Annual Report 1998
Crustal Deformation Velocity Map
Zhengkang Shen and Li-yu Sung, UCLA
Group E

Crustal Deformation Velocity Map V2.0

The Crustal Deformation Working Group released its crustal deformation velocity map v2.0 (http://www.scecdc.scec.org/group_e/release.v2) at the SCEC annual meeting October 18, 1998. This product was achieved under intensive collaboration of numerous research groups, particularly the group E members at MIT, JPL, USGS, and UCLA. The UCLA group played a leading role in the effort. This newly released velocity map results from an analysis of nearly all the EDM, VLBI, and SCEC archived GPS data acquired for southern California between 1970 and 1997. The map includes 363 station velocities (Fig. 1) for which the uncertainty in horizontal velocity is less than 5 mm/yr. For stations close to the Landers epicenter, we have provided estimates of both the pre- and post-Landers velocities.

The most important differences between v2.0 and v1.0 (October 1996) are the direct use of the VLBI data and the addition of GPS data from continuous observations since 1992, post-Landers surveys of the epicentral region, a 1992 survey of about 60 stations in and around the Los Angeles basin, and a 1997 re-survey of about 60 stations in the southern San Andreas system. These additions have added 76 stations to the map and have reduced 2/3 of the station velocity uncertainties to about 1 mm/yr. Details about the data origins, data processing and modeling procedure, and numerical results can be found at the web site given above and will not be repeated here.

Temporal Change of Crustal Deformation after Landers Earthquake

The v2.0 velocity map was derived under the assumption that no velocity change occurred except at a few sites where enough pre- and post-earthquake measurements were available to derive pre- and post-velocities that show significant difference. To investigate the possibility of large scale deformation rate change after the earthquake, we tried another modeling of the GPS data, allowing different velocities for the southern California sites while keeping velocities of the global fiducial sites constant. The result is shown in Fig. 2. It is evident that the sites located near the epicentral region of the Landers earthquake have had significant changes of the velocities after the earthquake. The individual changes are marginal at some sites, but the overall pattern is consistent and convincing. The data collected immediately after the earthquake were excluded from the analysis because transient post-seismic effects affected them. The data included in the analysis were those collected in a time period from late September 1992 (3 months after the event) until 1997. While post-seismic transients may still affect the estimated velocities in the second time period, the secular deformation over several years should dominate; thus our results strongly suggest that the long-term deformation velocity really changed at the time of the Landers earthquake. Fig. 2 also shows the Landers co-seismic displacements at the sites. The velocity changes seem to point in the same directions as the co-seismic displacements,

suggesting the deformation originated from the epicentral region. The velocity changes decrease with distance less than the co-seismic displacements do, suggesting that the post-seismic effects have a source deeper than the seismogenic zone, or that they involve viscoelastic deformation over a broad region. We also combined the pre-Landers GPS velocity solution with that of VLBI and EDM. The result and the post-Landers velocities have been used in our modeling and interpretation of the pre- and post-Landers deformation field (see our report to Group A: Kagan at al, Stress Modeling).

Recent Data Processing

More data have been processed recently at UCLA and the solutions will be included in the next velocity map release. The data sets are Landers 97-98, Ventura Basin 93, Cholame 89, Caltrans (District 7) 92 and post-Northridge joint survey 94. The last two data sets will be useful for a complete update of the Northridge co-seismic solution.

Figure Captions

Figure 1. Crustal deformation velocity map v2.0 in a "plate boundary coordinate system" halfway between the North American and Pacific plates. Arrows represent horizontal station velocities with half of the NUVEL-1A Pacific-North America relative motion removed. Each arrow starts from the site location and points to the motion direction. Magenta and blue arrows are velocities derived from data with and without post-Landers deformation effects respectively. Error ellipses represent 95% confidence. Stars represent recent earthquakes whose co-seismic effects are modeled in the velocity map solution.

Figure 2. Velocity changes after the Landers earthquake, shown by red arrows. Error ellipses represent 95% confidence, assuming pre- and post-Landers velocities are uncorrelated. Light purple arrows are the co-seismic displacements solved by the project of SCEC velocity map v2.0.

Publications Resulting from This Project:

http://www.scecdc.scec.org/group_e/release.v2

Jackson, D. D., Z.-K. Shen, D. Potter, X.-B. Ge, and L. Sung, Southern California deformation, Science, 277, 1621-1622, 1997.

Rydelek, P. A., S. I. Sacks, Z.-K. Shen, D. D. Jackson, and L. Sung, Crustal deformation measured in southern California [discussion and reply], EOS, Trans. Am. Geophys. Union, 79, No. 22, p. 260, 1998.