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Crustal deformation across and beyond the Los Angeles basin from geodetic measurements

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Abstract. We combine 6 years of Global Positioning System (GPS) data with 20 years of trilateration data and a century of triangulation, taped distance, and astronomic azimuth measurements to derive 66 interseismic station velocities in the greater Los Angeles region. We interpolate the velocities to construct a regional strain rate map beyond the Los Angeles basin. Our results generally agree with the model proposed by the Working Group on California Earthquake Probabilities in 1995. Important regional findings of this study are as follows: (1) There is a significant N-S convergence and E-W extension, about 0.22 and 0.17 $\pm$ 0.05 μstrain/yr, respectively, for the two components, along the southern frontal fault system of the San Gabriel Mountains. (2) The crustal deformation around the Big Bend of the San Andreas fault (SAF) cannot be explained solely by wrench-style motion across the SAF. Remaining motion could be part of a NW-SE extension which is the response to NE-SW compression in the central Transverse Ranges region. Alternatively, it could be caused by left-lateral faulting on an oblique blind thrust beneath the San Gabriel Mountains. (3) Low strain rates are found along the Elsinore fault and Newport-Inglewood fault. (4) North-south compression decreases from the Raymond Hill fault westward to the Santa Monica fault. There is little east-west extension along this fault system.

Introduction

The greater Los Angeles region continues to challenge the research community because it is tectonically complex and subject to perilous seismic hazards. Geological studies show the Los Angeles basin to be a deep sedimentary basin at the junction of the northern Peninsular Ranges and the central Transverse Ranges. Formation of the basin started during Miocene time [*Wright*, 1987] through a pull-apart process. Five million years ago, the opening Gulf of California migrated the boundary between the Pacific and the North America plates to the San Andreas fault (SAF) east of the basin and created a left step, known as the Big Bend, along a right-lateral strike-slip SAF north and east of the basin [*Atwater*, 1989]. The region started to undergo compression as it moved NW toward the Big Bend. Evolution of the basin involved volcanism, uplift, extension, block rotation, pulling apart, shear faulting, compression, and folding [*Campbell and Yerkes*, 1976; *Wright*, 1987]. At present, the sediments in the central basin are more than 10 km thick, forming a northwest-southeast elongated synclinorium, with its flanks folded and cut by a group of Quaternary active faults [*Ziony and Yerkes*, 1985].

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South of the basin, present-day crustal deformation is dominated by NW trending strike slip faults such as the SAF, the San Jacinto fault (SJF), the Elsinore fault, and the Newport-Inglewood fault. The SJF merges with the SAF east of the basin. The Whittier-Elsinore fault system, the Newport-Inglewood fault, and the Palos Verdes fault cut through the east and west flanks of the basin [*Ziony and Yerkes*, 1985] (Figure 1). North of the basin, the San Gabriel Mountains have been pushed up by a frontal thrust fault system defined by the Sierra Madre-Cucamonga fault system along the SE and the Santa Susana fault along the SW. The E-W trending Malibu-Santa Monica-Raymond Hill fault system uplifted the Santa Monica Mountains [*Davis et al.*, 1989]. Horizontal detachment in the lower crust or at the Moho boundary has been suggested beneath most of the central and western Transverse Ranges [*Bird and Rosenstock*, 1984; *Weldon and Humphreys*, 1986; *Namson and Davis*, 1988]. Furthermore, such thrust and horizontal detachment in the Los Angeles basin region have been identified by recent geomorphological and trenching studies [*Dolan et al.*, 1995; *Huftile and Yeats*, 1995].

Earthquakes also help illuminate the tectonics of the Los Angeles basin. Earthquake focal mechanisms show a mixture of NW dextral strike slip and N-S convergence [*Hauksson*, 1990]. Earthquakes of right-lateral strike-slip faulting represented by the 1933 M 6.4 Long Beach earthquake dominate the seismicity south of the basin. (Throughout this paper, M represents moment magni-