Quantification of seismic hazards in southern California using cosmogenic nuclide dating of geomorphic strain markers

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Project aim:
The aim of this project was to collect samples for cosmogenic exposure dating and isochron burial dating of key geomorphic and stratigraphic horizons within the Ventura basin, California, USA. These samples can then be used to calculate fault displacement rates at high spatial and temporal resolutions to understand the tectonic history of several faults which are thought to represent significant seismic hazards.

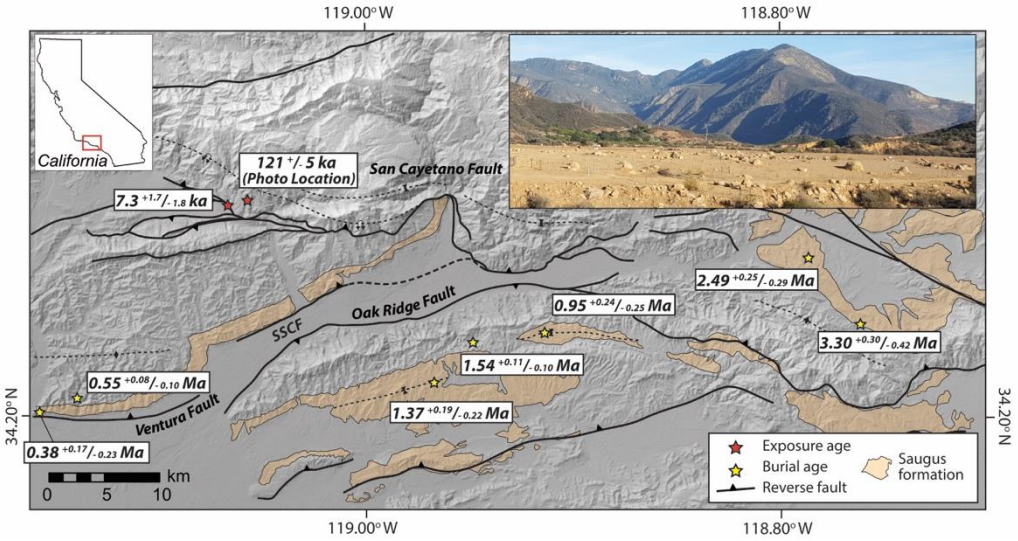

Figure 1 Sample locations and the distribution of the Saugus formation. The inset photo shows boulders on an uplifted alluvial fan surface used for exposure dating.

Methods:
Rocks and soils near the Earth's surface accumulate terrestrial cosmogenic nuclides (TCN) by nuclear spallation reactions via the interaction of cosmic rays from space with minerals contained in rocks or soils. By measuring the concentration of cosmogenic nuclides in a rock or soil (in this case ^{10}Be or ^{26}Al) it is possible to either calculate the time that a rock or soil has been exposed at the Earth's surface (exposure dating) or the time since the rock was buried below the penetration depth of cosmic rays (burial dating), both of which can be used as a proxy for age, given a number of assumptions.
We conducted geomorphic and geologic mapping in the hanging wall of the San Cayetano, Ventura, and Oak Ridge faults (Fig. 1) and used the maps to identify potential sample locations. We collected samples for exposure dating on a series of uplifted alluvial surfaces in the hanging wall of the San Cayetano fault (Fig. 1). We also collected a series of samples for isochron burial dating of the Saugus formation, an important but poorly dated late Pleistocene strain marker in the Ventura basin (Fig. 1). Isochron burial ages for the Saugus formation record the onset of surface uplift of several major faults in the Ventura basin and resulting drainage reorganisations. We combined ages for the Saugus formation with data from published cross sections to calculate long-term displacement rates for the Oak Ridge and San Cayetano faults.

Main Findings:
The isochron burial ages from the Saugus formation confirm that the Saugus formation increases in age from west to east across the basin. We find that surface uplift due to folding as a result of slip on the Ventura fault began at some point after 0.38 Ma. Furthermore, our age range for the Saugus formation of 2.6–3.3 Ma in the east Ventura basin indicates that the Saugus formation could be much older than the previous estimate of 0.6–2.3 Ma. Our age for the base of the Saugus formation in the central Ventura basin of 1.15–1.19 Ma was used to calculate slip rates of 3.3–3.5 mm yr^{-1} of Oak Ridge fault and a fault throw rate of 6.5–7.9 mm yr^{-1} for the San Cayetano fault. Our surface exposure ages for alluvial surfaces in the hanging wall of the San Cayetano fault are 7.3 +1.7/-1.8 ka and 121 +/- 5 ka. We used these ages as first order inputs to calculate throw rates of 0.8–1.8 mm yr^{-1} and 1.2–1.6 mm yr^{-1}, respectively. When all throw rates for the San Cayetano fault are combined, they show that the throw rate for the San Cayetano fault has decreased over time since 1.15 Ma, possibly due to strain partitioning between the San Cayetano fault and the Southern San Cayetano fault.

Funding from the BSG was essential for covering the cost of vehicle rental and accommodation during the field campaign to collect samples. The samples collected provided important data for a PhD thesis, which is currently being written up for a paper intended for submission to GSA Bulletin.