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Velocity structure of the Los Angeles and San Fernando Basins from Sonic Logs and Stacking Velocities

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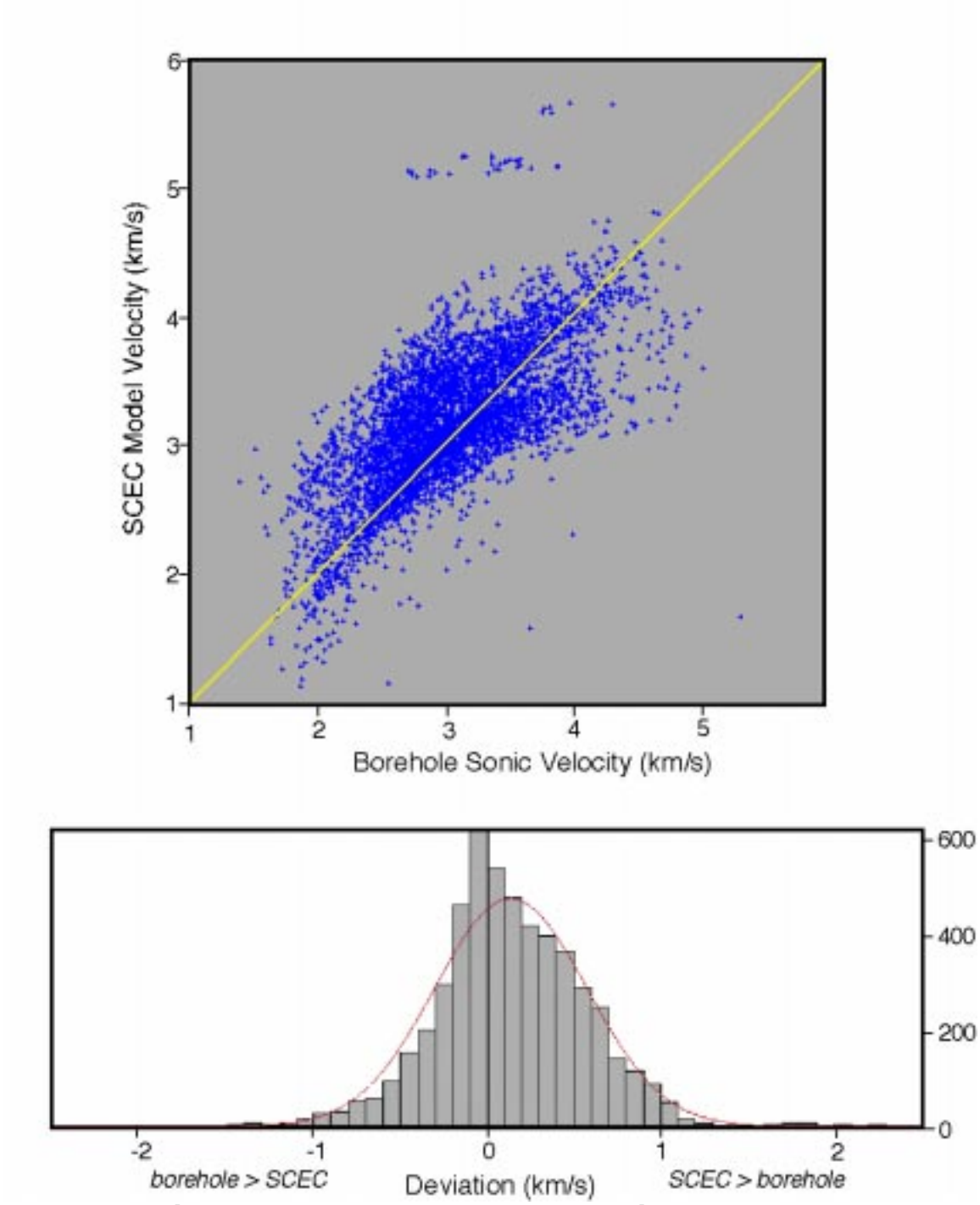
Introduction
We employed direct velocity measurements from our database of sonic logs and industry reflection profiles to evaluate the SCEC Phase 1 velocity model in Los Angeles basin and to develop regional velocity functions in the northern San Fernando basin. Our evaluation measures of the accuracy of the SCEC Phase 1 model, and defines systematic discrepancies between predicted and observed velocities that can be removed in subsequent iterations of the model. Our velocity functions in the northern San Fernando basin are being used by another SCEC investigator (P. Shearer) to relocate aftershocks of the 1994 Northridge (M 6.7) earthquake. These functions and supporting data from 10 sonic logs have been made available to the broader SCEC community through our webpage (http://structure.harvard.edu) for various seismological efforts, including processing of the LARSE 2 transect and calibration of the SCEC velocity model.

Evaluation of the SCEC 3D Velocity Model
We compared P-wave velocities in the SCEC Phase 1 model with measurements from more than 180 sonic logs in the Los Angeles basin. From the model, we prescribed velocities along the borehole paths and compared these values with borehole measurements averaged over 10 meter intervals. Our analysis demonstrates that the SCEC model provides a reasonable estimate of the average sediment velocities, with mean and median deviations of about 100 m/s between the bulk averages of the SCEC model and borehole velocities. The standard deviation between modeled and observed velocities is about 440 m/s, which represents up to 25% of the modeled velocities (Fig. 1).

Some of the deviations between modeled and observed velocities have spatial correlations. For example, the SCEC model typically over-estimates velocities on the basin margins, and underestimates the values in the central basin (Fig. 2). These lateral velocity variations are observed in all of our data types (borehole, stacking, and checkshot velocities), and can often be correlated with large structures (e.g., faults and folds) or stratigraphic facies variations. These insights may be used to calibrate subsequent iterations of the SCEC model, by calibrating parameters used in the rule-based functions and/or by helping to define new subregions of the model over which the functions are applied.



mean deviation = 134 m / s maximum deviation = 2422 m / s
median deviation = 99 m / s standard deviation = 440 m / s

Figure 1: Comparison of velocities in SCEC Phase 1 model with borehole sonic log measurements in the Los Angeles basin.

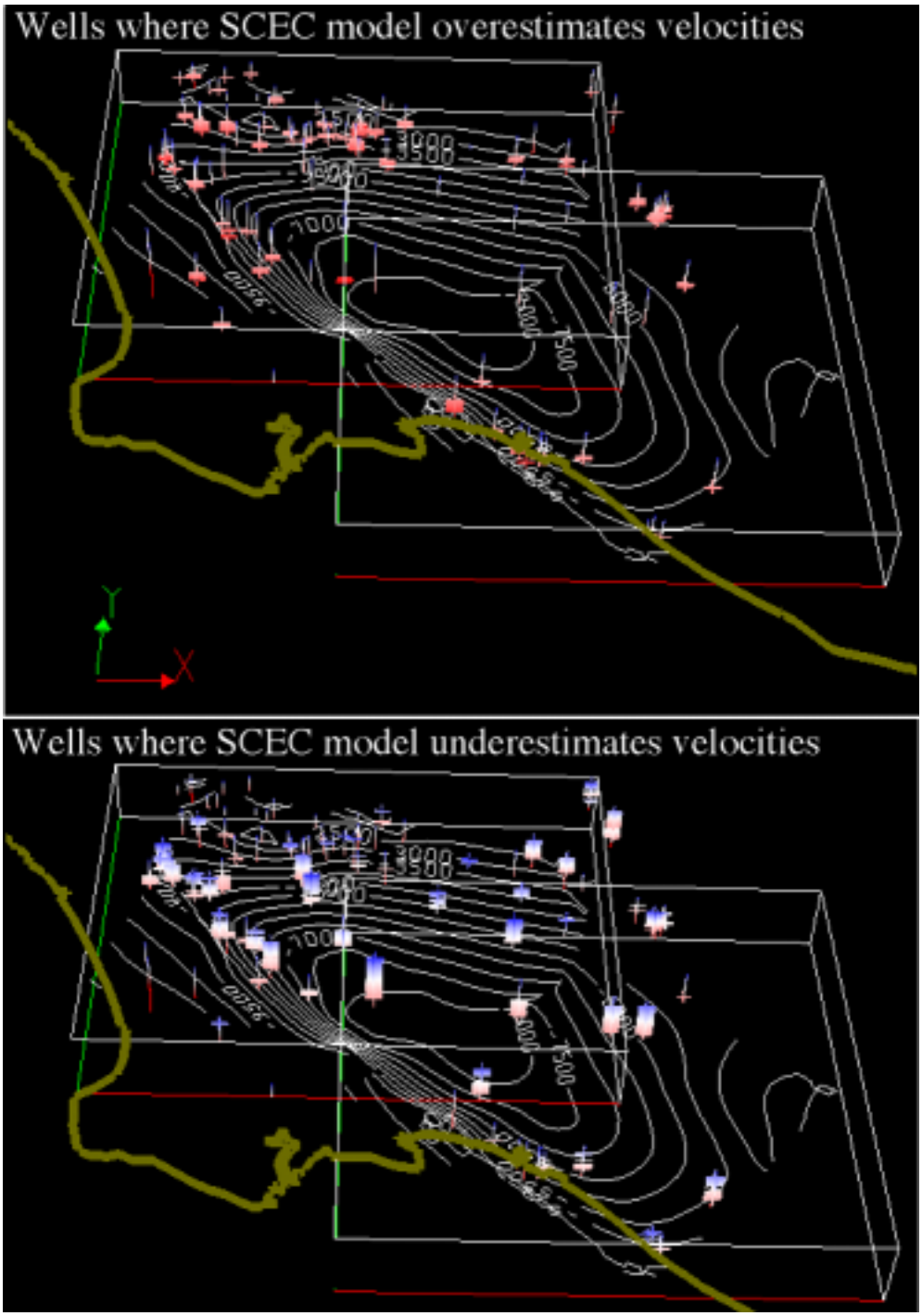


Figure 2: Perspective view of LA basin model showing locations of wells where observed velocities differ from those prescribed by SCEC Phase 1 model. Rectangular areas denote portions of wells that differ from modeled velocities.

New velocity functions in the northern San Fernando basin

In related efforts, we developed one regional velocity function and three SCSN station velocity functions for the northern San Fernando basin using borehole sonic log data. The functions show moderately increasing velocities with depth to about 3000 m subsea, below which the velocity gradient decreases (Fig. 3). The three SCSN station functions are located in the foothills of the Santa Susana Mountains, whereas the regional function includes wells in the mountains and the northern San Fernando Valley.

The lower limit of the functions represents the deepest log measurements in the region that are available in our database. These wells do not reach basement. The San Fernando basin contains a thick lower Miocene to Eocene clastic sequence above granitic basement. The deepest penetrated marker horizon in the vicinity of the stations is the top of the lower Mohnian stage of the Kleinpell in the Modelo Formation, which is an upper Miocene shale-siltstone sequence. This occurs at -3350m beneath stations VVD and NHL2, and -2590 m beneath NHL (depths subsea). Based on wells elsewhere in the basin, we estimate that ≥ 3,750 m of sediments may underlie the lower Mohnian marker in each of the wells.

Distribution of data and results

We provide the regional and SCSN velocity functions in the San Fernando basin, along with sonic logs (.las format) from ten wells, to the SCEC community through our webpage (http://structure.harvard.edu). Various logs, functions, and structural information were also provided to SCEC and other investigators to support their research efforts, including: P. Shearer, Scripps; R. Clayton, Caltech; M. Roy, Univ. of New Mexico, Don Argus, JPL; Robert Yeats, Oregon State; and Gary Fuis, USGS.

Related Publications

Shaw, J.H., and P. Shearer, 1999, An elusive blind-thrust fault beneath metropolitan Los Angeles, *Science*, 283, 1516-1518.

Shaw, J.H., M.P. Süss, & C. Rivero, 1999, Structural and seismologic investigations of concealed earthquake sources in the Los Angeles metropolitan area, SCEC Annual Meeting, Palm Springs, CA, (abs.)

Shaw, J. H., C. Rivero, M. P. Suess, and K. Mueller, 1999, Defining concealed earthquake sources with subsurface structural models, seismicity, and surficial neotectonic constraints, GSA Annual Meeting, Denver, Colorado, Abstracts with Program (abs).

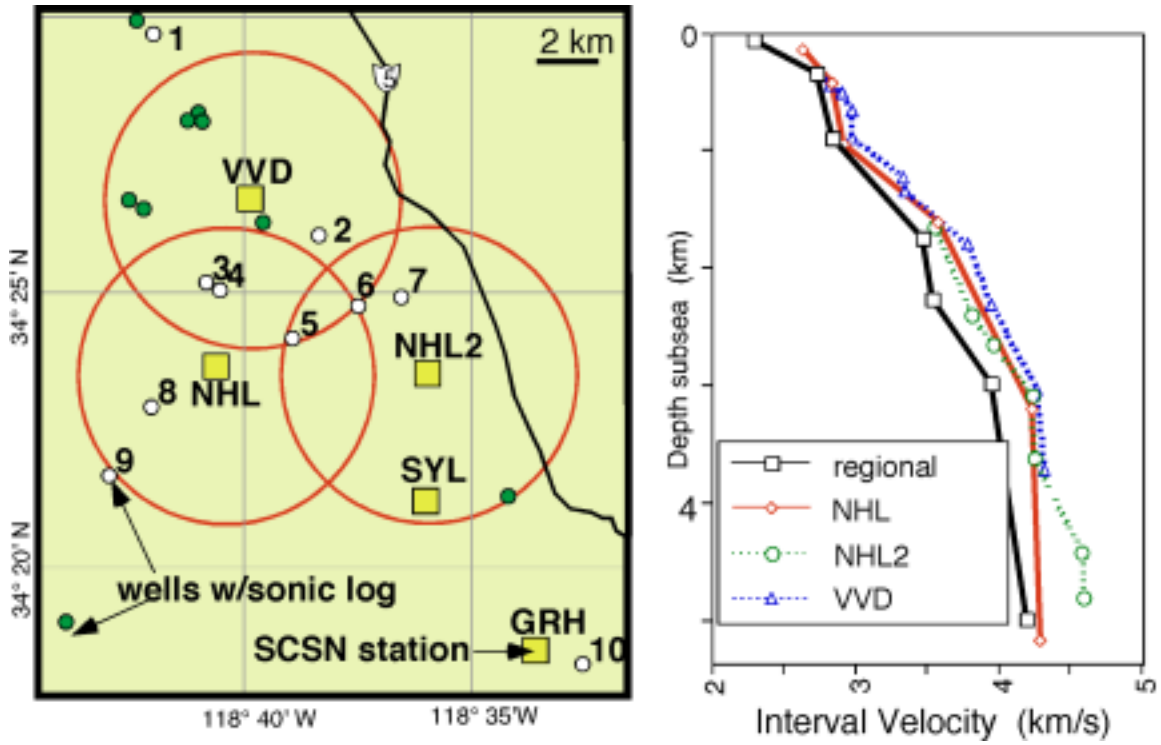


Figure 3: (left) map showing locations of wells with sonic logs used to develop regional and SCSN station velocity functions. Logs from numbered wells (listed below) are made available to the SCEC Community via our website. (right) Velocity functions derived from borehole sonic log data.

#	Well	Depth Range (ft, below kb)	
1	Hathaway30-1	900	6700
2	N.L.F-1	2980	10800
3	N.L.F.12-20	2400	4400
4	N.L.F.1-21	2600	5300
5	RanchoSanFrancisco_A-1	11600	17200
6	N.L.F.-28	5000	14100
7	N.L.F.-28B	14000	16700
8	N.L.F.1-19	700	6000
9	Broad_Oaks_120	100	2000
10	SFZU1B	3630	7700