Anomalous em signals and changes in resistivity at Parkfield: Collaborative research between the universities of California at Berkeley and Riverside and Oregon State University

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Investigations Undertaken

Fluctuations of resistivity are monitored with an array measuring natural electric currents (telluric currents) in Parkfield. Telluric coefficients x and y relate the electric field on dipoles to arbitrarily chosen reference dipoles 7 and 8 (Figure 1):

$$D_i = x\,D_7 + y\,D_8 \,. \qquad (1)$$

Fractional daily variations of the telluric coefficients are computed and then compared to the earthquake record from Parkfield in order to determine if significant changes occurred prior to or at the time of local earthquakes. Changes in the telluric coefficients are related to changes in resistivity, albeit in a complicated manner because the earth is heterogeneous.

Electrical resistivities of samples of sedimentary rocks outcropping in Parkfield were measured, and the results were used with structural geological information to reinterpret magnetotelluric data collected in the vicinity of SAFOD.

Results

No significant fluctuations in the telluric coefficients were observed in 2003 (Figures 2-6), as expected because there were no earthquakes with magnitudes greater than 4.0. Park (1997) determined that a minimum magnitude greater than 5.0 would be necessary to produce significant fluctuations. Degradation of telephone line quality is beginning to affect our data, as seen in Figures 4, 6, and 7. Gaps in the fluctuations are due to telluric data that are too noisy to yield stable projections. The only solution appears to be replacement of the buried cable, and Verizon is reluctant to do this.

Robust processing with Larsen et al.'s [1996] modified code is proceeding, but difficulties persist because of timing errors in the pre-1998 data. This fall, a week of intensive effort has identified most, if not all, of these and we anticipate that comparisons to magnetic fields at Fresno, Boulder, and Tucson should be complete by the end of the year. The timing is important if the signals are referenced to other data but not if the data are only internally referenced.

A major step this year has been to automate the routine data analysis and release PI time for construction of a 3-D resistivity model for Parkfield. This model will be combined with MT data from Unsworth et al. (1997;2000) for an inversion to refine this model.

Park and Roberts (2003) measured resistivities of samples of sedimentary rocks outcropping in Parkfield and then proposed that the low resistivities along the San Andreas fault south of

SAFOD are actually sediments of the Parkfield syncline and not fractured basement rock. They propose further that the seismogenic portion of the San Andreas fault is actually southwest of the Parkfield syncline, thus lining the fault up with seismicity mapped by Thurber et al. [2003].

Non-technical Summary

Prediction experiments worldwide fall into two types: widely distributed instruments monitoring signals from both local and distant earthquakes; and dense clusters of instruments focused on a specific earthquake zones. The Parkfield experiment is unique because it focuses a broad range of geophysical instruments on a specific earthquake source. It has become clear that the distribution and movement of fluid affects the generation of earthquakes, and electrical properties of rocks can detect this fluid. Monitoring of the electrical resistivity may detect a change before the earthquake but more importantly, will show how fluid affects the fault zone prior to its failure. Because Parkfield has experienced no earthquakes with magnitudes greater than 5.0 since the inception of the experiment in 1988, no reliable fluctuations of resistivity have been observed. The M~6 characteristic earthquake is expected to produce changes above the noise level (~0.2%) of the experiment.

Reports published

Park, S.K. and J.J. Roberts, Conductivity Structure of the San Andreas Fault, Parkfield, Revisited, *Geophys. Res. Lttrs, 30*, doi:10.1029/2003gl017689, 2003.

Data availability

Processed results and original time series data from 1988-2000 are available via anonymous ftp at vortex.ucr.edu in the directory pub/emsoc/1/pkfld. Time series for 1988-1997 are also available at the site.

References

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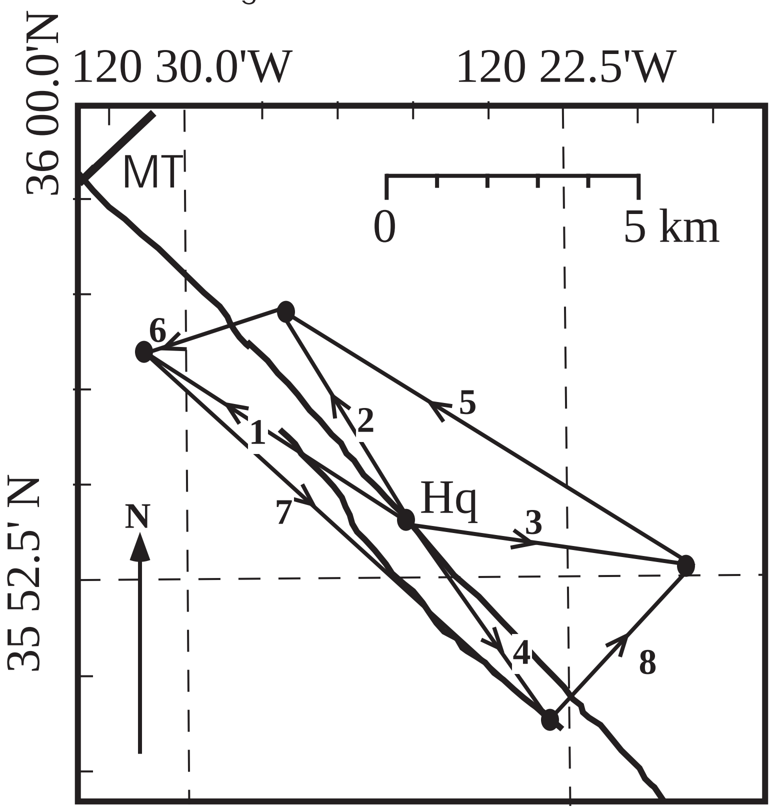
Park, S.K., Monitoring resistivity changes in Parkfield, California: 1988-1995, *J. Geophys. Res., 102*, 24545-24559, 1997.

Thurber, C., S. Roecker, K. Roberts, M. Gold, L. Powell, and K. Rittger, Earthquake locations and three-dimensional fault zone structure along the creeping section of the San Andreas fault near Parkfield, CA: preparing for SAFOD, *Geophys. Res. Lett., 30*, 10.1029/2002GL015004, 2003.

Unsworth, M.J., P.E. Malin, G.D. Egbert, and J.R. Booker, Internal structure of the San Andreas fault at Parkfield, California, *Geol., 25*, 359-362, 1997.

Unsworth, M., Bedrosian, P., Eisel, M., Egbert, G., and Siripunvaraporn, W., Along strike variations in the electrical structure of the San Andreas Fault at Parkfield, California, *Geophys. Res. Lett., 27*, 3021-3024, 2000.

Figure 1 - Location map showing array in Parkfield. Dipoles 1-8 are labeled and polarities are shown with arrows. Heavy Black lines are strands of the San Andreas fault. Dipoles 7 and 8 are used as references for dipoles 1-6. Line labeled 'MT' is the profile reinterpreted by Park and Roberts [2003] and shown in Figure 8.



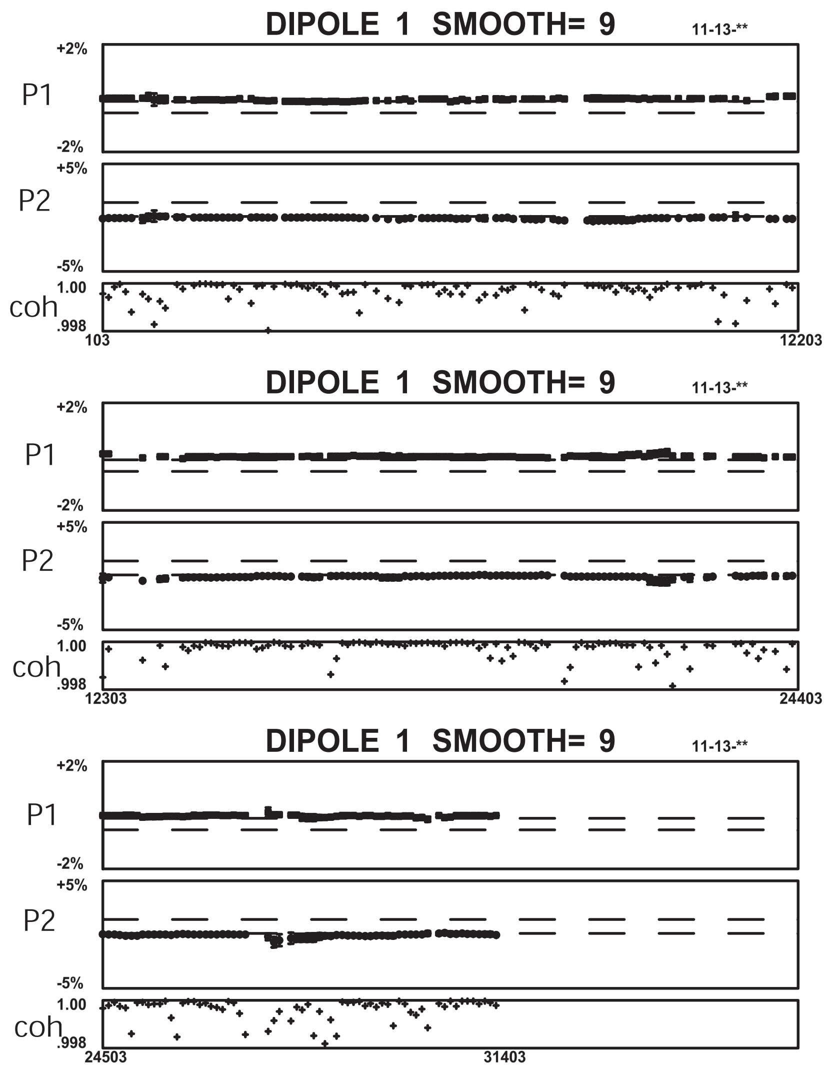


Figure 2- Projections of daily fluctuations of telluric coefficients for dipole 1 in directions perpendicular (P1) and parallel (P2) to the San Andreas fault. Coherency for the signals is shown as a measure of data quality. Nine day running average is used to smooth out the daily fluctuations and achieve stabilities of < 1%. Data are plotted through Julian day (31403; day 314 in 2003).

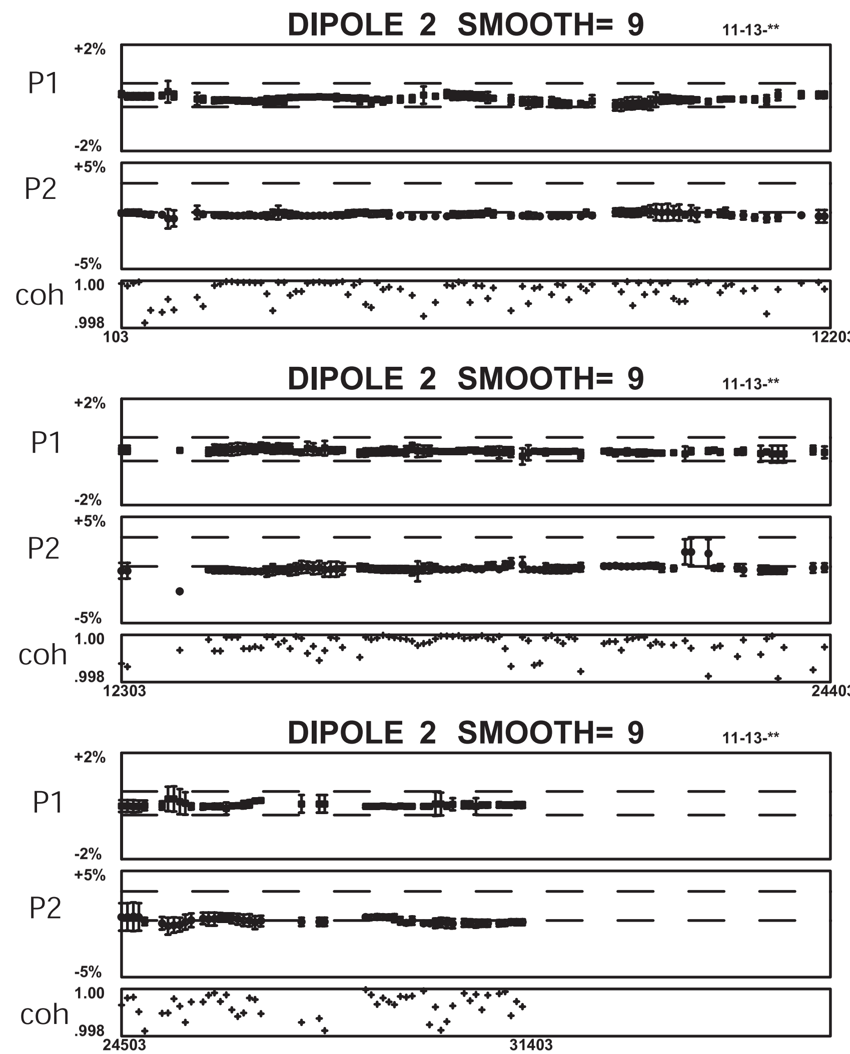


Figure 3- Projections for dipole 2 for 2003. See Figure 2 caption for explanation. Note that this dipole is much noisier than dipole 1, as indicated by the larger error bars. Gaps in data are due to noisy telephone line to electrode at Hr (Figure 1).

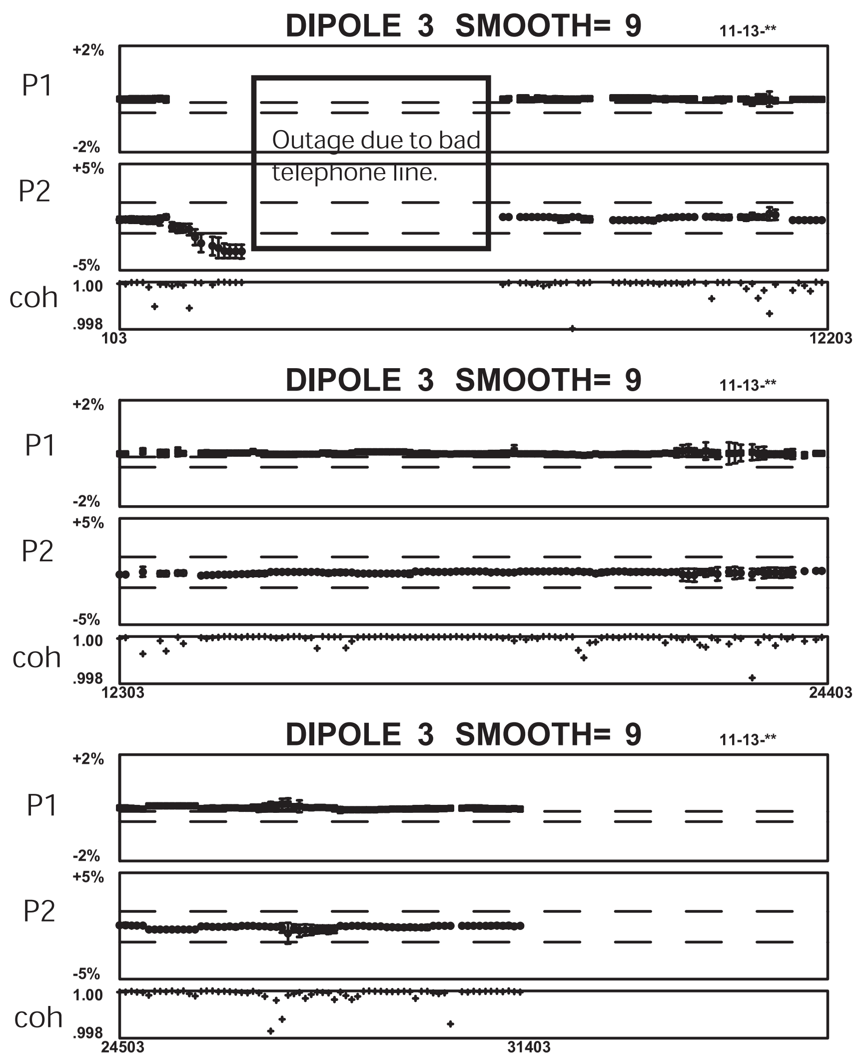


Figure 4- Projections for dipole 3 for 2003. See Figure 2 caption for explanation.

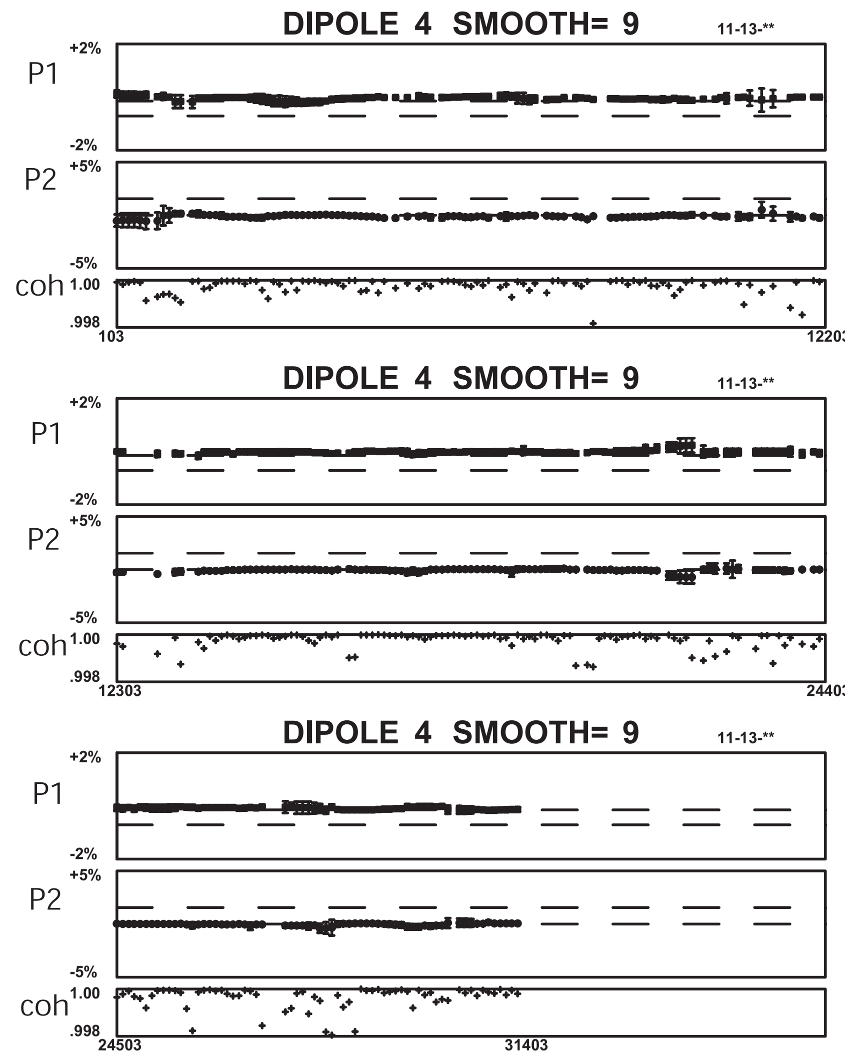


Figure 5- Projections for dipole 4 for 2003. See Figure 2 caption for explanation.

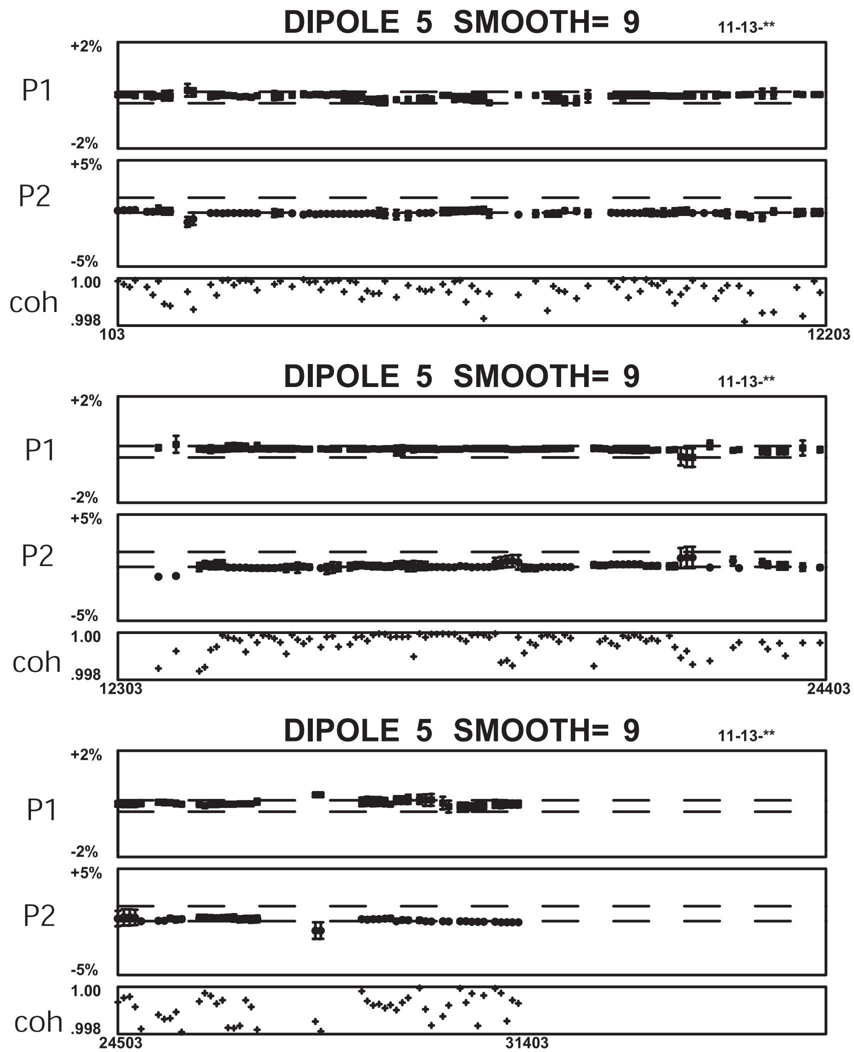


Figure 6- Projections for dipole 5 for 2003. See Figure 2 caption for explanation.

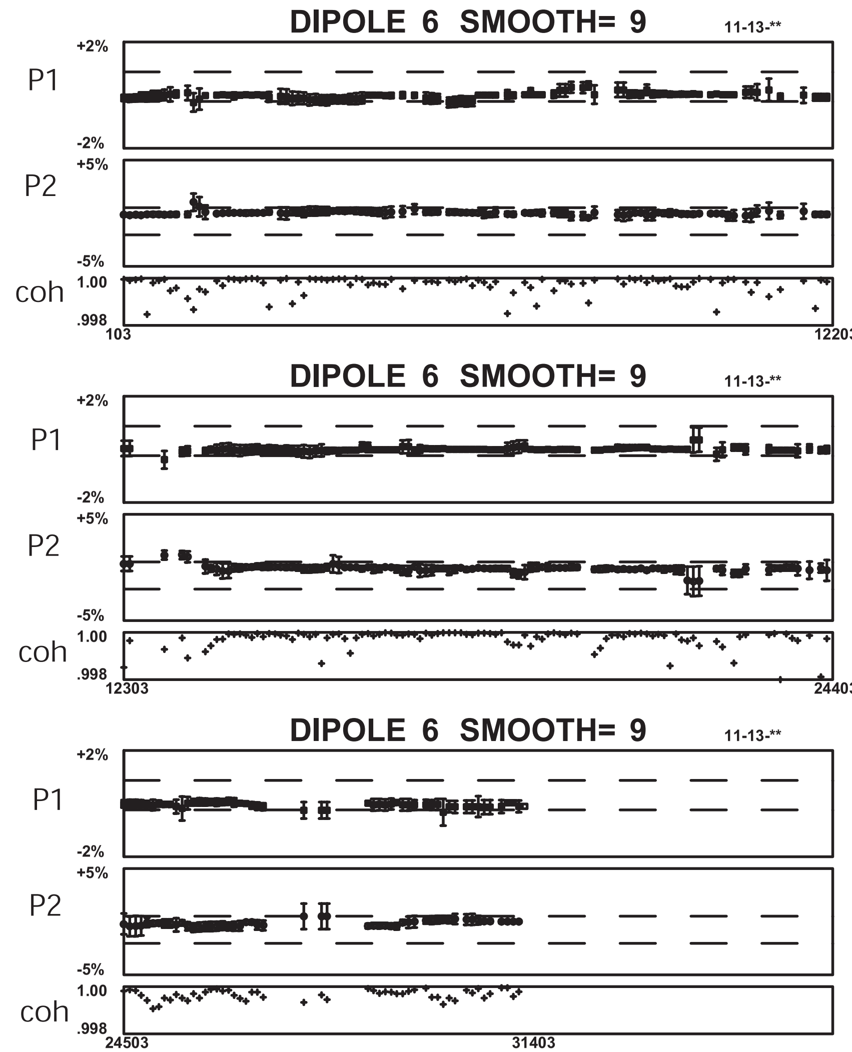


Figure 7-Projections for dipole 6 for 2003. See Figure 2 caption for explanation.

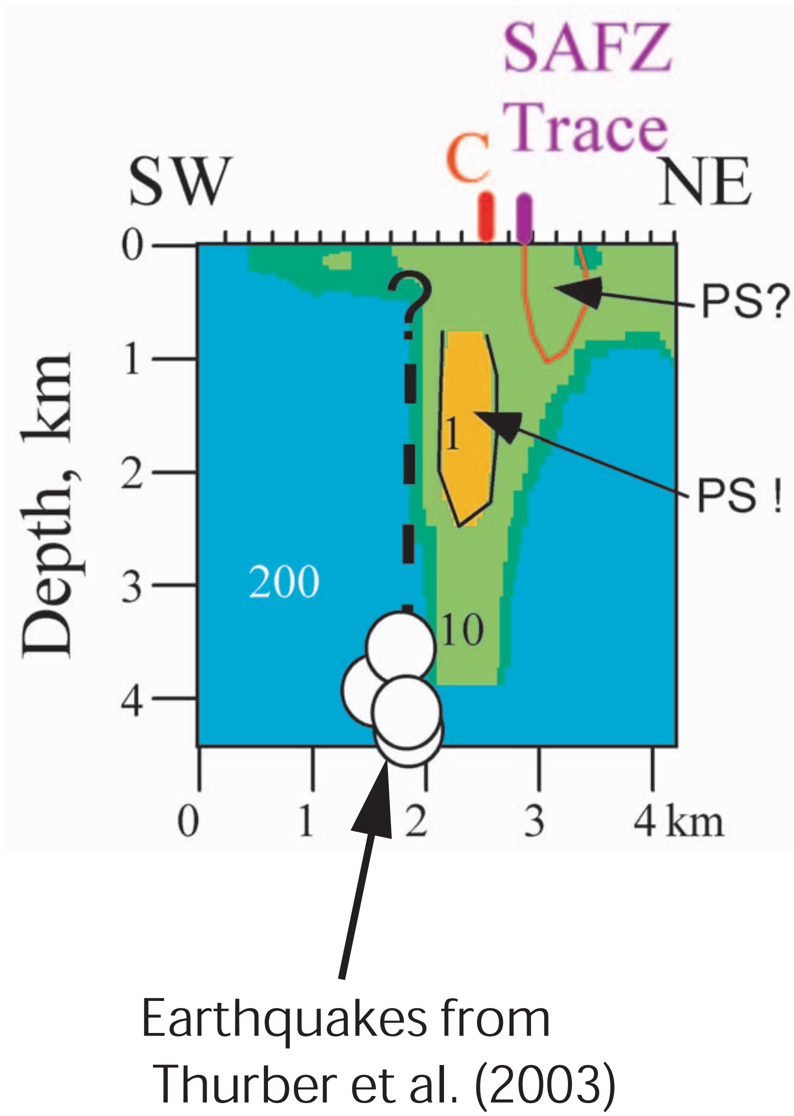


Figure 8 - MT-derived resistivity section showing expected location of Parkfield syncline (PS?) and proposed location (PS!). Dashed line is proposed location of seismogenic San Andreas fault to southwest of Parkfield syncline. Other symbols used are: C, crest of Middle Mountain; SAFZ trace, surface trace of San Andreas fault zone.