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3D Seismic Velocity Models of Populated Southern California Basins

Harold Magistrale
San Diego State University

Model Description. We developed 3D basin sediment velocity models of the densely populated Los Angeles basin, San Fernando Valley, San Gabriel Valley, San Bernardino basin, Chino basin, and Ventura basin in southern California. See the figures in the annual report of the project "Setup of 3-D Velocity Model Version 1". The basin models are constructed in a forward sense by compiling information from structural cross sections, stratigraphic contour maps, geologic maps, and hydrological studies. These data are converted into reference horizons with various configurations and ages for use in a sediment age-depth-seismic velocity relation. At a point of interest for which the velocity is desired: (1) The age of the point is interpolated from the reference horizons above and below the point; (2) The maximum depth of burial is found by correcting the current depth by any known uplift; (3) The P wave velocity is determined from the Faust equation $V_p = k(da)^{1/6}$ where d is the depth, a is the age, and k is a constant. Density is found from the P wave velocity; density is used to find Poisson's ratio; and S wave velocity is calculated from the P wave velocity and Poisson's ratio. The constant k can be calibrated with any independent seismic velocity information.

In undeformed sediments the velocity increases monotonically with depth, rather than having constant velocity layers. The model formulation permits faster-over-slower velocities across structural discontinuities such as thrust faults. Any type of reference horizon or any type of velocity-depth function can be incorporated into the model. For example, surface velocities in the Los Angeles basin and San Fernando Valley can be constrained with geotechnical borehole measurements, and deeper sediments can have velocities constrained by oil well sonic logs. Any background model can be specified for the area outside the model and for crystalline basement rocks within the model.

The velocities for all the basins are generated by a single code. The model formulation provides a convenient framework to incorporate new structural or velocity information in the future. The use of the geologic information provides the fine spatial resolution needed for ground motion simulations.

Project Tasks. The project accomplished these tasks:

(1) Preparation of the basin model to be the core of the SCEC 3D southern California seismic velocity model Version 1. The basins model was tuned to match recently released oil well P-wave sonic logs. This was accomplished by altering the constant k in the Faust relation. Each basin covered by sonic log data (Los Angeles, San Fernando, San Gabriel) had independent constants determined. Glitches due to inappropriately overlapping reference horizons were detected and fixed in the model generating code. I attended numerous SCEC workshops planning the Version 1 model.

(2) Construction of a Salton Trough velocity model. While not densely populated, the Salton Trough (comprising the Imperial and Coachella Valleys) plays an important role in the tectonic evolution of southern California and may influence regional seismic wave propagation. I digitized the P-wave seismic velocity cross sections (based on seismic refraction lines) from Fuis et al. (1982), Fuis and Kohler (1984), Mooney and McMechan (1982), and Parsons and McCarthy (1996), and converted the cross section information into isovelocity surfaces. The model is generated by a code (derived from the basins model code) that reads the isovelocity surfaces and interpolates the

velocity at any point of interest within the Salton Trough. Outside the Salton Trough, the code assigns velocities interpolated from the southern California tomographic model of Hauksson (1997; personal communication, 1998). This task provides a velocity model for a large area for southern California, and provides experience in merging rule-based models and tomographic results. Figure 1 shows a depth slice through the model.

(3) Distribution of the velocity model to researchers. I generated and distributed seismic velocity and density parameters at millions of points to scientists at the USGS Menlo Park, USGS Pasadena, UC Santa Barbara, Woodward-Clyde Federal Services, San Diego State University, Brigham Young University, the Jet Propulsion Lab, and University of Texas, Dallas. I worked with Rob Clayton to install the Version 1 3D model at the SCEC Data Center.

1998 Publications and Products:

Magistrale, H., R. Graves, and R. Clayton, 1998, A standard three-dimensional seismic velocity model for southern California: Version 1, *EOS Trans. AGU* **79**, p. F605.

The Version 1 3D model generating code and associated model files are available on the SCEC Data Center at <http://www.scecdc.scec.org>.

References

Fuis, G. S. and W. M. Kohler, Crustal structure and tectonism of the Imperial Valley region, California, in *The Imperial Basin-tectonics, Sedimentation and Thermal Aspects*, edited by C.A. Rigsby, pp. 1-13, Pacific Section SEPM, Los Angeles CA, 1984.

Fuis, G. S., W. D. Mooney, J. H. Healey, G. A. McMechan, and W. J. Lutter, Crustal structure of the Imperial Valley region, in *The Imperial Valley, California, earthquake of October 15, 1979*, p. 25-50, U.S.G.S. Pro. Pap. 1254, Washington, D. C., 1982.

Hauksson, E., Three-dimensional Vp and Vp/Vs velocity models of southern California, (abstract), *Seismol. Res. Lett.* **68**, p. 321, 1997.

Mooney, W. D. and G. A. McMechan, Synthetic seismogram modeling for the laterally varying structure in the Imperial Valley, in *The Imperial Valley, California, earthquake of October 15, 1979*, p. 101-108, U.S.G.S. Pro. Pap. 1254, Washington, D. C., 1982.

Parsons, T., and J. McCarthy, Crustal and upper mantle velocity structure of the Salton trough, southeast California, *Tectonics* **15**, 456-471, 1996.

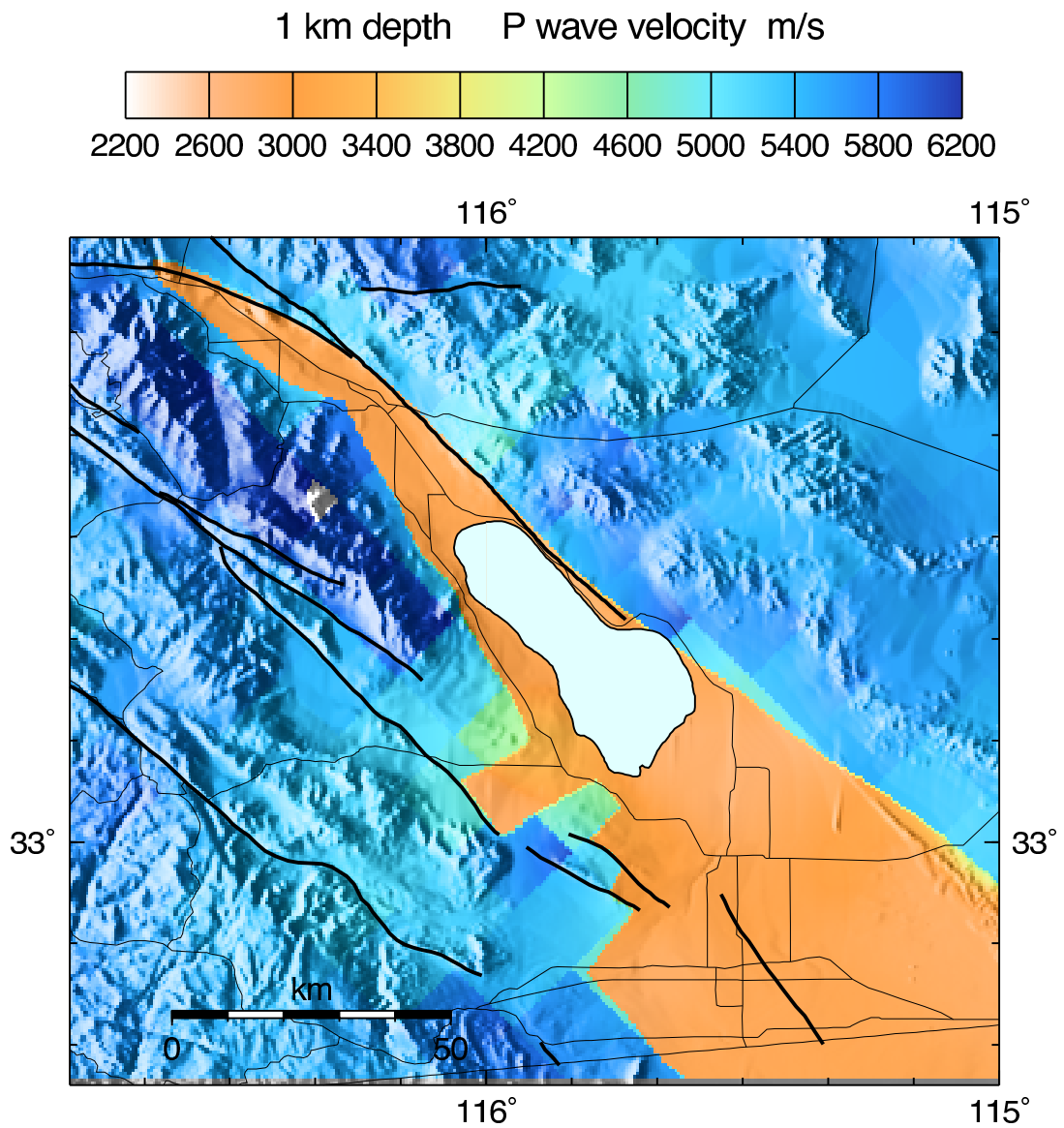


Figure 1. P-wave velocities at 1 km depth in the Salton Trough model. The velocities are given by a rule-based model within the trough, and by tomographic results outside the trough.