Northern California is bounded by geodynamic forces that should lead to active deformation, and thus, active faulting in the region. Despite geodetic evidence for such deformation, mapped active faults in the region are absent. Due to this, the KMP has been treated as a rigid block (McCaffrey et al., 2013; Unruh and Humphrey, 2017; McKenzie et al., 2022; Furlong et al., 2024). However, the likely rheology of the KMP indicates that it should not behave rigidly, and based on the deformation that should be here, I hypothesize that the KMP is transected by active faults that deform the region in response to the forces acting on its margins. These active faults have gone unnoticed until now because the region is elevated, eroding, and densely forested. Recent lidar surveys reveal at least four previously unrecognized faults in the KMP. I propose to document the slip rate of one such fault to characterize the non-rigid behavior of this region.

Methods

- Use **lidar** data to remotely **map active faults** within the Klamath Mountains province.
- Conduct field work to verify remote findings and map adjacent Quaternary deposits.
- Define and Prepare sites for future IRSL geochronology.

Tectonic Setting

- The Sierran block is moving **~4-5 mm/yr northwest** relative to the Oregon Coast block (Unruh and Humphrey, 2017; Hammond and Thatcher, 2005; McKenzie et al. 2022).
- This deformation must be accommodated across the relatively weaker crust of the KMP.

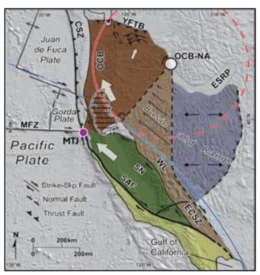

Figure 1. Active tectonic features of the broader plate boundary system, modified from Unruh and Humphrey (2017). KMP outlined in black. Sierran block (SN) rotates counterclockwise toward the MTJ; trajectory denoted by blue line. Oregon Coast block (OCB) rotates clockwise; trajectory denoted by red line. Walker Lane (WL) shear deformation diminishes northward as it is absorbed by Basin and Range extension. The remainder of this shear deformation is accommodated across the KMP.

New Faults

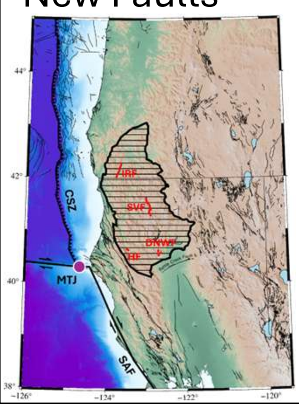

Figure 2. Mapped faults around the KMP from USGS Quaternary Faults and Folds database. KMP outlined in black. Note lack of known faults in the region.

Red lines denote new active faults found in the KMP thus far:

IRF: Illinois River Valley reverse fault (Kirby, 2023).

SVF: Scott Valley normal fault (Fig. 3).

HF: Hyampom dextral fault (Fig. 4).

DNWF: Dau Nom Wintu reverse fault.

Scott Valley Normal Fault

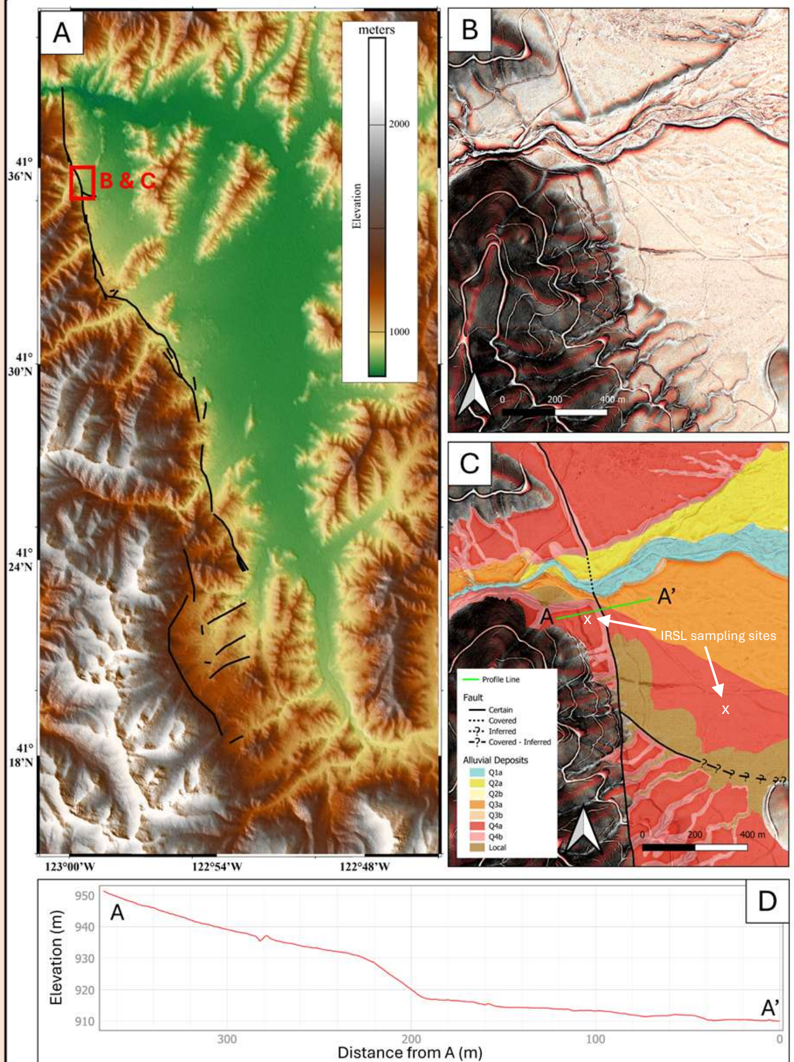

Figure 3.

A. Hillshaded topographic map of Scott Valley bounded on its west side by the Scott Valley normal fault. Note mountainous topography surrounded by alluvium in fault hangingwall.

B. Red relief map with slope shade highlights scarp of the Scott Valley normal fault at outlet of Shackleford Creek. Displaced terraces, at center, provide a target for age dating and determination of slip-rate.

C. Surficial map of alluvial deposits at outlet of Shackleford Creek. Deposits are categorized by age and young from Q4 to Q1. Units labeled "a" denote relict depositional surfaces (darker), while units labeled "b" denote fan deposits (lighter). Other alluvial deposits noted "Local". Unpatterned areas are bedrock. Sampling sites for future IRSL geochronology noted; terrace deposits uncovered by holes dug at these sites confirm that deposits are of the same age.

D. Terrain profile across the scarp of the Scott Valley normal fault near Shackleford Creek.

Hyampom Fault

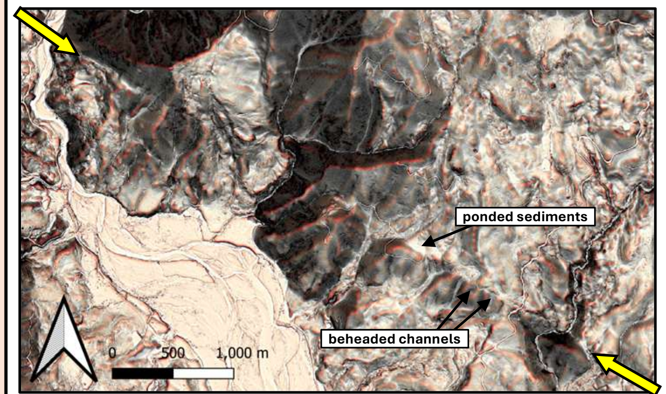

Figure 4. Red relief map with slope shade of Hyampom fault adjacent to south fork of the Trinity River. The dextral fault forms a lineament cutting across the landscape. Deflected and beheaded drainages visible. Alluvial deposits ponded against the fault scarp provide a target for age dating and determination of slip-rate.

Conclusions

- Evidence for **active normal**, **reverse**, and **strike-slip** faulting is observed in the Klamath Mountains.
- This region is accommodating some of the far-field contraction observed between the Sierran and Oregon Coast blocks.
- Faulting observed in the Klamath Mountains provide evidence the KMP acts as a rheologically weak, diffuse boundary zone accommodating varying styles of deformation due to the boundary conditions on its margins

Future Work

- Conduct further field work to verify remote observations and map Quaternary deposits.
- Apply single-grain feldspar **IRSL geochronology** to constrain the slip rate of the Scott Valley normal fault and test its contribution to regional strain accommodation between the Sierran and Oregon Coast blocks.

References

Furlong, K.P., Villaseñor, A., Benz, H.M., McKenzie, K.A., 2024. Formation and Evolution of the Pacific-North American (San Andreas) Plate Boundary: Constraints From the Crustal Architecture of Northern California. Tectonics 43, e2023TC007963. https://doi.org/10.1029/2023TC007963

Hammond, W.C., Thatcher, W., 2005. Northwest Basin and Range tectonic deformation observed with the Global Positioning System, 1999–2003. J. Geophys. Res. 110, 2005JB003678. https://doi.org/10.1029/2005JB003678

Kirby, E., von Dassow, W., Mahan, S., 2023, Active shortening and differential uplift across the southern Cascadia forearc: Geomorphic evidence for Pleistocene displacement along the Illinois River fault, in: Abstracts with Programs. Presented at the Cordilleran Section Meeting, Geological Society of America, Reno, NV. https://doi.org/10.1130/abs/2023CD-387169

McCaffrey, R., King, R.W., Payne, S.J., Lancaster, M., 2013. Active tectonics of northwestern U.S. inferred from GPS-derived surface velocities. JGR Solid Earth 118, 709–723. https://doi.org/10.1029/2012JB009473

McKenzie, K.A., Furlong, K.P., Herman, M.W., 2022. Regional and Local Patterns of Upper-Plate Deformation in Cascadia: The Importance of the Down-Dip Extent of Locking Relative to Upper-Plate Strength Contrasts. Tectonics 41. https://doi.org/10.1029/2021TC007062

Unruh, J., Humphrey, J., 2017. Seismogenic deformation between the Sierran microplate and Oregon Coast block, California, USA. Geology 45, 415–418. https://doi.org/10.1130/G38696.1

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

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