**2025 SCEC Report: Extending the Geologic Framework Model to Northern California**

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**Summary and Motivation:** SCEC5, the final iteration of the *Southern* California Earthquake Center, featured a geologic framework model (GFM, Figure 1) as part of the larger effort to build a community rheology model (CRM, Hearn et al., 2026). The CRM characterizes bulk-rock and fault constitutive laws and their implications for strain localization, fault-zone evolution, the brittle-ductile transition, and coupling of crustal deformation to mantle convection. The ultimate goal of the CRM is to support the mechanical modeling of a plate-boundary deformation zone that is permeated by faults, edge-loaded by rigid plate interiors, and basal-loaded by mantle convection. With the expansion of SCEC *Statewide,* there is an urgent need to extend the geologic framework model to Northern California. This project supported UC Davis Ph.D. student, Sierra Rack, to synthesize the literature and stakeholder input to extend the GFM to northern California. A companion workshop was held at UC Davis in the summer of 2025 to gather community input.

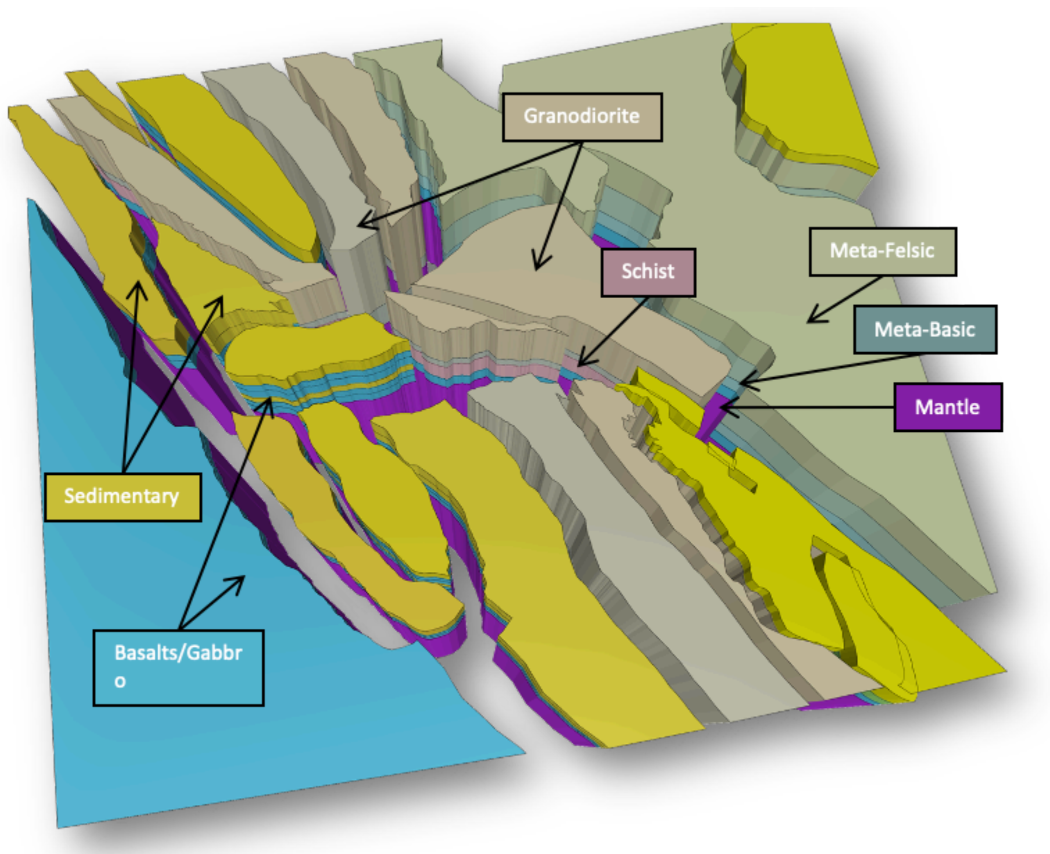


**Figure 1.** Expanded view of the SCEC5 Geologic Framework Model (visualization by L. Montesi). Southern California and adjacent parts of Arizona, Nevada, and Mexico are divided into 23 lithotectonic blocks. Boundaries between blocks formed by faults (active and inactive), rift boundaries, and suture zones. Each block is described by a column of rock types inferred from geologic maps, tectonic history, and deep crustal exposures, if available.

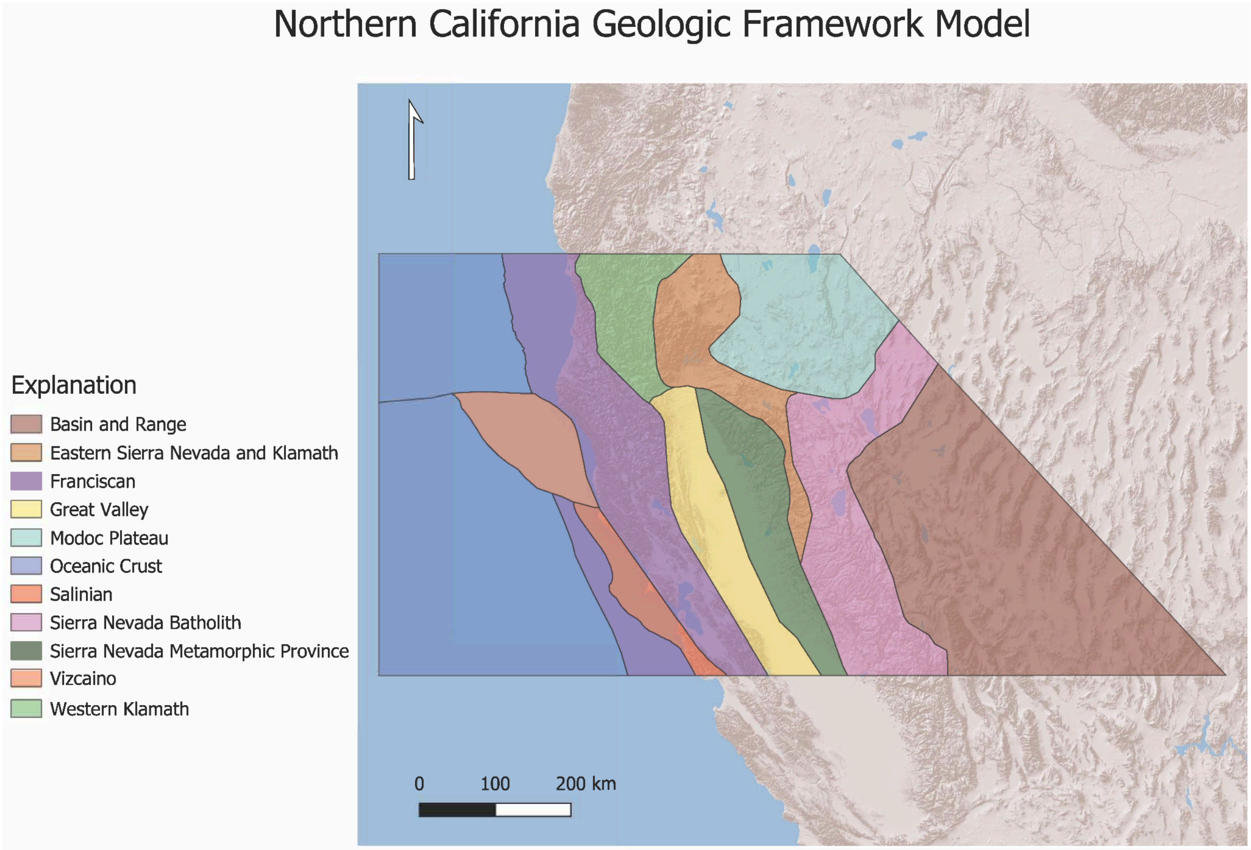


**Figure 2.** Map of lithotectonic provinces of the northern California geologic framework model.

**Project Results:** We extended the SCEC Geologic Framework Model (GFM) statewide (Figure 2) and developed a preliminary set of crustal columns describing appropriate lithologies to represent each lithotectonic block in the model (Table 1). Similar to the original GFM, the northern California model simplifies the complex geology of California by dividing it into lithotectonic blocks and associated lithologic columns. Existing data including geologic maps, geophysical datasets (aeromagnetic, gravity, seismic), and isotopic data were integrated into the GIS-based northern California GFM. Provinces defined in the southern California GFM were extended northward where appropriate, and additional provinces unique to northern California, such as those defining the Klamath Mountains and Modoc Plateau are incorporated. The existing southern California model consists of 23 lithotectonic blocks (Figure 1). The new northern California model extends six of these blocks northward and adds five new blocks (Figure 2). Some work remains to reconcile differences in the model at their shared boundary, reflecting new knowledge gained in the process of extending the GFM northward.

West of the San Andreas fault, three blocks were extended northward: Oceanic crust of the former Farallon plate, the former accretionary prism, and the Salinian block, a granitic and schist terrane separated from the southern Sierra Nevada and Mojave Desert region (Weibe, 1970; Mclaughlin et al., 1996). To these we add the Vizcaino block (McLaughlin et. al 1997, Godfrey et al 1998), a terrane floored by oceanic crust that was added to the Pacific plate by a northward jump of the triple junction early in the evolution of the plate boundary (Atwater, 1989). This event led to the abandonment of the Pioneer microplate, which may include a slab of oceanic lithosphere stranded beneath the northern coast ranges, underneath and east of the San Andreas fault (Furlong et al., 2024) that strongly affects the tectonics of the Mendocino Triple Junction region.

East of the San Andreas fault we extend the Franciscan block, Great Valley and Sierra Nevada batholith northward. These form the accretionary prism-forearc-arc triplet of the former subduction margin of California (Crouch and Suppe, 1993). We adjusted the crustal structure of the Great Valley to reflect information gained from crustal imaging in northern California (Frassetto et al., 2011), and to this we added the western Sierra Nevada metamorphic province, a zone of accretted Mesozoic oceanic crust and melange (Moores and Day, 1984). This belt tapers southward into the southern California GFM, where it becomes overprinted by extensive magmatism of the western Sierra Nevada batholith (Kistler, 1990). East of the Sierra Nevada, we merged the Walker Lane and Basin and Range lithotectonic blocks, reflecting their identical crustal structure in the southern California GFM.

Four new blocks located in the northern part of the state complete the northern California GFM. Because the batholith block curves northeastward into northwest Nevada, the northern Sierra Nevada preserves much more of the metamorphic framework rocks than the central and southern Sierra Nevada. These framework rocks are traditionally divided into three belts (western, central, and eastern; Day et al., 1985). The western and central belt exhibit abundant evidence for the presence of oceanic basement rocks and serpentinized mantle rocks (Moores and Day, 1984) and are combined into a single block in the northern California GFM. The basement of the eastern belt is less clear. Hafnium isotopes of plutons intruded into this belt indicate a more evolved mantle composition than for the central and western belt (Campbell, 2023). Based on geologic and geophysical data indicating continuity, we connect the eastern belt with the eastern Klamath terrane to form a single composite lithotectonic block (Figure 2; Zucca et al., 1986). The adjacent Western Klamath block exhibits an upper crustal composition similar to that of the Western Sierra Nevada, but is underlain by underplated accretionary prism rocks and oceanic crustal rocks (Chapman et al., 2024), distinguishing it from other blocks. The Modoc Plateau block is an enigmatic terrane overlain by up to several kilometers of flood basalt and other volcanic rocks, obscuring the underlying basement. The seismic lines of Fuis et al. (1987) define the deep crustal structure here to be similar to the central Basin and Range province, except for the presence of a thicker volcanic and volcaniclastic section that has accumulated since the Eocene (Lerch et al., 2007; 2009). The Modoc Plateau is cut by an array of normal faults, few of which exhibit much structural relief except at Surprise Valley and the Warner Range, located at the NE corner of California. We include this area with the Modoc Plateau based on the seismic velocities from Fuis et al., (1987) and the thickness of volcanic cover observed in outcrops (Egger and Miller, 2011).

The transition in crustal structure between the Modoc Plateau and the Klamath mountains occurs at the location of the Cascade arc. The pile of low velocity volcanic, volcaniclastic, and sedimentary rocks capping the Modoc plateau is the thickest here (up to 12 km; Fuis et al., 1987). The lower crustal seismic velocity also transitions here. We found there to be insufficient difference between the Cascade arc velocity structure and adjacent provinces (Fuis et al., 1987) to divide out a separate lithotectonic block in this area.

| **Extensions of Existing Lithotectonic Blocks** | | **Additional Lithotectonic Blocks** | |
|---|---|---|---|
| Oceanic Crust | 3 km basalt flows and dikes<br>4 km of gabbro | Vizcaino | 3 km of sediment, 9 km of melange, 8 km of basalt and gabbro. |
| Accretionary Prism & Franciscan | 8 km melange (quartz-rich meta sediments + oceanic crust fragments)<br>7 km of basalt and gabbro | Sierra Nevada Metamorphic Province | 6 km or intermediate to mafic volcanic rocks interspersed with ultramafic rocks.<br>14 km of high Ps rocks, likely mafic to ultramafic<br>15 km of gabbro |
| Salinia | 15 km of granodiorite, 3 km of quartz diorite, 7 km of schist, 5 km of gabbro. | Eastern Sierra Nevada and Klamath Terrane | 2 km of sedimentary and volcanic rock, 8 km of ultramafic rock, middle and lower crust indeterminate. |
| Great Valley | 6 km sedimentary rock (quartz)<br>3 km basalt flows and dikes<br>4 km of gabbro | Western Klamath Terrane | 6 km intermediate to mafic plutonic and metamorphic rocks<br>4 km quartz and mica schist<br>30 km of basalt or gabbro |
| Sierra Nevada Batholith | 30 km of granodiorite, 5 km Quartz diorite. | Modoc Plateau | 6 km mafic volcanic rocks. 16 km granitic or metamorphic rocks of intermediate composition, 13 km of gabbro or mafic metamorphic rock |
| Basin and Range / Walker Lane | 25 km quartzo-feldspathic, sometimes calcareous, middle and upper crust consisting of thrust sheets of metasedimentary rocks and gneiss.<br>5 km of gabbro | | |

**Table 1.** Proposed crustal compositions for lithotectonic provinces of the northern California extension of the GFM.

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