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Formation and Development of the San Andreas Fault System with Migration of the Mendocino Triple Junction

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The faults that accommodate Pacific - North America plate motion along the San Andreas plate boundary occupy a region that previously served as part of the upper plate of the Cascadia subduction zone plate boundary. After the passage of the Mendocino triple junction (MTJ), several fault systems develop within the newly formed Pacific-North America plate margin, with one fault system eventually evolving to become the primary plate boundary structure (termed the San Andreas Fault in central California). As a result of the northward migration of the MTJ, the Cascadia subduction zone, undergoing NNW-directed shortening at a rate of ~ 50 km/Ma, replaced by the equivalent lengthening of the San Andreas system. In northern California, three primary fault systems are identified: on the west (along the western margin of the North America plate) is the San Andreas fault (which does not serve as major component of the lithospheric scale plate boundary structure in northern California; moving inland (eastward) is the Maacama - Rodgers Creek (M-RC) fault system; further east is the Lake Mountain - Bartlett Springs (LM-BS) fault system. These latter two faults primarily accommodate Pacific -North America motion in the region just to the south of the MTJ.

New tomography imagery of this region of northern California provides crustal constraints on deformation and fault localization, both within Cascadia, north of the MTJ, and south of the transition from subduction to translation. Using these tomographic images and analyses of GPS data within the region, we have developed a tectonic model that both explains the present fault systems north and south of the MTJ, and helps us understand why one of these fault systems - the M-RC fault system - develops to become the primary plate boundary structure over several million years after MTJ passage. Two fundamental aspects of the North America and Pacific plates control the location of these primary fault systems - the existence of relatively rigid upper-plate backstops (the Great Valley and Klamath blocks), and a small remnant (the Pioneer fragment) of the subducted Farallon plate accreted to the eastern margin of the Pacific plate and migrating northward with it. As a result of these structures, the LM-BS fault system develops as an upper-crust (brittle) fault system, while the M-RC system initially forms as a shear zone (ductile) along the eastern margin of the Pioneer fragment, with the upper-crustal faults developing in response to the deeper plate boundary shear zone. This lithospheric shear zone localizes the plate boundary development and leads to the M-RC system becoming the main plate boundary fault.