Bulletin of the Seismological Society of America, Vol. 92, No. 2, pp. 590–599, March 2002

Coastal Uplift of the San Joaquin Hills, Southern Los Angeles Basin, California, by a Large Earthquake since A.D. 1635

by Lisa B. Grant, Leslie J. Ballenger, and Eric E. Runnerstrom

Abstract Late Holocene marsh deposits and a shoreline along the coast of the San Joaquin Hills, southern Los Angeles basin, range from 1 to 3.6 m above the active shoreline. Radiocarbon dating of ancient marsh shows that emergence occurred after A.D. 1635. The age, distribution, and geomorphic expression of elevated marsh and shoreline are best explained by tectonic uplift due to a **M** >7 earthquake. Radiocarbon dates and the historic record of seismicity suggest the earthquake occurred between A.D. 1635 and 1855, possibly in 1769. The historic record of earthquakes in the Los Angeles basin begins in A.D. 1769 and contains no other earthquakes greater than **M** 6.7. Therefore, the San Joaquin Hills earthquake may be the largest historic earthquake in the Los Angeles basin.

Introduction

The San Joaquin Hills in coastal Orange County, California, are the surficial expression of a faulted anticline parallel to the active Newport–Inglewood fault zone at the southern margin of the Los Angeles basin (Vedder, 1975; Wright, 1991; Grant *et al.,* 1999) (Fig. 1). The San Joaquin Hills have been rising tectonically at an average rate of 0.21–0.27 m/k.y. during the last 122,000 yr (Grant *et al.,* 1999). Grant *et al.* (1999, 2000) proposed that uplift was generated by movement on an underlying blind thrust fault due to partitioned strike-slip and compressive shortening across the southern Newport–Inglewood fault zone.

Several investigations have addressed the generally low level of seismicity in the Los Angeles basin relative to levels expected from analysis of regional deformation (e.g., Dolan *et al.,* 1995; Working Group on California Earthquake Probabilities [WGCEP], 1995; Stein and Hanks, 1998). The southern Los Angeles basin, including the San Joaquin Hills, has been estimated to have low seismic hazard relative to the greater Los Angeles region (WGCEP, 1995), in part because it has fewer known active faults and historically lower rates of seismicity. Grant *et al.* (2000) suggested that the San Joaquin Hills be considered a seismic source in regional hazard assessment. However, like many blind faults, the recency of movement and Holocene slip rate of the San Joaquin Hills fault was not known. Recognition and characterization of seismogenic blind faults is a major challenge in seismic hazard assessment (Lettis *et al.,* 1997). This article addresses the seismic potential of the San Joaquin Hills by documenting and analyzing evidence of late Holocene uplift. We present data showing that tectonic uplift of the San Joaquin Hills has occurred within the last several centuries and may have generated the largest earthquake in the Los Angeles basin since western explorers reached the area.

Coastal Observations and Measurements

The Marsh Bench

Our investigation was guided by 1950s studies of formation and evolution of salt marsh in upper Newport Bay (Stevenson, 1954; Stevenson and Emery, 1958). Newport Bay is a late Pleistocene erosional gap between the northern San Joaquin Hills and Newport Mesa (Fig. 1). Stevenson (1954) and Stevenson and Emery (1958) described a bench of ancient marsh deposits around the margins of the bay above the active marsh. Stevenson (1954) conducted leveling profiles of the marsh bench on both sides of Newport Bay and reported that the "bench averages 38 inches [0.96 m] above the present marsh on the western shore and 62 inches [1.57 m] on the eastern bank. It is approximately 6 inches [0.15 m] higher in the central part of the Bay than at the north and south ends. This bench contains remnants of marsh flora. . . . " (Stevenson, 1954, p. 36). After comparing the stratigraphy and remnant marsh flora on the bench with the active marsh, Stevenson (1954) concluded that the marsh bench was created by emergence of late Holocene marshland and subsequent death of the elevated marsh community. Stevenson (1954) hypothesized that "the greater height of the 'marsh bench' in the central area is probably the result of movement during Recent time of a major anticline and fault system which cut through the Bay in a NW–SE direction" (p. 36). He reported observations and measurements of the marsh bench to support a tectonic emergence hypothesis so that he could exclude the marsh bench from his primary study of active marsh processes. Stevenson estimated that the marsh bench emerged due to "relative uplift within historic time" (p. 176) a few hundred years before his study, but he did not date it directly.