Annual Report, 1998

Neotectonics and Holocene Paleoseismology of the San Joaquin Hills, Orange County, California

Submitted by Lisa B. Grant
Dept. Environmental Analysis & Design, University of California
Irvine, CA 92697-7070; lgrant@uci.edu

This project consist of two related tasks: 1) culmination of collaborative research on late Quaternary neotectonics and earthquake potential of the San Joaquin Hills and 2) a new paleoseismic study to date and measure the most recent co-seismic uplift of the San Joaquin Hills. Progress and results from each task are presented separately below.

I. Late Quaternary Neotectonics and Earthquake Potential of the San Joaquin Hills

The goal of this project is to evaluate the earthquake potential of the San Joaquin Hills at the southern margin of the Los Angeles basin by mapping and dating late Quaternary marine terraces to constrain the style and rate of deformation. This task was previously funded by SCEC as a collaborative effort between myself, Karl Mueller (Univ. of Colorado, Boulder) and Eldon Gath (Earth Consultants International and UC Irvine). George Kennedy (San Diego State Univ.) and Roz Munro (Leighton and Assoc.) contributed paleotological analysis and terrace data, respectively, with modest SCEC support. Larry Edwards and Hai Cheng (Univ. of Minnesota) made substantial contributions of U-series dating at no cost to SCEC.

In 1998 I worked on resolving uncertainties in the age of the marine terraces and the elevation of shorelines which are essential for constraining structural interpretations of the San Joaquin Hills thrust, and led the write-up of results. We submitted a manuscript to *Science* which went out for review but was ultimately deemed too narrow for a general audience. Reviewers recommended publication in a more specialized journal. Reviewers also encouraged further studies of the "marsh bench" in Newport Bay to try to date the last earthquake (see progress report below and continuation proposal); improved understanding of the relationship between the San Joaquin Hills thrust and the Newport-Inglewood fault (see attached proposal); and additional coral dates.

In early January 1999, Larry Edwards and Hai Cheng completed three additional analyses of corals collected by George Kennedy. We have now dated six corals from well documented paleontological sites in the San Joaquin Hills. Age calibration of the fossil assemblages will provide one of the best chronostratigraphic controls on late Quaternary marine deposits in coastal southern California. Although this was not the immediate goal of our project, it is an important by-product that can be applied toward resolving questions about regional uplift rates and blind thrust movement in the LA basin. In addition, one of the new coral dates has potentially important implications for sea level and global climate change which may warrant a separate publication. Two of the three corals confirm previous terrace dates and correlations with the sub-stage 5e sea level high stand (at ~122ka), and strengthen our existing conclusions about late Quaternary uplift. The third coral correlates with a substage 5c highstand, with high confidence. This result is important because it is one of only two known Pacific Coast substage 5c fossil localities (G. L. Kennedy, written communication 1999) and might constrain the elevation of sea level at 105ka. We have nearly completed a revised manuscript for *Geology* which will include the new coral dates, and we expect to submit it in late January.

The major results of our research are summarized in the following abstract from Grant *et al* (in prep).

> Analysis of emergent marine terraces in the San Joaquin Hills and ^{230}Th dating of fossil solitary corals from these terraces reveal that the San Joaquin Hills have risen at a rate of 0.21 - 0.24 m/ka during the last 122,000 yrs. Movement of a blind thrust fault in the southern Los Angeles basin has uplifted the San Joaquin Hills and has the potential to generate a M_W6.8 - 7.1 earthquake within this densely populated area. Recognition of this blind thrust extends the known area of active blind thrusts and fault-related folding southward from Los Angeles County into coastal Orange County. Based on structural modeling the fault dips to the southwest and slips approximately 0.48 m/ka, suggesting an average recurrence interval of approximately 2500 yrs for moderate-sized earthquakes.

II. Holocene Paleoseismic uplift of the San Joaquin Hills

The most compelling evidence of Holocene uplift of the San Joaquin Hills is "a ledge or bench of ancient marsh deposits" around the margins of upper Newport Bay that was first documented by Stevenson (1954) before Newport Bay was modified by development (see **Figure 1a**). Stevenson (1954) investigated the "marsh bench" and proposed that it was created by tectonic uplift of late Holocene-age marshland. If tectonic uplift of the San Joaquin Hills occurred during the late Holocene, it should have caused uplift and incision of fragile Newport Bay marsh deposits with abundant organic material for radiocarbon dating. The goal of this task is to date the most recent earthquake on the San Joaquin Hills thrust and estimate its magnitude by dating the marsh bench and measuring its height.

Stevenson (1954) studied the processes which influence growth and formation of salt marsh. He identified the marsh bench as an anomalous feature that could not have formed solely by growth of the active salt marsh that was his primary focus. He presented evidence to demonstrate that the marsh bench could not be part of the active marsh and therefore was outside the scope of his project. He reported numerous observations, but did not document them in detail. Therefore, my first task was to search for any remaining portions of the marsh bench, and compare my observations with Stevenson's. Leslie Ballenger, an undergraduate student from Chapman Univ., provided assistance as part of an honors research project. We reviewed aerial photos, maps and reports, and surveyed upper Newport Bay on foot and by kayak to map undisturbed remnants of marsh bench for sampling and analysis.

More than half of the original marsh bench has been modified or destroyed by construction. We found remnants of marsh bench at the base of cliffs on the west side of upper Newport Bay, immediately above the present shoreline angle (see **Figure 1b**). At some locations, the marsh bench is being eroded by wave action at high tide. Comparison with photographs taken by Stevenson (Figure 1a) indicate that significant plant growth has occurred on the marsh bench since 1950. These two observations imply that the marsh bench is late to latest Holocene in age.

Where exposed, the marsh bench consists of fossiliferous unconsolidated sediments in sharp contact with underlying shale bedrock (Figure 1b). The bedrock/sediment contact is approximately 42 cm (average of 36 measurements) above the active shoreline angle. The top of the unconsolidated sediments is approximately 102 cm (average of 24 measurements) above the shoreline, consistent with Stevenson's average measurement of 96 cm "above the present marsh on the western shore". By confirming Stevenson's measurements along the western shore, we conclude that his elevation measurements of the marsh bench (average 157 cm) on the eastern shore (now paved) are reliable.

The topography and stratigraphy of the marsh bench (as derived from both our measurements and Stevenson's) are best explained by 1.0 – 1.6 m tectonic uplift of late Holocene salt marsh by growth of a northwest plunging anticline. The geometry of the inferred anticline is consistent with late Quaternary growth of the San Joaquin Hills anticline, as described by Grant *et al* (1998 and in prep). This suggests that the last significant earthquake on the San Joaquin Hills thrust generated ≥ 1.6 m maximum uplift, and approximately 1.3 m average uplift along upper Newport Bay.

During the remaining budget year, we will collect samples for preliminary radiocarbon dating of the marsh bench and search for additional evidence of Holocene uplift along the coast. As shown in **Figure 2**, there is a wavecut platform along the coast in Laguna Beach which appears to be approximately the same elevation above sea level as the marsh bench in Newport Bay. We will search for other areas along the coast with elevated platforms or features similar to the marsh bench.

References

Grant, L. B., Mueller, K. J., Gath, E. M., Cheng, H., Edwards, R. L., Munro, R. and Kennedy, G. L., (in prep), Late Quaternary Uplift and Earthquake Potential of the San Joaquin Hills, in the southern Los Angeles basin, California: for submission to **Geology**.

Grant, L. B., K. Mueller, E. M. Gath, H. Cheng, L. Edwards, R. Munro and G. L. Kennedy, 1998, Evidence for an Active Blind Thrust Fault in the Southern Los Angeles Basin: Abstracts 1998 Annual Meeting Southern California Earthquake Center.

Grant, L. B. and L. Ballenger, Holocene Paleoseismology of the San Joaquin Hills thrust, Orange County, California – Preliminary results, Abstracts 1998 Annual Meeting Southern California Earthquake Center.

Stevenson, R. E., 1954, The Marshlands at Newport Bay, California [Ph.D. Thesis]: University of Southern California, Los Angeles, 199 p.

Publications and Products – Included in Annual Report on Request for Use of Residual Funds to Support Earthquake Geology Research.