

2026 NORCAT Workshop Technical Report

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Objectives

The Mendocino Triple Junction (MTJ) is where the southern boundary of the Cascadia subduction zone undergoes a transition into the transform plate boundary of the San Andreas Fault system during its northward migration (Fig. 1). This region is critically important for seismic and tsunami hazard along the western North America plate boundary, structurally highly complex, and remains understudied compared to other sections of Cascadia and the San Andreas system. This workshop's objectives were to convene researchers and public-facing officials to synthesize current knowledge of the MTJ system, to highlight new and emerging datasets in the region, and to identify priority research directions, with an eye toward producing a community white paper, planning follow-on discussions, and coordinating proposals focused on the region. The program combined (1) invited talks on transition region tectonics, geodesy, seismicity, imaging, modeling, and structure, (2) a set of short lightning talks on related ongoing work, and (3) a moderated discussion to identify consensus points, testable models, and priorities for future research.

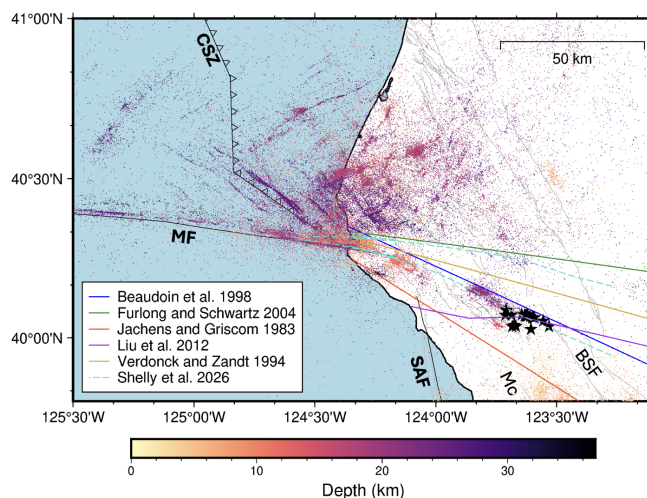


Figure 1: Map of Mendocino triple junction region. Dots are depth-colored seismicity from a machine learning seismicity catalog (Rong et al., 2025). Stars are low frequency earthquakes (Shelly et al., 2026). Colored lines show the southern edge of the subducting Gorda slab from a range of published studies. CSZ-Cascadia subduction zone trench; MF-Mendocino fault; SAF-San Andreas fault; Mc-Maacama fault; BSF-Bartlett Springs fault; plate boundaries with bolded labels from McPherson et al. (2025) and Prentice et al. (1999).

Introduction

The workshop kicked off with a welcome by SCEC director Ahmed Elbanna, who welcomed the participation by people not previously affiliated with SCEC and noted that the MTJ was a possible site for a cutting-edge digital twin earthquake cycle model. Kathryn Materna introduced the goals of the workshop. Jay Patton provided an overview of the tectonics and noted that the region hosts many open questions related to plate configuration, earthquake potential, and fault system interactions, followed by a geodesy overview by Kathryn.

Session 1: Tectonic Evolution

Invited talks traced the tectonic evolution of the MTJ from its initiation to its present three-dimensional configuration. Kevin Furlong framed his models as having progressed through three stages, from early two-dimensional pictures to a current view based on tomographic imaging; building on Atwater's (1970) original model of the Mendocino and Pioneer triple junctions, he traced the slab window opened by passage of the Gorda slab, the anomalously thick North American crust (35-40 km) identified by the offshore-onshore MTJSE seismic experiment, and new 2 km resolution tomography interpreted as showing a captured microplate named the Pioneer fragment (Fig. 2a) together with corridors of differing vertical motions tracking the migrating junction. Doug Wilson used time- and space-varying ages for coastal volcanics (24.5-23.5 Ma) to constrain the historical position of the slab window and showed that the Pioneer fragment underlies the volcanics (Fig. 2b), even if the Pioneer fragment's eastern edge is at the Maacama fault, putting the fragment's geometry in question. Jonathan Delph's new three-dimensional receiver function imaging in southern Cascadia found thick, fluid-rich low velocity layers in the overriding North American plate lower crust beneath the Klamath Mountains, coincident with tremor and elevated topography and broadly analogous to underplating signatures documented beneath the Olympic Mountains. South of the MTJ, a subduction-like dipping reflector is seen, while a low-velocity gap further south may mark a transition between SAF- and subduction-driven processes. Mike Oskin remarked on the conspicuous lack of active known faults in the Klamath Mountains and reported new LiDAR-based mapping identifying the Scott Valley normal fault (slip rate at least 0.7 mm/yr). He argued that Klamath Mountains deformation, despite present-day GNSS-measured E-W compression that would ordinarily suppress normal faulting, reflects underplating-driven episodic extension modulated by the Cascadia megathrust cycle. He further noted candidate extensional signatures near Clear Lake that may instead reflect pull-apart deformation along strike-slip faults. Discussion following these talks addressed why evidence for extension is not preserved south of the MTJ if underplating-driven uplift began before the junction's passage. Oskin noted that intact cover strata in the Coast Ranges suggest comparatively little post-MTJ exhumation there. Fluids in underplating persist at depth long afterward and are attributed to a persistently weak plate interface allowing progressive fluid release from the subducting slab. Collectively, these results establish that the three-dimensional geometry of the MTJ system is complex and debated, and that resolving the geometry and dynamics of the system will require integrating multidisciplinary constraints.

Session 2: Geometry, Seismicity, and Deformation

Several talks presented new seismological results enabled by machine learning methods and dense station networks. Jianhua Gong relocated over 70,000 earthquakes near the MTJ using onshore-offshore data, finding a 5 km offset between the seismicity-derived slab edge and Mendocino-transform seismicity and demonstrating the possibility that local, three-dimensional velocity structure biases earthquake locations. Two independently built machine learning catalogs presented by Ian McBrearty and Bo Rong (Fig. 1) increased the cataloged event count in the region roughly three-fold; Rong's analysis further resolved conjugate faulting within the Gorda-plate mantle and repeating earthquakes implying an average creep rate of about 9 mm/yr along a NW-striking fault. David Shelly noted that tremor and low frequency earthquakes (LFE) occur along plate boundaries and identified 27 (LFE) families near the MTJ (Fig. 1). These were relocated with HypoDD and provided LFE focal mechanisms using tidal modulation and Pacific-

Gorda relative motion. He interpreted the results as evidence for ongoing accretion at the southern edge of the Gorda plate and noted that tremor and LFEs elsewhere in the MTJ region still need to be studied. Taka'aki Taira presented a new finite-fault model of the December 2024 M7 Mendocino fault earthquake, combining seismic and GNSS data to resolve up to 5 m of slip on a western fault segment and 2 m on an eastern segment propagating from shallow to deep depth. His model does not require supershear rupture. Together, these results demonstrate that new machine learning catalogs and dense observational networks substantially improve resolution of MTJ seismicity, LFE and tremor, and recent large-earthquake rupture processes, but also raise new questions even on basic plate configuration. In the following discussion, the need for 3D visualization for seismicity, fault models, tomographic results, and slab geometry was raised and agreed upon.

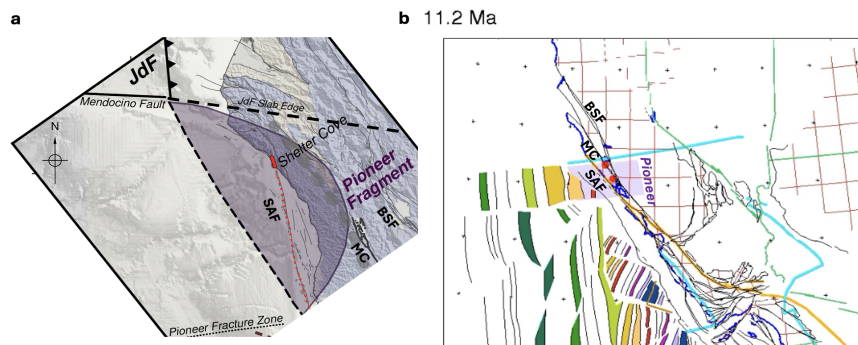


Fig. 2: a) Proposed present-day position of Pioneer fragment (modified from Herman and Furlong, 2025). b) Plate reconstruction with dated volcanics (red dots) that are interpreted as stemming from the passage of a slab window, but reconstruct above the location of the Pioneer fragment at the time (modified from Doug Wilson's NORCAT workshop presentation). Fault labels see Fig. 1.

Lightning talks

A set of lightning talks surveyed complementary ongoing work. Sue Hough presented on inferred shaking in the 1906 SAF event from tree damage, Alice Gabriel for Yohai Magen on rate-and-state friction modeling of interseismic coupling and slow slip events, Amanda Thomas for Brenton Hirao on a new CRESCENT community machine learning catalog for the Cascadia Subduction Zone, Benchun Duan on dynamic earthquake cycle modeling, Noel Jackson on geodetic evidence for dynamically triggered coupling changes on the Gorda subduction interface, Vera Schulte-Pelkum and Debi Kilb on deep shear-fabric evidence from receiver functions near the Pioneer Fragment detachment, and William Marfo on a new CRESCENT catalog-comparison and 3D-visualization viewer.

Session 3: Hazard and Fault System and Interactions

Matt Herman presented evidence for a deep shear zone and shallowly dipping detachment potentially involved in the 1906 earthquake, drawing a comparison to the 2016 Kaikōura, New Zealand earthquake (Fig. 3). Jeff Beeson showed new minisparker, multibeam, and magnetic survey data testing for a continuous offshore San Andreas Fault strand between Point Arena and Shelter Cove, finding near-continuous shallow fault offsets along most of the proposed trace but concluding that no offshore King Range strand is found that connects the SAF to the MTJ, unlike

the representation in popular plate boundary maps; his results exclude its presence except for the unlikely case that the fault happens to be hiding in the shallow surf zone along that entire coastal segment. He also presented turbidite work that suggests partial synchronization of SAF and Cascadia ruptures (Goldfinger et al., 2025). Philip Labra from Cal OES described California's tsunami warning communication system, including the 24/7 State Warning Center, the statewide Earthquake Early Warning system, and the graduated Watch/Advisory/Warning process for remote and local tsunami sources.

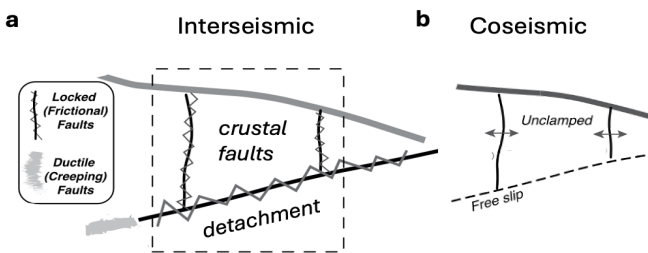


Fig. 3: Schematic of the interaction of crustal faults with a subhorizontal detachment surface, modified from Herman et al., 2023 (based on Kaikoura earthquake). a) Interseismic period. In the MTJ setting, the subhorizontal surface could be the Gorda slab top north of the MTJ or the Pioneer detachment south of it. b) Coseismic behavior. Slip on the detachment can amplify displacement on crustal faults.

Session 4: Discussion

The workshop closed with an hour-long moderated discussion, led by Amanda Thomas, structured around three questions: (1) conclusions considered well supported, (2) disagreements or open questions, and (3) needed actions, observations, or coordinated activities. Those at each table discussed these three questions over lunch and reported their responses, which were then used to structure the discussion and produce summaries listed below.

1. Consensus

- MTJ complexity: The MTJ is critically important for seismic hazard and is structurally complicated, reflecting interactions between three plates as well as the ongoing transition along the western North American margin from a subduction to a transform plate boundary.
- Depth dependence: Structures and seismicity behavior vary significantly with depth, exemplified by seismicity location challenges and short-wavelength variations in seismic velocities across the MTJ region.
- Terrane vs. plate boundaries: A terrane boundary is not necessarily the same as an active plate boundary.
- Data coverage: Many available datasets have low spatial resolution, and the region is underinstrumented.
- Seismic quiescence: The Cascadia Subduction Zone is unusually quiet, making the accuracy of earthquake cycle simulations especially important given the scarcity of large events to calibrate against; the MTJ offers a seismically active constraint.

2. Open Questions and their hazard implications

- a) Three-dimensional tectonic structure: What is the 3D fault structure, seismic velocity structure, and tectonic boundary geometry of Northern California, including the origin of the region's anomalously thick crust, whether the imaged low-velocity feature is a detachment or a slab window, and where the slab edge and slab-top surface lie?
- b) Strain partitioning: How is strain partitioned across the region, including as a depth dependent quantity, and where are the largest sources of slip deficit?
- c) Fault linkage and triggering: How do faults link together and interact? Is there a triggering mechanism connecting the Cascadia Subduction Zone and the San Andreas Fault through the triple junction, extending to minor faults as well, and how does the Eastern California Shear Zone connect back to the CSZ?
- d) Inherited structure and fluids: What is the role of inherited crustal structures and fabrics, and what is the complex role of fluids in fault behavior?
- e) Rupture potential and the detachment: Could the MTJ host Kaikōura-type events (with the Gorda interface in the north and possible Pioneer detachment in the south unpinning crustal faults)? Does the Pioneer detachment exist, and if so, what role does it play, and how far south and east does it extend?
- f) State of stress: What is the state of stress in the region and how can it be measured and constrained in three dimensions?

3. Actions

- a) Shared 3D viewer: Develop a community three-dimensional viewer integrating fault boundaries, seismicity, seismic velocity models, earthquake slip models, and other datasets (e.g., temperature isochrons, velocity contours), with a key open question of whether it should be built as an automated API or a visual, GUI-based tool. Allow associated metadata to be downloaded directly from the viewer.
- b) Onshore fault characterization: Systematically characterize the region's onshore crustal faults (most of which currently lack known recent event history, recurrence intervals, or well resolved geometry) using geophysical imaging.
- c) Seafloor data: Expand seafloor data collection, including geodesy to constrain Gorda plate deformation, high resolution seafloor imaging, ocean bottom seismometer deployments, and offshore seismic surveys, particularly west of the San Andreas Fault.
- d) Joint seismology/geodesy products: Combine seismology and geodesy toward joint focal mechanism and stress inversion products; continue developing more realistic earthquake cycle models.
- e) SCEC-CRESCENT coordination: Strengthen coordination between SCEC and CRESCENT on this region, including via community models (Community Fault Model / Community Velocity Model), earthquake catalogs and data assimilation/visualization (shared cyberinfrastructure), and earthquake and tsunami modeling (dynamic earthquake cycle and tsunami source models). Possible additional mechanisms are a shared benchmark exercise, shared products, a joint topical workshop, joint observing proposals, and a cross-center working group.

Acknowledgments

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