Where will "The Big One" in Los Angeles be? : Earthquake hazards in the Western Transverse Ranges of California

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Background: High rates of shortening (more than 1 cm/yr) across the Western Transverse Ranges (WTR) in densely urbanized southern California (USA) results in a series of east-striking active reverse faults (Fig. 1). In the past 4 decades, all of the earthquakes with magnitudes greater than M_w6.0 in southern California occurred on such faults. Some of these major structures may be capable of multi-fault earthquake ruptures generating ~M_w8 earthquakes. As such, these faults represent some of the **greatest earthquake hazards to the millions of people living in Los Angeles and vicinity** (Rockwell et al., 1988; Dolan et al., 2003; Hubbard et al., 2014). However, the seismic hazards associated with many of these faults are highly uncertain because their long-term slip rates are poorly known. For example, current slip rate estimates on the Oak Ridge fault (Fig. 1) are both high and uncertain, ranging between 5.9 mm/year and 12.5 mm/year (Yeats, 1988). These rates are based on the inferred age of the Saugus Formation, with the 2-fold range reflecting the uncertainty in the upper age of the youngest deformed strata (200-400 ka). Without well-defined long-term slip rates for such faults, it is not possible to develop accurate earthquake hazard models.

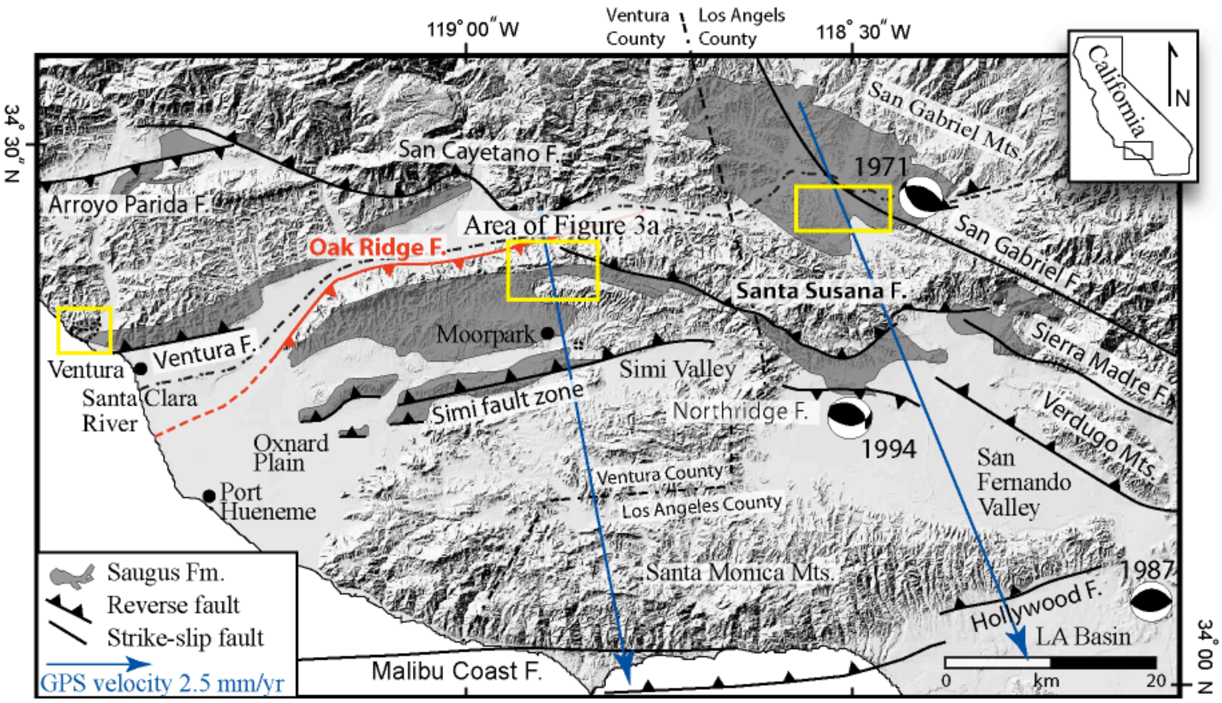

Figure 1. *Simplified index map showing the distribution of deformed Saugus Formation strata (dark gray) and study areas (yellow box) within the Western Transverse Ranges with respect to active faults and local geography. Selected earthquake focal mechanisms show the approximate epicenter locations for the 1971 M_w6.5 San Fernando/Sylmar, 1987 M_w6.0 Whittier Narrows, 1994 M_w6.7 Northridge earthquakes (lower hemisphere projections). GPS velocities are from Shen et al., 2003 and show more than 10 mm/a of shortening across the region.*

Methods: The primary goal of this PhD project is to combine geologic and geomorphic data with cosmogenic isotope burial dating techniques (Balco and Rovey, 2008) to quantify the deformation rates across faults in the WTR. An important aspect will be to precisely date an important Quaternary strain marker, the Saugus Formation, which has poor age constraints and is variably deformed across numerous major structures in the WTR, including the San Gabriel, Sierra Madre, Santa Susana, Northridge, Oak Ridge, Simi, San Cayetano, Arroyo Parida, and Ventura faults (Fig. 1). The PhD student will:

1) Create detailed digital geologic and geomorphic maps (using ArcGIS), including mapping of deformed Saugus Formation strata along major structures;
2) Utilize geologic and geomorphic mapping and subsurface data (wells and seismic) to construct cross sections across structures and determine the magnitude of uplift and fault slip;
3) Determine the upper and lower age of Saugus Formation strata exposed along the faults utilizing cosmogenic isotope isochron burial dating methods;
4) Combine geochronology results and structural analysis to precisely quantify the timing and rate of deformation on the faults and folds;
5) Use cosmogenic burial dating methods to determine the upper age of the youngest Saugus Formation strata along an E-W transect, in order to quantify the spatial pattern in the timing and rate of deformation along strike of the WTR (Fig. 1).

Outcomes: This project will produce the first radiometric ages for the Saugus Formation, and use them to calculate deformation rates. Developing high precision slip rates for faults in the WTR will directly contribute to and reduce uncertainties in earthquake hazards assessments for southern California. Results will be published in high-profile journals and the PhD student will have the opportunity to present major findings in at least one international conference.

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Training: The ideal candidate will be interested in field geology, geomorphology, isotope geochemistry, and hazard analysis. **A passion for science that matters to society is critical**. This is a multidisciplinary project, with significant training in field, laboratory, and analytical methods. Fieldwork (including mapping and sample collection) will be conducted in southern California; the candidate should be prepared to camp for significant periods of time and must be able to drive a vehicle. Laboratory work will involve mineral separation and chemistry preparation of cosmogenic isotope samples in Imperial's newly developed ICosmo lab; the candidate should thus be meticulous and attentive to detail. Analytical work will involve travel to the San Francisco Bay Area (USA) and/or Scotland for Accelerator Mass Spectrometry (AMS) measurements. The student will collaborate with international project partners in academia, government, and industry, and establish skills and networking connections important for further career opportunities in any of these scientific realms.

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