Analysis of Earthquake Data from the Greater Los Angeles Basin and Adjacent Offshore Area, Southern California

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Element I & III

Key words: Geophysics, seismology, seismotectonics

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ABSTRACT

The goals of this project are to provide seismotectonic synthesis of earthquake data recorded by the CIT/USGS Southern California Seismic Network, including TriNet, and Anza seismic networks during the last 20 years in southern California. In addition we are improving models of the velocity structure to obtain more accurate earthquake locations including depth and to determine focal mechanisms. We also perform studies of the earthquake potential and the detailed patterns of faulting along major faults in the greater Los Angeles metropolitan area and adjacent regions.

RESULTS

Interseismic Background Seismicity of the Southern San Andreas Fault, California

In this part of our study we focus on analyzing seismicity within 2 km distance of the San Andreas fault (Figure 1). The San Andreas fault can be divided into five segments in southern California, the Carrizo, Mojave, San Bernardino, Banning, and Indio segments, based on seismicity and geological mapping (*Sieh et al.*, 1989; *Jones*, 1988). These segments have all generated large earthquakes in the past (*Sieh et al.*, 1989). The two segments that most recently ruptured in the 1857 Fort Tejon earthquake, are the Carrizo and Mojave segments. We have chosen to exclude the Banning segment of the San Andreas fault because the active trace is not clearly expressed and it is unclear, if the fault dips to accommodate the localized curvature and the rapid change in strike. Also the relative slip rates of the Mill Creek and the Banning strands of the San Andreas are not well understood.

We analyze the spatial distribution of background seismicity located within 2 km of the surface trace of the San Andreas fault. The spatially scattered seismicity surrounds an approximately 0.4-km-wide aseismic zone that spans the whole length of the southern San

Andreas fault. The maximum depth of seismicity is greater to the west and smaller to the east of this aseismic zone. We presume that this aseismic or locked region is the damage zone that surrounds the slip plane where major or great earthquakes rupture along the San Andreas fault. This lack of seismicity along the locked zone is possibly related to fault properties such as the strength of the fault, the local stress field, and the mechanics of major or great earthquakes. Thus the seismicity adjacent to the San Andreas appears to occur within the edges of major crustal blocks rather than occurring within the locked fault zone itself. We also compare the seismicity distribution of the San Andreas fault with the distribution of the foreshocks and aftershocks of the 1992 M_w7.3 Landers mainshock relative to the mapped surface rupture. The foreshocks occurred within a 0.5-km-wide zone. The mainshock and immediate aftershocks occurred within and adjacent to this 0.5-km zone. The aftershocks within this zone appear to decay more rapidly than events outside of it. Thus the Landers data suggest that the locked zone accommodates foreshocks, the mainshock, and some of the aftershocks but remains aseismic during most of the interseismic period.

The 1999 Mw7.1 Hector Mine, California Earthquake Sequence: Complex Conjugate Strike-Slip Faulting

The 1999 Hector Mine earthquake sequence occurred near the eastern edge of the eastern California shear zone (ECSZ), an 80 km-wide, more than 400 km-long zone of deformation that cuts across southern California, (Dokka and Travis, 1990). This zone extends into the Death Valley region and accommodates about 12 to 25% of the plate motion between the Pacific and North American Plates (Sauber et al. 1994). Four earthquakes of M>6 have occurred near the southernmost extent the ECSZ during the last decade. Previously the 1947 M6.5 Manix earthquake occurred approximately 50 km to the north the Hector Mine earthquake. These earthquake sequences illuminate the slip transfer zone between the ECSZ to the southern San Andreas fault.

The1992 Landers sequence began with the Mw6.1 April 1992 Joshua Tree sequence and a migration of seismicity to the north. This seismicity culminated by the occurrence of the June 28 Mw7.3 Landers earthquake that was followed within three hours by the Mw6.3 Big Bear aftershock (Hauksson et al. 1993). The 1999 Hector Mine mainshock occurred within 7 years of the 1992 Mw7.3 Landers earthquake. The epicentral distance between the two events is about 50 km while the closest points between the two ruptures are about 20 km (Figure 1).

The Hector Mine mainshock that was preceded within 20 hours by 13 recorded foreshocks of $1.5 \leq M \leq 3.8$ at the hypocenter of the mainshock, showed right-lateral strike-slip faulting, with an initial strike of N6°W with vertical dip. The aftershocks delineate how the Hector Mine earthquake ruptured with strike N6°W to the south for a distance of 15 km, and possibly to the north for a distance of several km. The two largest aftershocks of M5.9 and M5.7 occurred near the north and south end of the first mainshock rupture segment. The second segment of rupture, starting 15 km N6°W away from the mainshock, delineated by strike-slip and thrust faulting aftershocks, extends 10 km further away with a strike of S140°E along the Bullion fault. The aftershocks also outline an unusual third rupture segment, extending from about 5 km south of the hypocenter, to the N 30° to 35°W for a distance of 20 km. Approximately 10 to 25 km further to the north and west, several clusters form a complex rupture zone and aftershock distribution. Three-dimensional Vp and Vp/Vs models of the region are slowly varying, as is typical for the Mojave region. Nonetheless, the mainshock rupture started within a region of rapidly varying Vp and at least three regions of low Vp/Vs are imaged within the aftershock zone. The rate of decay for Hector Mine has been slightly above the mean for both p-values and b-values in southern California. The focal mechanisms of the aftershocks and the state of stress are consistent with strike-slip faulting, including a component of normal faulting most prominent to the north. The orientation of the regional maximum horizontal stress and the variation in orientation of the mainshock fault segments by 30° suggest that the mainshock and aftershock deformation field exhibit volumetric deformation and thus form a complex conjugate set of faults.

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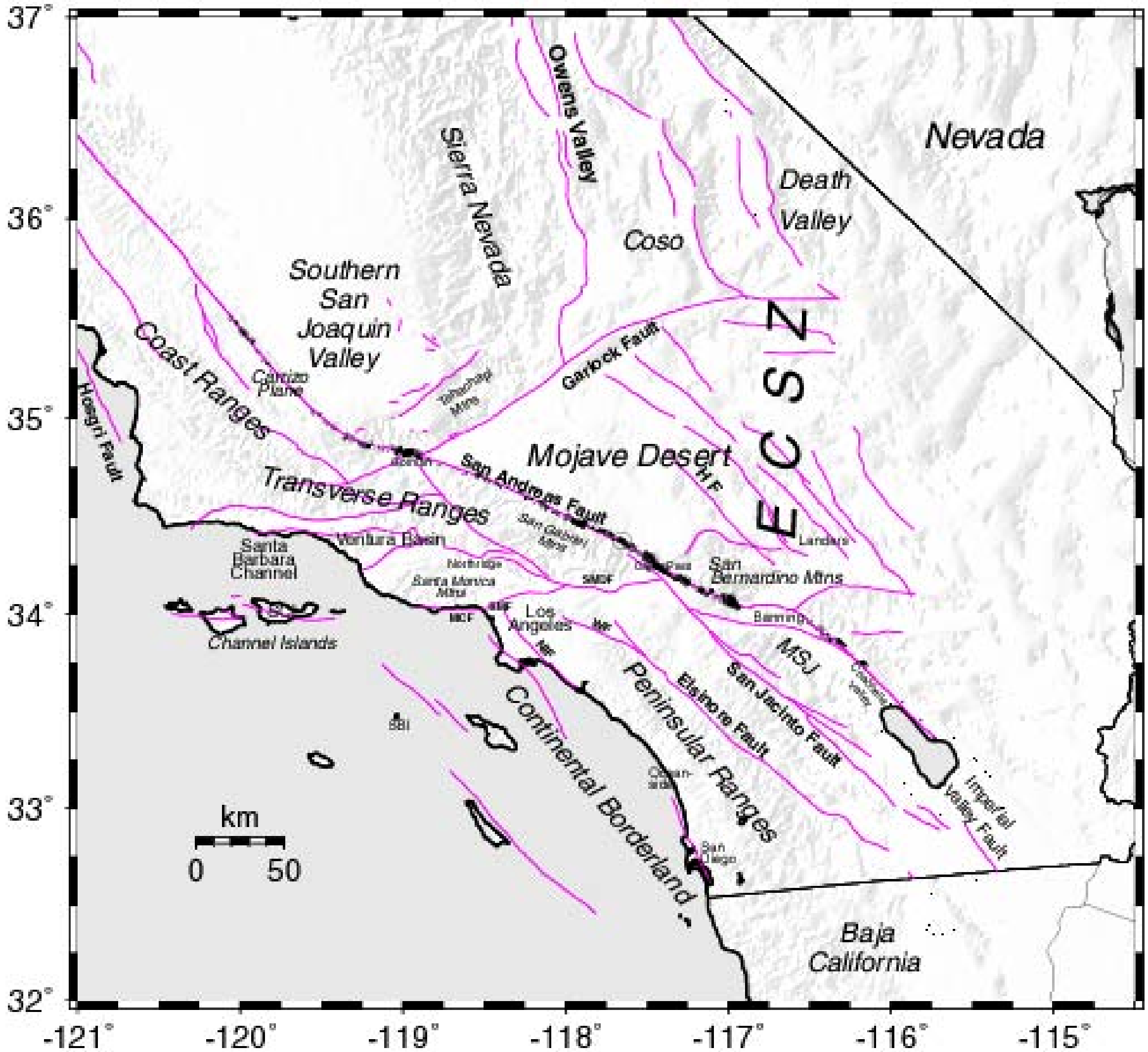

Figure 1. A map showing the location of the study area, including the San Andreas fault and other late Quaternary faults. The seismicity within 2 km of the southern San Andreas fault is also shown.

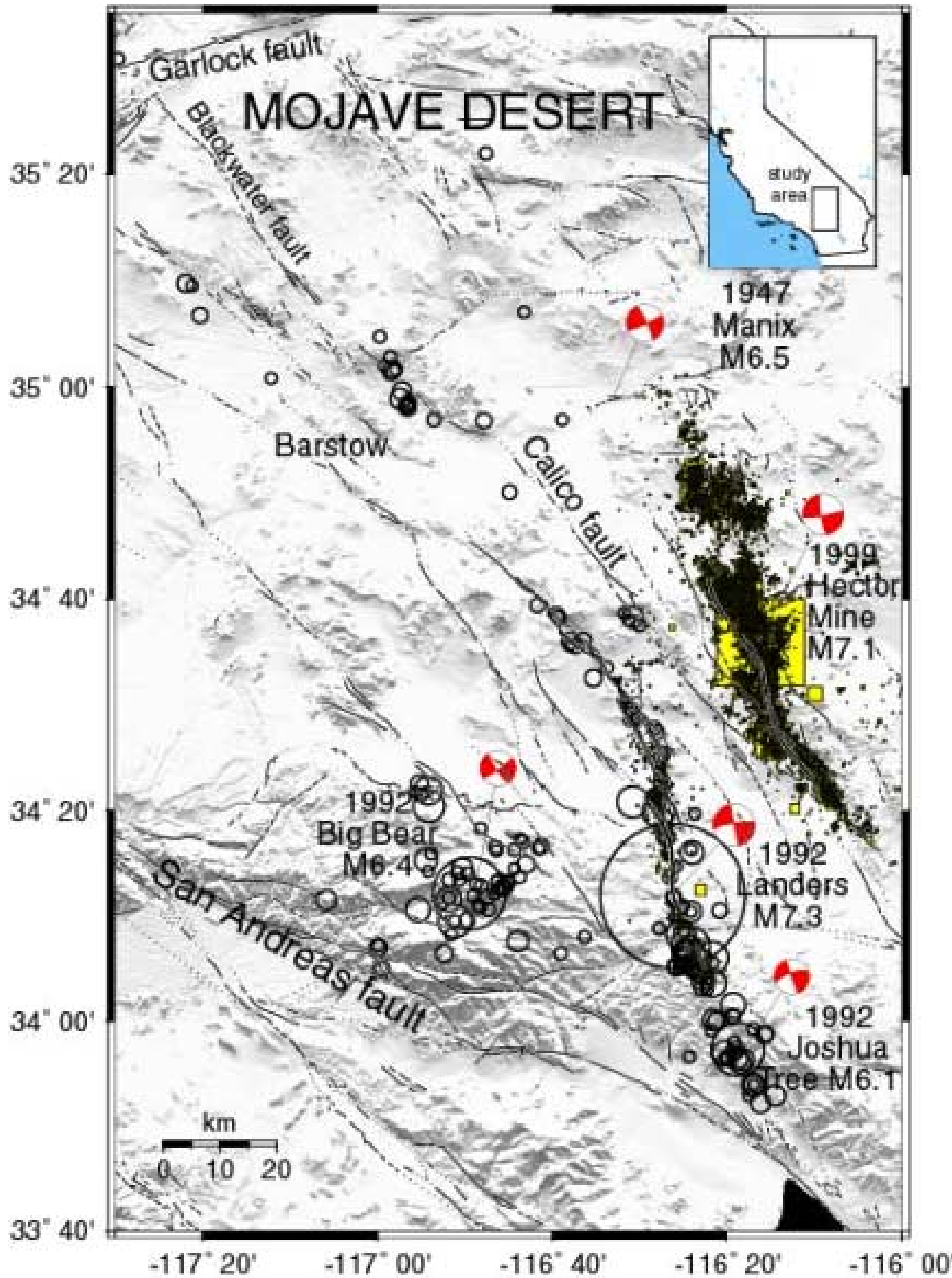

Figure 2. Overview map of the Hector Mine sequence, including M≥3.0xx 1992 Landers aftershocks, focal mechanisms of the M>6 earthquakes that have occurred in the region since 1947. Both the surface ruptures of the 1992 Mw7.3 and the 1999 Mw7.1 Hector Mine earthquakes are shown as line segments drawn on white background.

NON-TECHNICAL SUMMARY

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We synthesize data from earthquakes that occur in southern California and the Los Angeles area in particular, to improve understanding of the earthquake hazards. To determine a three-dimensional image of the crust, we have completed the inversion for the three-dimensional V_P and V_P/V_S velocity structure of southern California. We are also analyzing the seismicity along the San Andreas fault. We are also studying the 1999 Mw7.1 Hector Mine earthquake sequence.

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