Episodic deformation and uplift in the Santa Maria Basin and implications for long-term earthquake hazard in the western Transverse Ranges.

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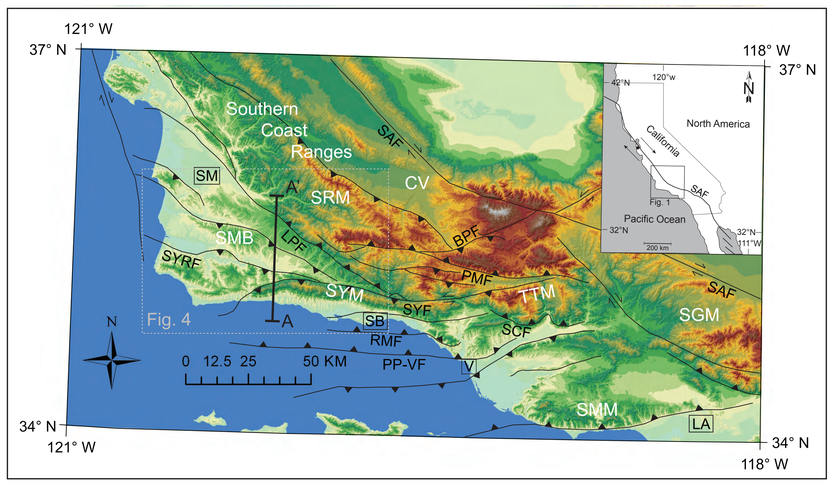
Summary

Faulted and folded fluvial terraces in the Santa Maria Basin show that deformation rates have changed over the past 100 kyr. A widespread fluvial plain, with very little relief, developed between ~125 ka and 85 ka and suggests little uplift or deformation during this time. This period of quiescence was followed by a period of rapid deformation and topographic growth in the area between ~85 ka and ~65 ka. Deformation rates appear to have decreased dramatically since ~65 ka and terraces younger than 65 ka show very little disturbance across structures within the basin.

We are unsure what caused this “episodic deformation”, but the structures involved have been active since late Miocene, so we suspect the episode recorded in the Quaternary terraces is not a singular event. Our best hypothesis for the deformation pattern is that regional shortening and displacement on a detachment at depth is accommodated at the surface in different places at different times- possibly alternating between a thrust front at the southern edge of the WTR and a backthrust system farther north within the WTR.



Methods

-LIDAR and field mapping of fluvial terraces (Fig. 2)

-Measurements of terrace deformation; broad folding and fault displacement (Fig. 3)

-Dating of fluvial terrace deposits using pIR-IRSL luminescence techniques

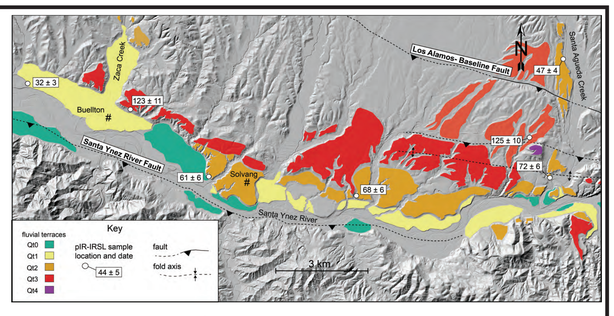


Figure. 2. An example of terrace mapping and luminescence dates along a section of the Santa Ynez River. Terrace treads are shown in color and blind faults shown as dashed black lines.

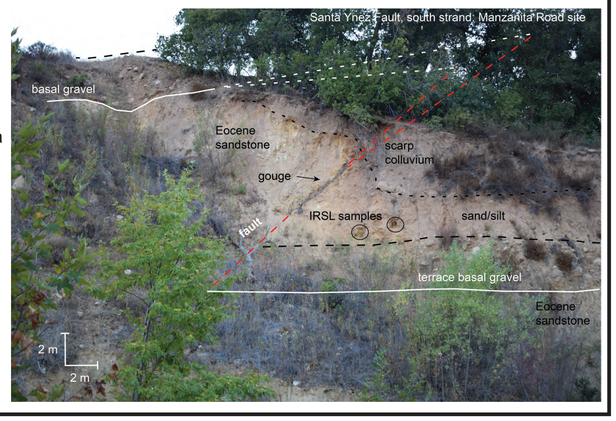


Figure. 3. A ~40 Ka fluvial terrace displaced by a strand of the Santa Ynez Fault. The terrace strath (white line) is displaced 20 m by a fault dipping 40° to the south. The resultant dip-slip rate is ~ 0.5 mm/yr.

Results

There are three prominent terrace levels that are present throughout the area. These ages of these terraces correspond to interglacial periods.

The oldest (red) is the Orcutt Fm. that was deposited across the entire area during MIS stage 5. It has since been lifted and folded across the blind faults and provides are marker for deformation over the past 100 Kyr.

The younger terrace levels (orange and yellow) show little to no folding and indicate that deformation rates across structures within the basin have slowed dramatically since ~ 65 ka.

Because of the long history of these blind faults, we believe this Quaternary episode of deformation was not a unique event, but rather suggests a long-term pattern in the area.

Fluvial strath terraces are present in both lifted hanging-wall blocks and subsiding foot-wall blocks of the major reverse faults. This indicates that there is a regional component of uplift in addition to localized uplift along individual structures. The regional component of uplift appears to be relatively constant, while activity along individual structures varies.

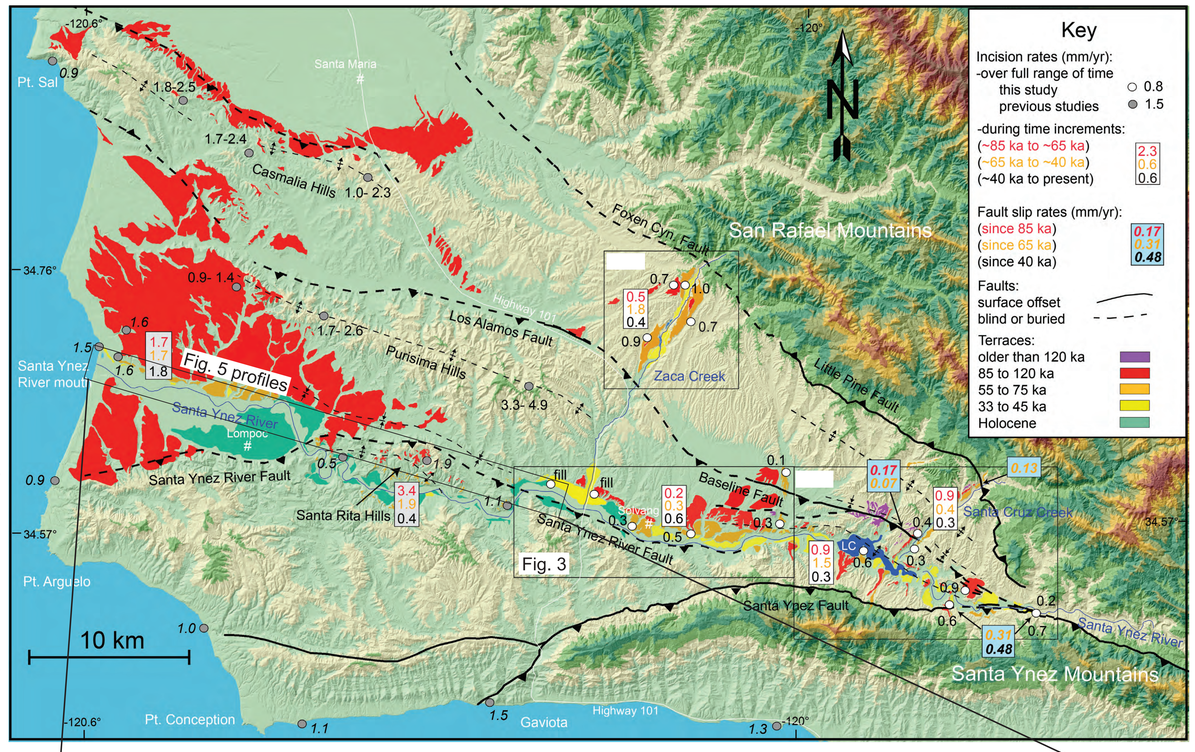


Figure 4. Fluvial terraces and faults of the Santa Maria Basin. Blind faults are shown as dashed lines. Black numbers indicate rock uplift rates calculated at sites where pIR-IRSL dates were determined. Colored numbers in boxes indicate uplift rates or fault slip rates over certain time periods.

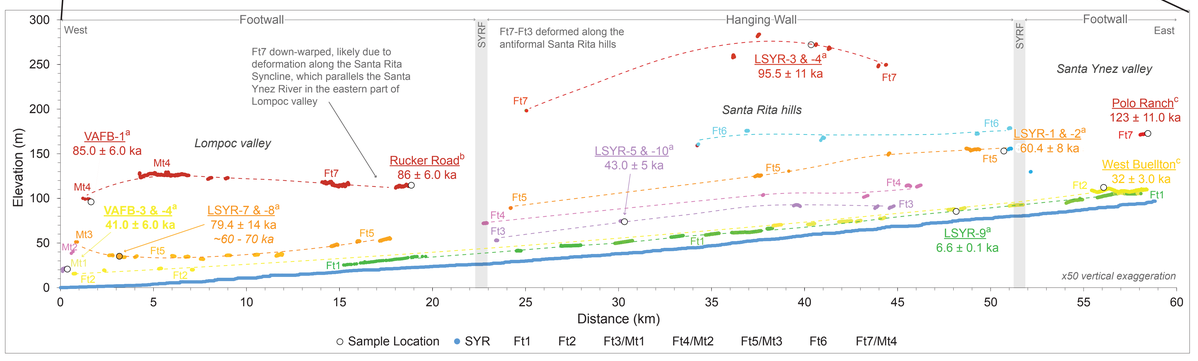


Figure 5. Profiles of fluvial terraces along the lower Santa Ynez River showing deformation across the blind Santa Ynez River Fault and associated folds.

Implications

Our best hypothesis for the changes in deformation rates is that regional shortening and displacement on a detachment at depth is accommodated at the surface in different places at different times.

We suggest that deformation may alternate between a thrust front at the southern edge of the WTR and a backthrust system farther north within the Santa Maria Basin.

If this is correct it would mean earthquake hazard estimates solely based on Holocene activity may not truly represent the long-term regional hazards.

Figure 6. Simplified regional cross-section A - A’

Modified from Namson and Davis (1990) to include elements from Wirtz (2017), Levy et al., (2019), and McGregor and Onderdonk (2021).