Quantifying landscape response to the growth and interaction of reverse faults, Western Transverse Ranges, USA.

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Background: There has been considerable focus in recent years on the extent to which it is possible to extract information about rates of fault motion from landscape analysis over timescales of $10^3$-$10^6$ years. In principle, channels, hillslopes and river terraces can all act as recorders of active faulting over varying timescales. Additionally, recent work suggests that it is during the transient response of erosional systems to tectonic perturbation that landscapes record information on the growth and evolution of faults with the greatest fidelity. However, the speed at which landscapes respond to active tectonics, and how this governs sediment supply to basins remain key challenges. Nevertheless, when landscapes can be used as ‘tape recorders’ of tectonics, this provides a powerful tool to constrain the locus and slip rate of faults when subsurface data is sparse, or to discriminate between competing structural models. Additionally, as an important aspect of seismic hazard assessment involves an understanding of the position, length and displacement rates of faults, such work has important societal implications. Consequently, the aim of this PhD project is to quantify the relationship between active tectonics and landscape response along the strike of several active structures in a highly populated part of the United States - the Western Transverse Ranges of California.

Location: The Western Transverse Ranges lies south-west of the “Big Bend” in the San Andreas Fault, which causes regional transpressional deformation across the area. This is reflected in significant crustal shortening rates, which have been measured by GPS to be around 7-10 mmyr$^{-1}$ and by geological constraints to range from 10-14 mmyr$^{-1}$ (e.g. Hubbard et al., 2014). The area of study is bounded by the Santa Ynez and Topatopa Mountains to the north, the San Gabriel Mountains to the east and the Ventura Basin,
Oak Ridge and Santa Monica Mountains to the south. Crustal shortening in the region is accommodated by a series of east-west striking folds and reverse faults. These include the San Cayetano, Ventura and Oak Ridge Faults (e.g. Fig. 1). However, the position and slip rates of the structures and their seismic hazard is uncertain, and their impact on landscape evolution poorly documented.

Methods: The student will:

a) Conduct extensive ArcGIS analysis on digital elevation model data to extract river-long profiles and the location of knickpoints upstream of key structures. The presence of transient landscape responses at fault segment boundaries will particularly be explored.

b) Conduct fieldwork and exploit LIDAR data to characterize the hydraulic geometry of rivers crossing faults, upstream and downstream of knickpoints. This will be used to quantify whether and how the fluvial system is keeping face with on-going uplift, including the downstream distribution of stream power and fluvial erosivity.

c) Compare field observations and geomorphic analysis with neotectonic indicators of uplift to establish the relationship between faulting and landscape along strike of known active structures.

d) Collect samples of river sediment for catchment-averaged erosion rate analysis and date fluvial terraces where necessary using cosmogenic nuclide dating techniques. This will be used to constrain incision and erosion rates, and constrain landscape response times to faulting.

e) Invert the distribution of knickpoint and long profile geometries for fault evolution using established stream power erosion laws, and compare the results of this with subsurface analysis from other studies.

f) Use the results from (a) to (e) to improve constraints on the location and activity of the reverse faults, and their potential seismic hazard.

Outcomes: 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. This PhD project would suit a numerate student who is interested in geomorphology, active tectonics and structural geology. The student will gain training and experience in the use of ArcGIS, Matlab (e.g. Topotoolbox) and cosmogenic nuclide analysis. A passion for science that matters to society is critical.