A characteristic scale of plate-boundary strike-slip fault obliquity and earthquake rupture

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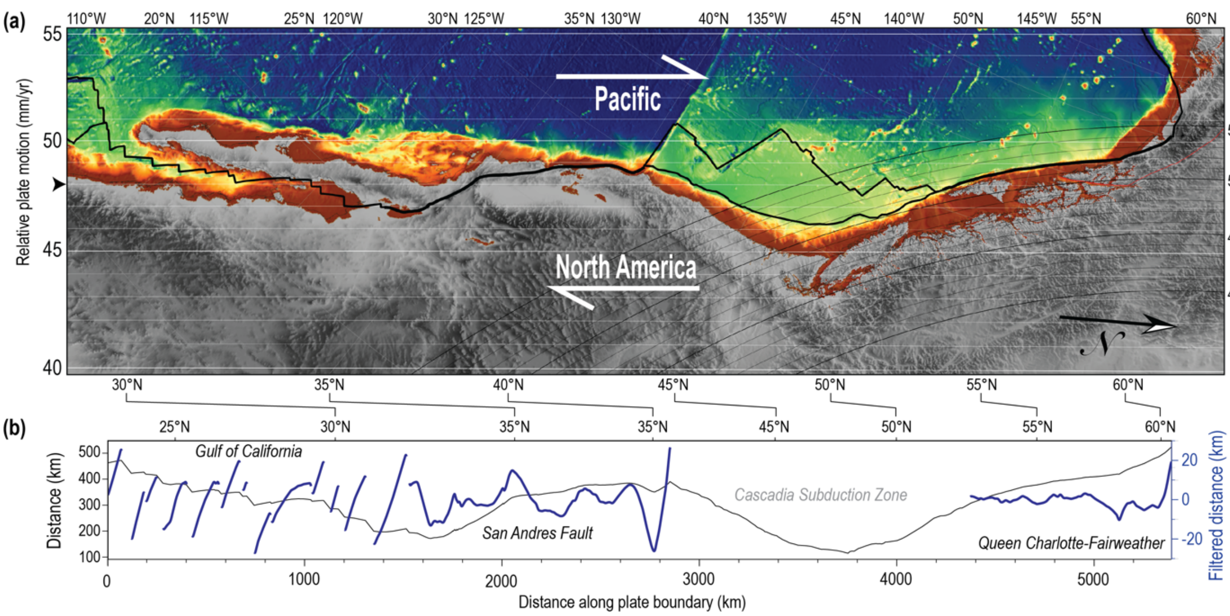
For ~4000 km of strike-slip motion on the Pacific/North America boundary, either the angle of obliquity between plate-boundary faults and relative plate motion or slip rate varies with a characteristic ~200 km wavelength. Accommodation of tectonic stress by faulting and fault orientation are fundamentally linked: Plate-boundary stress is a function of the speed and direction of relative motion between adjacent plates, and the amount of stress accumulated and/or accommodated by slip on a particular fault plane depends on the angle of obliquity between the fault and plate-boundary motion. On the spherical Earth, motion of one plate with respect to a reference plate traces a small circle, quantified as rotation about a Euler pole. In the absence of lithospheric strength, such as at Gulf of California (GoC) spreading centers, oceanic transform faults neatly localize along these small circles. Along continental strike-slip faults, such as the Queen Charlotte (QCF) and San Andres Faults (SAF), a brittle lithosphere promotes planar faults, which can only strictly align with plate motion at a single point of tangency. We propose that this conflict between a spherical Earth and planar faults is responsible for the ~200 km wavelength obliquity variations observed along the QCF and SAF and for a similar characteristic length of GoC transform faults. On the QCF and SAF, obliquity variations are less than ~5 to 20°, which produces only minor changes in static stress on the faults. However, the distance between the actual trace of these faults and small circle paths varies by ~5 to 10 km at the ~200 km wavelength, producing a type of large-scale fault roughness. The aspect of this roughness is consistent with general scaling laws based on outcrop and experimental data and specific locations of obliquity variations correlate with models of rupture segmentation on the QCF and SAF, leading us to suggest that, as with smaller scale roughness, misalignment between strike-slip faults and the ideal small circle path of relative plate motion can control earthquake rupture initiation, termination, and recurrence.



(a) Mercator projection centered on a Euler pole for present-day Pacific plate motion relative to a stable North America based on GPS observations and a global plate-circuit reconstruction. Lines of constant velocity around a Euler pole draw small circles, which plot as the horizontal white lines in the Euler-pole centered Mercator projection. Thin black lines mark small circles for a best-fit pole to the Queen Charlotte Fault for the velocities marked on the right-hand axis. Plate boundaries and faults are marked by think black lines. (b) Distance on Earth's surface of plate boundary faults from the small circle path about the PA/NA Euler pole. Thin black line is absolute distance. The thick blue line is distance from the small circle at wavelengths of 10 to 500 km, which shows a ~200 km characteristic wavelength.