QUATERNARY INVESTIGATIONS TO EVALUATE SEISMIC SOURCE CHARACTERISTICS OF THE FRONTAL THRUST BELT, PALO ALTO REGION, CALIFORNIA

Collaborative Research with the Desert Research Institute and Geomatrix

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INVESTIGATIONS UNDERTAKEN

Quaternary tectonic activity of contractional faults adjacent to and east of the San Francisco Peninsula segment of the San Andreas fault (SAF) is expressed by localized deformation (folding and faulting) of Plio-Pleistocene deposits, uplift and preservation of Quaternary alluvial deposits and geomorphic surfaces, and the instrumental record of earthquake activity. A model of the kinematics and geometry of faulting in this region has been developed based on preliminary Quaternary investigations combined with analysis of bedrock structure and construction of a retrodeformable cross section (Angell and others, 1997). Results of the earlier study show that the structures in this area have been active during the latest Pleistocene and possibly the Holocene. Preliminary age estimates and vertical separations of the terraces suggest relative uplift rates of 0.15 m/kyr for the Hermit fault, 0.15 to 0.2 m/kyr for the Pulgas fault, and 0.4 to 0.6 m/kyr for the Stanford fault zone. Ongoing studies are utilizing the established Quaternary framework to improve slip rate estimates with additional age control, more detailed topographic survey data, and tectonic geomorphic analyses.

RESULTS

Field Investigations. Field investigations to date have focused on refining the terrace mapping along San Francisquito Creek across the Pulgas fault and the Stanford fault zone. We are currently working with the Stanford archaeologist, Laura Jones, to incorporate available radiocarbon analyses, topographic survey data, and archaeological information on the lower Holocene terraces along San Francisquito Creek from the Pulgas fault east to the vicinity of the Stanford man site (Figure 1). Detailed topographic maps are being developed for this reach of San Francisquito Creek using existing pre-building construction survey and archaeological survey data. At least three terraces previously designated as Qty (latest Pleistocene/Holocene undifferentiated) can be distinguished. Additional mapping and detailed surveying is planned to correlate these terraces with terraces upstream of the Pulgas fault.

Reconnaissance mapping indicates that there are fluvial and colluvial deposits and soils present on many of the older terraces and surfaces as well as on the more continuous better preserved younger terraces. Terrace correlations at this time rely chiefly on elevation above base level, altitudinal spacing, and general geomorphic characteristics. We plan to explore the feasibility of utilizing cosmogenic dating methods applied to soil profiles to aid in correlating the higher terrace remnants.

Geomorphic Analysis. Geomorphic studies to date have been performed to help identify subtle tectonic indicators in the landscape that can then be investigated in detail during future field investigations. Analyses include stream morphometry (longitudinal profile, stream gradient, and channel pattern), spatial differences in stream incision across the piedmont, and topography (e.g., envelope-subenvelope-residual maps; slope maps; basin asymmetry).

The behavior of stream systems may reflect tectonic activity such that characterizing the stream morphometry in the region can help to identify potential locations of active or recent deformation. This study recognizes the potential effect of longer-term climate change on hydrology, sediment yield, and geomorphic processes and, hence, interpretation of morphometric data. In attempting to work within those constraints, a goal is to strive for ways to differentiate the climate and tectonic signals. For example, the thickness and distribution of depositional units over bedrock strath surfaces may indicate geomorphic responses to climate change that tend to mask the tectonic signal.

Figure 2 summarizes the results for a few of the morphometric analyses. Relief associated with long-term deformation is depicted by the topographic residuals, which is obtained by contouring the differences between the topographic subenvelope and the envelope tangential to the land surface. When compared with the tectonic map of the area, these residual highs roughly correspond to mapped axes of deformation. Alignments of topographic residuals northeast of Telescope Ridge may be reflecting the leading edge of deformation related to underlying structures.

Shaded reaches of San Francisquito, Los Trancos, and Matadero creeks have increased stream gradient and sinuosity that are distinct from adjacent reaches. The locations of these reaches tend to be associated with long-term axes of deformation and areas northeast of the deformation front, although as noted, further investigation is warranted to distinguish the causative factors.

For example, increases in gradient can result from a variety of causes including local base level change, resistant bedrock, aggradation or incision, or tectonic deformation. Similarly, sinuosity can be influenced by a number of fluvial geomorphic factors including discharge, sediment load, and change in slope.

Depth of stream incision into the adjacent piedmont south and north of Telescope Ridge differs notably from northwest to southeast. The spatial differences in fluvial erosion in this region may be related to spatial variation in the underlying zones of active deformation. Additional field investigations are necessary to distinguish between possible climatic, tectonic, or drainage basin influences.

NON-TECHNICAL SUMMARY

Active blind and emergent faults that occur in a zone of deformation adjacent to and east of the San Andreas fault pose a not yet well understood seismic hazard to communities and infrastructure in the Palo Alto and adjoining regions of the San Francisco Peninsula. These ongoing studies, which include mapping of Quaternary deposits and surfaces that have been deformed across this zone, will provide information that can be used to evaluate the location and activity of individual faults and the expected style of deformation that may occur in future earthquakes.

REPORTS PUBLISHED

Angell, M.A., Hanson, K.L., and Crampton, T., 1997, Characterization of Quaternary contractional deformation adjacent to the San Andreas fault, Palo Alto, California: Final Report submitted to the U.S. Geological Survey, National Earthquake Hazards Reduction Program, Award No. 1434-95-G-2586.

Hanson, K.L., Wesling, J.R., Angell, M.M., and Bullard, T.F., 2001, Quaternary Investigations to Evaluate Seismic Source Characteristics of the Frontal Thrust Belt, Palo Alto region, California: Status report of ongoing morphometric and geochronology studies, (abs): Seismological Research Letters, v. 72, no. 2, p. 246-247.

DATA AVAILABILITY

Contact authors at the addresses listed above for data and information regarding ongoing investigations.

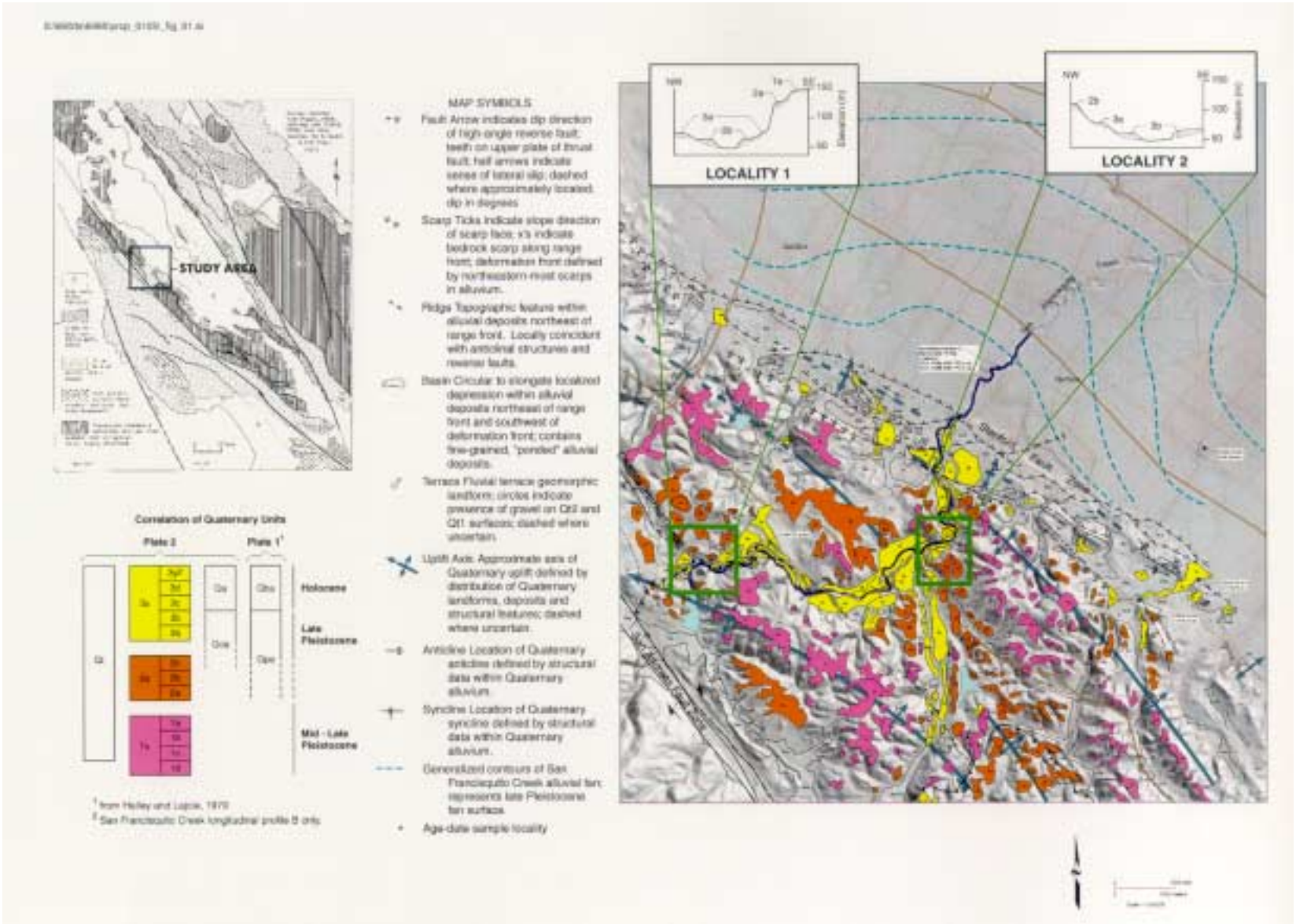

Figure 1. Location of Study and The Quaternary Geology of the Palo Alto Quadrangle

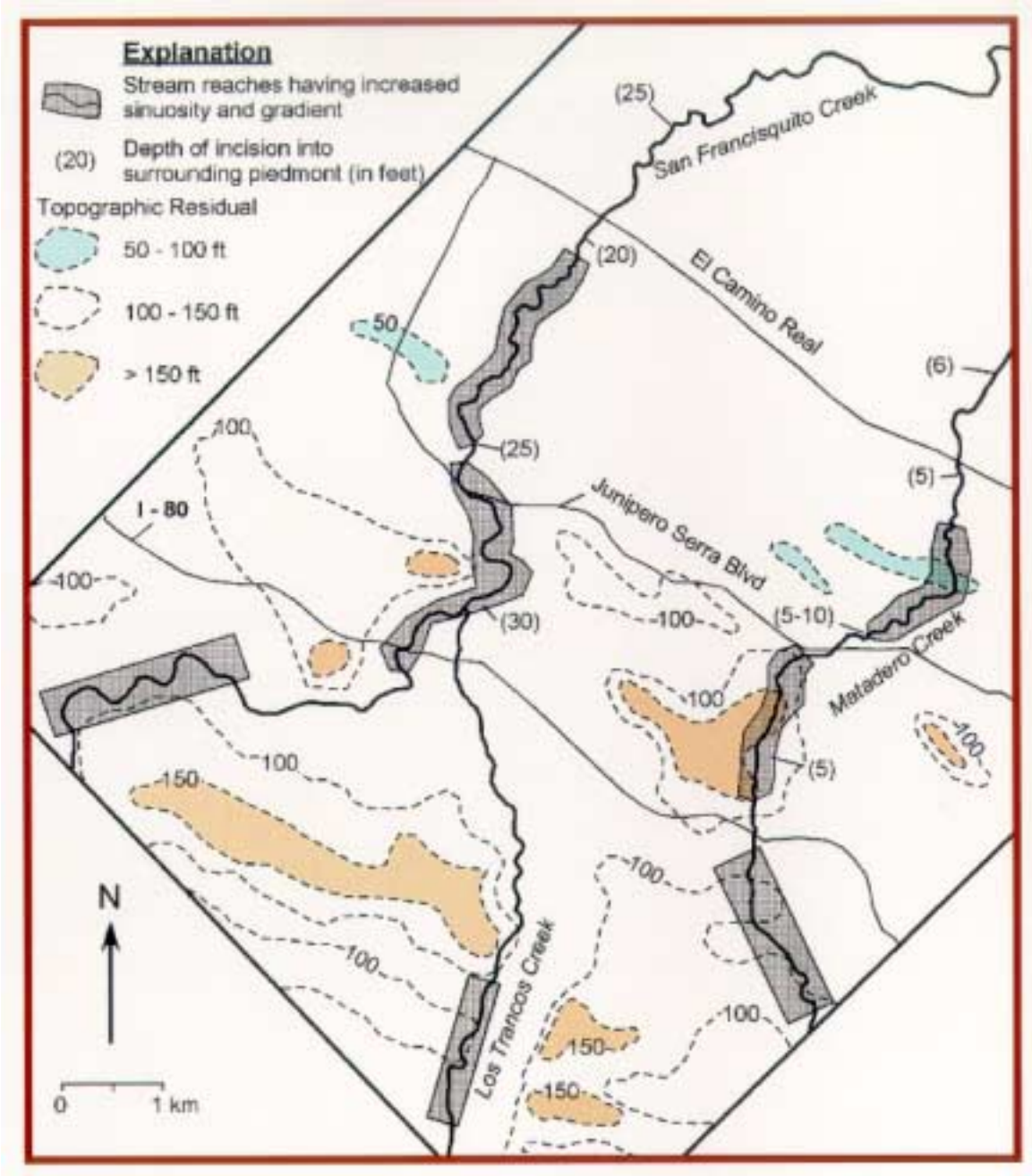

Figure 2. Map summarizing the results of tectonic geomorphic analysis