Characterizing hazard for low-slip-rate strike-slip faults offshore Southern California

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Understanding seismic hazard due to offshore faults lags behind our understanding of hazard due to their onshore counterparts because of the challenges and costs associated with imaging submarine faults and sampling seafloor sediments. Nevertheless, offshore faults pose considerable hazard to coastal communities and infrastructure, especially when these communities are located near long strike-slip or subduction zone faults that have the ability to produce large earthquakes.

In Southern California, geodetic data indicate that offshore faults collectively accumulate 6-8 mm/yr of right-lateral shear strain, approximately 15% of the total 50 mm/yr of Pacific-North American plate boundary deformation. This shear is distributed across a series of northwest-striking, sub-parallel, right-lateral strike-slip faults that cut highly extended, rotated, and translated submarine continental crust in a tectonic province referred to as the Inner California Borderlands. Despite the proximity of these faults to densely populated coastal communities in Southern California, uncertainties regarding basic seismic source parameters such as fault dip, length, mode of deformation, slip rate, and potential connections between the offshore faults force assumptions about fault geometry, potential earthquake magnitude, rupture length, and recurrence interval that increase epistemic uncertainty in regional seismic hazard models such as UCERF3. Confusion remains, in part, because previous studies based on the interpretation of low-resolution, deep-penetration legacy geophysical datasets with limited high-resolution supplemental data have resulted in contradictory conclusions about which faults are active and whether the primary mode of deformation is compressional or strike-slip. The alternate representations of the offshore fault network in the UCERF3 fault models (Field et al., 2014) highlight key questions such as the extent and orientation of offshore faults, potential connections between mapped fault systems, and the existence of north-northwest striking regional blind thrusts.

Here, we present observations from a series of marine geophysical investigations aimed at 1) identifying the primary mode of deformation on the offshore fault system, 2) distinguishing the active structures that accommodate modern plate boundary deformation from relict structures formed during Miocene plate boundary reorganization, and 3) detailed characterization of fault geometry, rupture history, and potential rupture connectivity for individual seismic sources in the offshore fault network.

Sequence stratigraphic interpretation of reprocessed legacy deep-penetration seismic reflection data and newly acquired high-resolution multichannel seismic reflection data indicates that modern deformation in the Inner California Borderlands is consistent with tectonic models of right-lateral faulting where localized compressional and extensional features form at geometric complexities along the fault trace (Maloney at al, 2016). We identify the Newport-Inglewood/Rose Canyon, Palos Verdes, and San Diego Trough faults as the major active structures within our study region. The Carlsbad Ridge fault and the southern Coronado Bank fault may also play roles in accommodating modern deformation, but the resolution of the datasets and local stratigraphic relationships prevent confirmation of activity on these structures. Our mapping indicates that structural relationships along the Newport-Inglewood/Rose Canyon fault system (Sahakian et al., 2017) and the San Diego Trough and San Pedro Basin faults may allow ruptures to propagate between faults, increasing the potential rupture length and maximum magnitude for events on these systems to M 7.3 and M 7.7, respectively. In efforts to constrain the extent of past ruptures along these systems, we present preliminary results from on-going paleoseismic investigations using CHIRP and multichannel seismic reflection sub-bottom profiles, multibeam bathymetric data, and coring surveys to characterize recent earthquakes on the San Diego Trough and San Pedro Basin fault zones. By using nested marine geophysical data with increasing levels of resolution, our work answers many first-order questions regarding the deformation kinematics and the geometry of active faults in the Inner California Borderlands.

References:

Field, E.H., et al., 2014, Uniform California Earthquake Rupture Forecast, Version 3 (UCERF3)-The Time-Independent Model: Bulletin of the Seismological Society of America, v. 104, no. 3, p. 1,122–1,180, doi: 10.1785/0120130164.

Maloney, J.M., Driscoll, N.W., Kent, G.M., Duke, S., Freeman, T., and Bormann, J.M., 2016, Segmentation and step-overs along strike-slip fault systems in the Inner California Borderlands: implications for fault architecture and basin formation, *in* Anderson, R., and Ferriz, H., eds., Applied Geology in California: Association of Environmental and Engineering Geologists, Special Publication Number 26, p. 655-677.

Sahakian, V.J., Bormann, J.M., Driscoll, N.W., Harding, A.J., Kent, G.M., and Wesnousky, S.G., 2017, Seismic constraints on the architecture of the Newport-Inglewood Rose Canyon fault: Implications for the length and magnitude of future earthquake ruptures: Journal of Geophysical Research: Solid Earth, v. 157, no. 3, p. 2085-2105, doi:10.1002/2016JB013467.