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

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Element I & III

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ABSTRACT

We synthesize and interpret local earthquake data recorded by the Caltech/USGS Southern California Seismographic Network (SCSN/CISN) in southern California. The goal is to use the existing regional seismic network data to: (1) refine the regional tectonic framework; (2) investigate the nature and configuration of active surficial and concealed faults; (3) determine spatial and temporal characteristics of regional seismicity; (4) determine the 3D seismic properties of the crust; and (5) delineate potential seismic source zones. Because of the large volume of data and tectonic and geologic complexity of the area, this project is a multi-year effort and has been divided into several tasks.

RESULTS

Fault-Perpendicular Aftershock Clusters Following the 2003 Mw=5.0 Big Bear, California, Earthquake

We determined differential travel-times and applied the double-difference technique to relocate the 2003 Big Bear, California earthquake sequence. The aftershocks illuminate at least three distinct clusters in a 4 km x 4 km x 3 km volume (Figure 1). A 3-km long aftershock cluster coincides with the northwest striking sub-vertical mainshock fault. The other two sub-vertical clusters are almost perpendicular to the mainshock fault trace, contradicting the 60° separation angle of conjugate faults as predicted from classical frictional laws. The style of aftershock faulting consists mostly of strike-slip and some dip-slip movement, which was determined from detailed moment tensor inversion of the

larger events using complete waveforms and first motion focal mechanisms of the smaller aftershocks. Most of the P-axes trend due north, which is consistent with the regional crustal stress direction. We use a conceptual slip model of the Big Bear mainshock to derive Coulomb Failure Stress (CFS). In turn the CFS pattern is used to interpret the perpendicular seismicity. We conclude that perpendicular aftershock clusters were possibly induced by the static stress perturbation caused by the mainshock. (This is joint work with Dr. Wu-Cheng Chi, and a manuscript is in press in GRL.)

Attenuation Models (Q_P and Q_S) in Three-Dimensions of the Southern California Crust: Inferred Fluid-Saturation at Seismogenic Depths

We analyze high-fidelity waveform spectra to determine t^* values for both *P*- and *S*-waves from earthquakes in southern California. We invert the t^* values for three-dimensional (3D) frequency-independent Q_P and Q_S regional models of the crust (Figures 2 and 3). The models have 15 km horizontal grid spacing and an average vertical grid spacing of 4 km, down to 30 km depth, and extend from the US-Mexico border in the south to the Coast Ranges and Sierra Nevada in the north. In general, Q_P and Q_S increase rapidly with depth, consistent with crustal densities and velocities. The 3D Q_P and Q_S models image prominently the major tectonic structures and to a much lesser extent, the thermal structure of the southern California crust. The near-surface low Q_P and Q_S zones coincide with major sedimentary basins such as the San Bernardino, Chino, San Gabriel Valley, Los Angeles, Ventura, Santa Maria basins, and the Salton Trough. In contrast, at shallow depths beneath the Peninsular Ranges, southern Mojave Desert and southern Sierras, we image high Q_P and Q_S zones, which correspond to the dense and high velocity rocks of the mountain ranges. Several clear transition zones of rapidly varying Q_P and Q_S coincide with major late Quaternary faults and connect regions of high and low Q_P and Q_S. At mid-crustal depths the Q_P and Q_S form imbricate stacks of slightly higher and lower Q_P or Q_S zones, which is consistent with reported crustal reflectivity. In general, for the southern California crust, Q_S/Q_P is greater than 1.0, suggesting dry crust. A few limited regions of Q_S/Q_P less than 1.0 correspond to areas around some of the major strike-slip faults and the Salton Trough and suggest a larger reduction in the shear modulus compared to the bulk modulus or fluid saturation. (A manuscript describing this work is in press in JGR).

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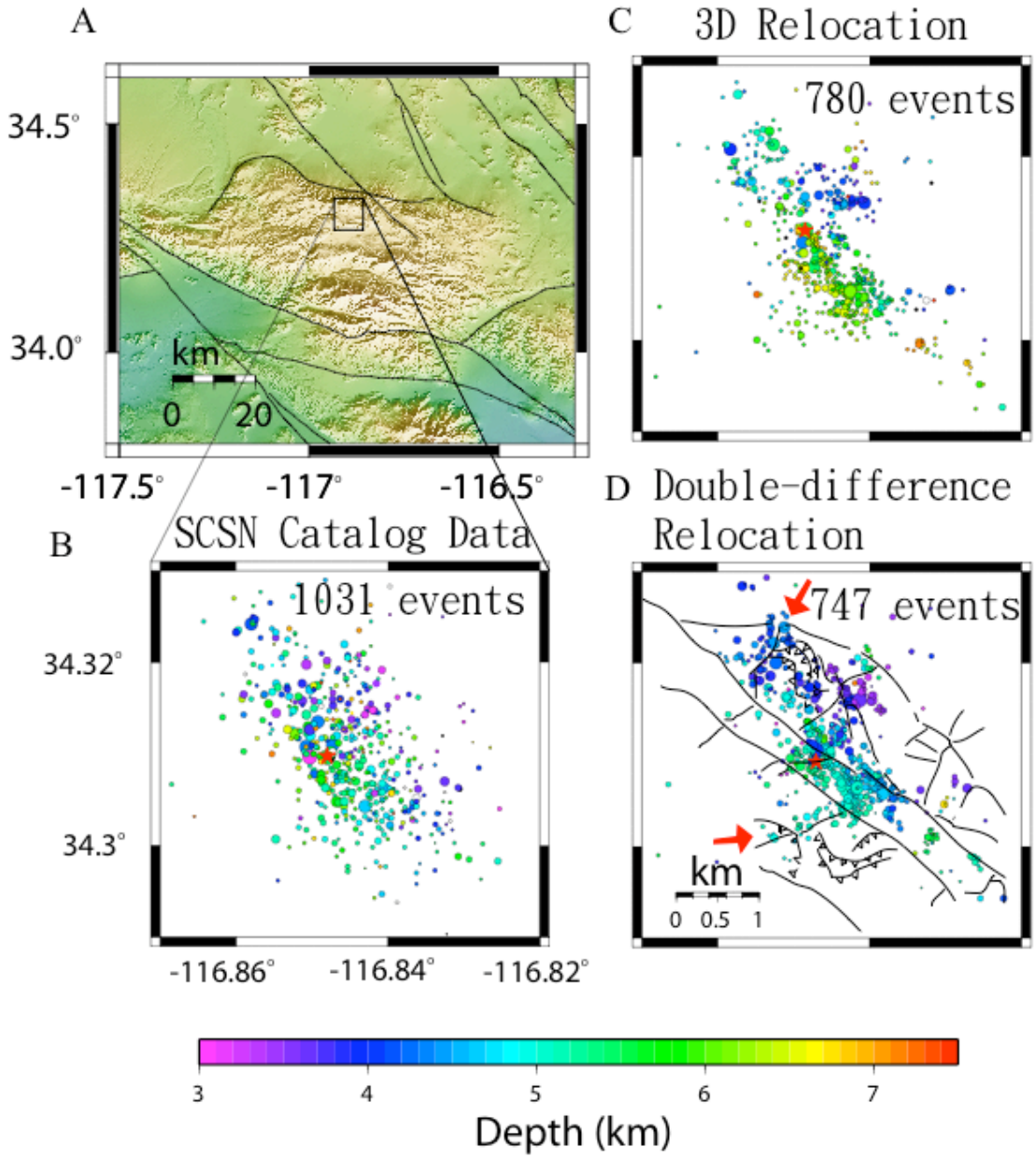

Figure 1. A) Location map of the 2003 Big Bear Sequence. For comparison, we have plotted the seismicity using the following: B) SCSN catalog, C) from 3D relocation (Hauksson, unpublished data), and D) from this study using double-difference relocation. The size of the circle is proportional to the magnitude of the earthquake. Color code shows the focal depth. The red star is the mainshock. We found good correlation between the double-difference relocated hypocenters and a published geologic map (Sadler, 1982) in this region. The 2 red arrows depict the 2 subvertical aftershock clusters which are perpendicular to the NW-SE trending mainshock fault.

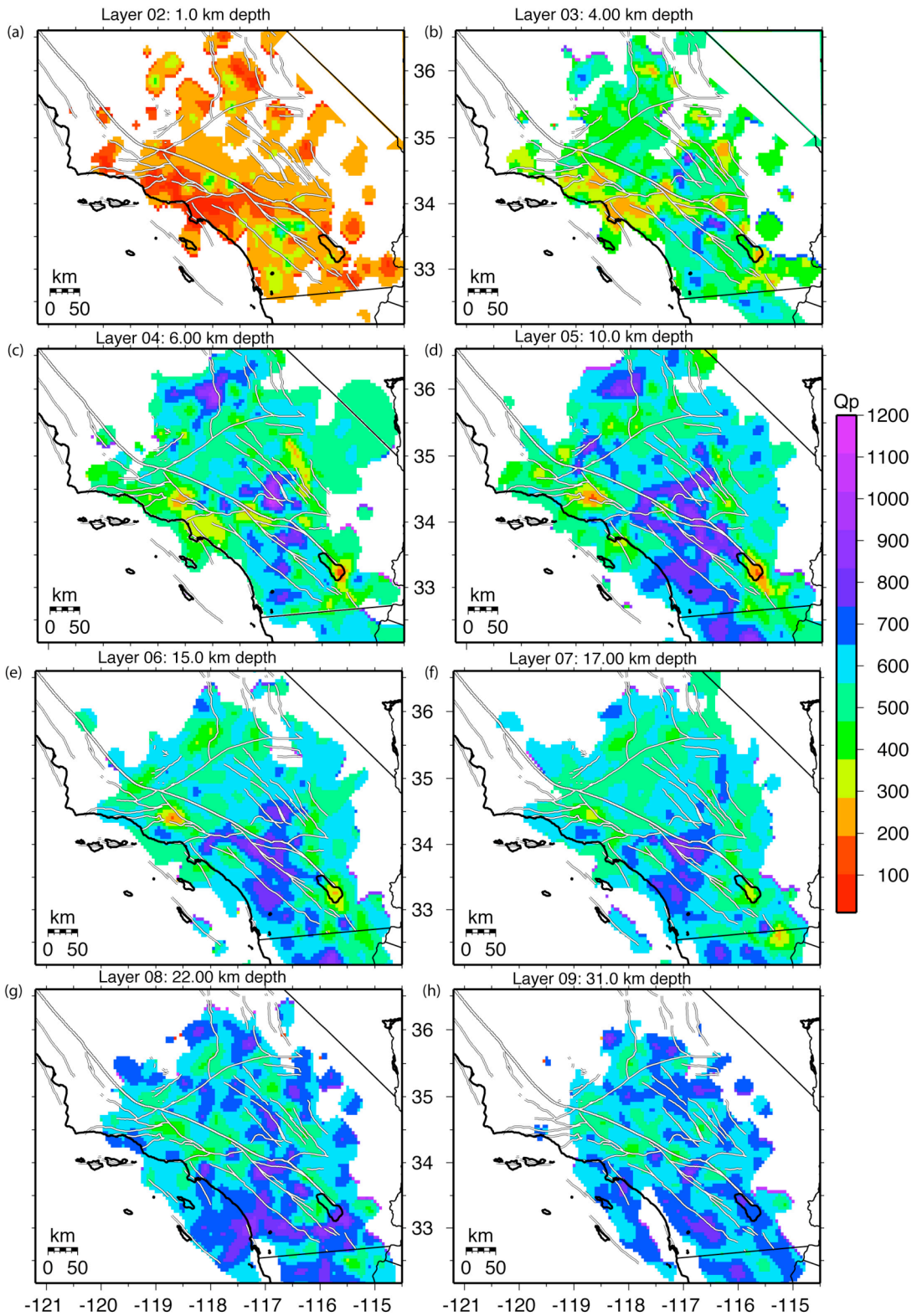

Figure 2. Q_P 3D model shown in map view in eight depth sections, at 1, 4, 6, 10, 15, 17, 22, and 31 km. The color bar shows the variations in Q_P. The model is not shown in areas with sparse ray coverage, or where the derivative weighted sum (DWS) is less than 2000.

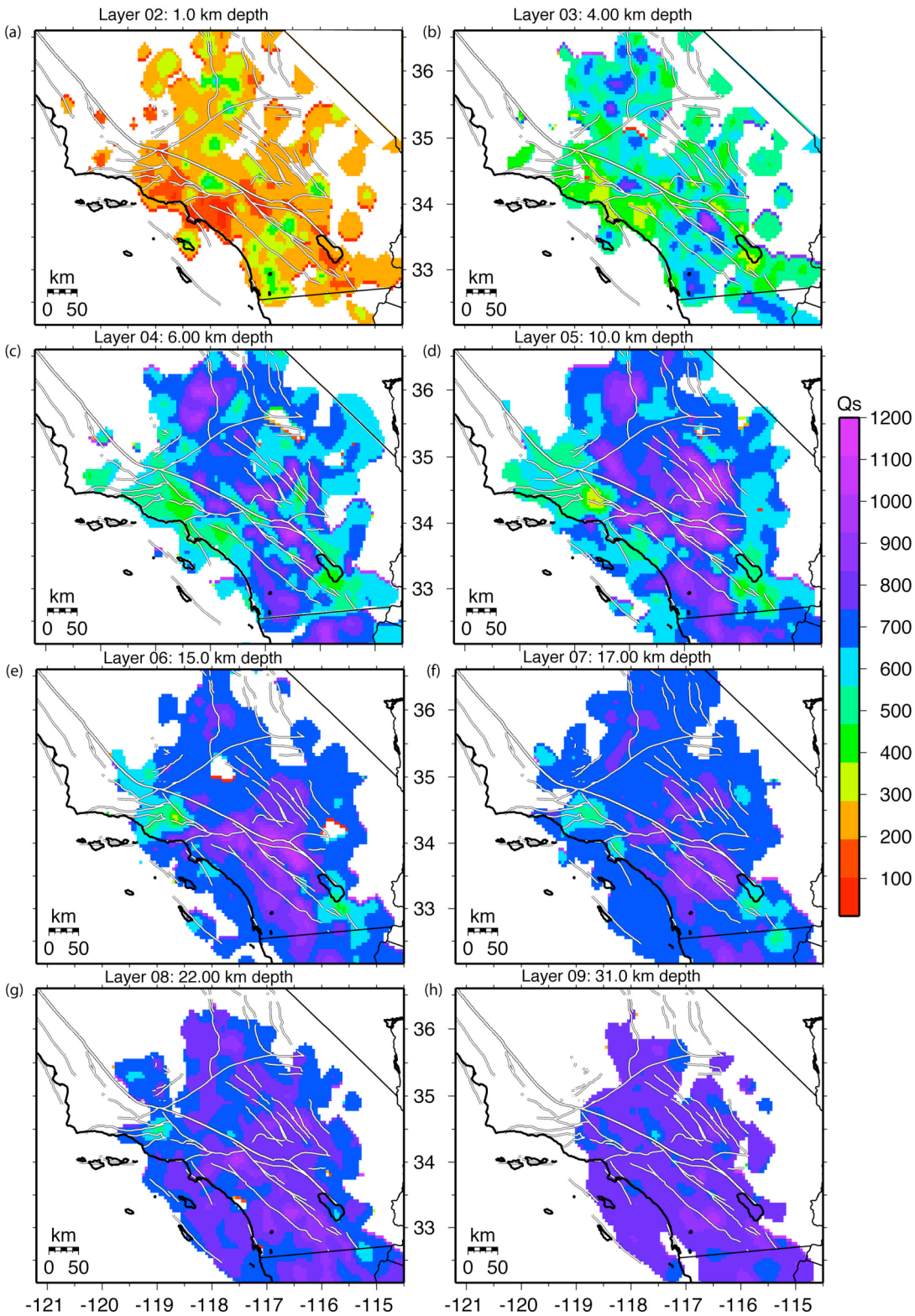

Figure 3. Q_S 3D model shown in map view in eight depth sections, at 1, 4, 6, 10, 15, 17, 22, and 31 km. The color bar shows the variations in Q_S. The model is not shown in areas with sparse ray coverage, or where the derivative weighted sum (DWS) less than 1000.