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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Element 1 - Keywords: geophysics,tectonophysics

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:

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

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.

Results

In 2001, the geometry of the array was changed because the central electrode (Hq; Figure 1) had to be moved. New average coefficients were determined by averaging all results for 2001, and these are now used as a reference for fluctuations in 2002. The daily variations for dipoles 1-6 (Figures 2-7) are compared to these new average coefficients. A block of missing data is seen from day 190 to day 240 is due to failure of the telephone line to Hr (Figure 1); it was unclear that a substitute cable pair could be found for this electrode. Otherwise, the data acquisition was unremarkable.

One M3.8 earthquake occurred in Parkfield during this reporting period. No significant fluctuations were observed in association with this earthquake. This lack of variation is expected for an earthquake this small (Park, 1997; Park, 2002). Although the system was altered in 2001, the data continue to show good stability of the residuals (Figures 2-7).

Larsen et al.'s [1996] robust processing program was modified to analyze the telluric data and produces results similar to those shown in Figures 2-7. Residuals are comparable, but comparison of the telluric data to magnetic data from observatories from Fresno, Boulder, and Tucson results larger variations. These variations are due partly to timing errors in the older data and possibly noise at Fresno. Efforts are continuing to reduce the random fluctuations seen in Figures 2-7 to lower levels, thereby increasing the sensitivity of the array to small resistivity fluctuations.

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., Perspectives on Monitoring Resistivity Changes with Telluric Signals at Parkfield, California: 1988-1999, *J. Geodynamics, 33*, 379-400, 2002.

Uyeda, S. and S.K. Park, Preface (to special issue on Recent Investigations of Electromagnetic Variations Related to Earthquakes), *J. Geodynamics, 33*, 377-378, 2002.

Data availability

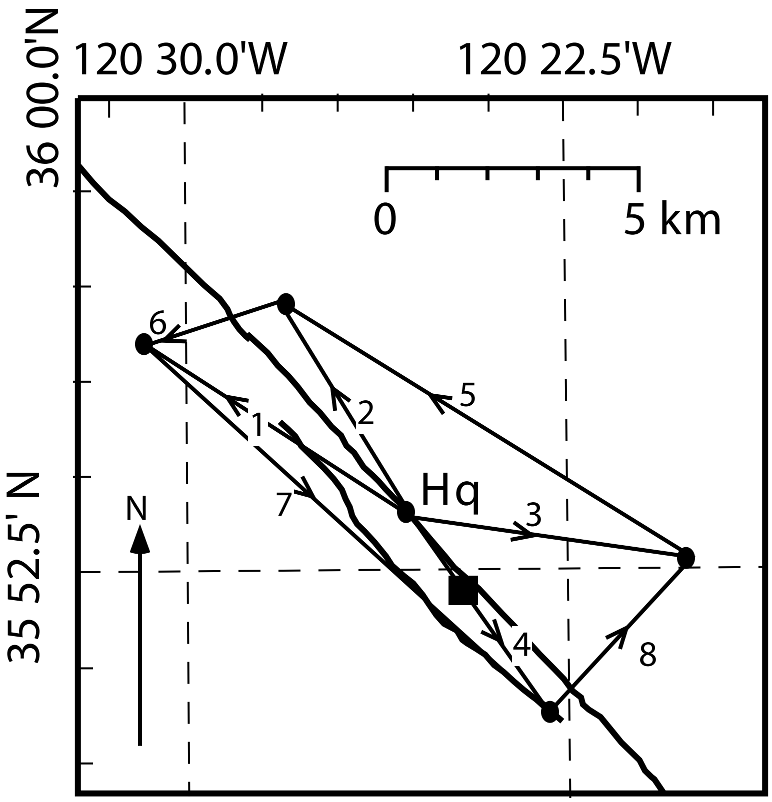
Processed results and original time series data from 1988-2000 are available via anonymous ftp at vortex.ucr.edu in the directory pub/emsoc/1/pkfld. Time series for 1988-1997 are also available at the site.

References

Larsen, J.C., Mackie, R.L., Manzella, A., Fiordelisi, A., and Rieven, S., Robust smooth magnetotelluric transfer functions. *Geophys. J. Intl., 124*, 801-819, 1996.

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

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. Black square shows location of M3.8 earthquake in September, 2002.



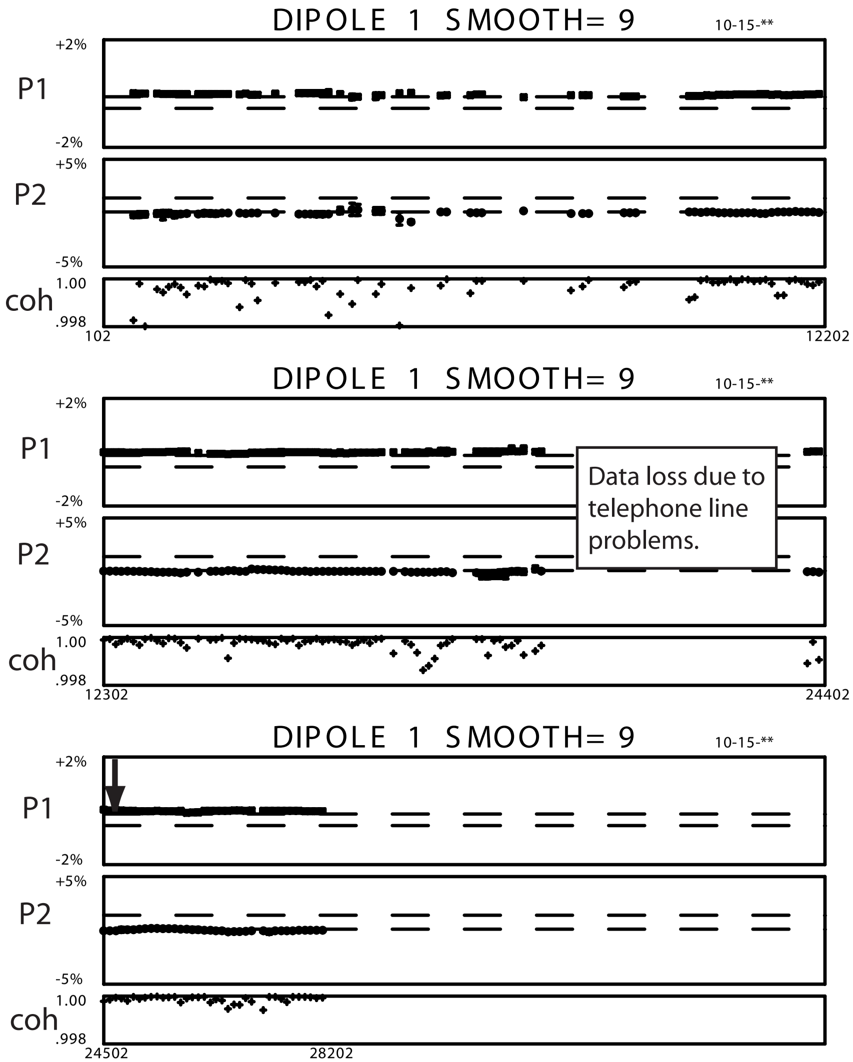


Figure 2- Projections of daily fluctuations of telluric coefficients for dipole 1 in directions perpendicular (P1) and parallel (P2) to the San Andreas fault. Coherency for the signals is shown as a measure of data quality. Nine day running average is used to smooth out the daily fluctuations and achieve stabilities of < 1%. Data are plotted versus Julian day (12302 is day 123 in 2002). Note lack of changes assocaiited with 2002 earthquake (arrow).

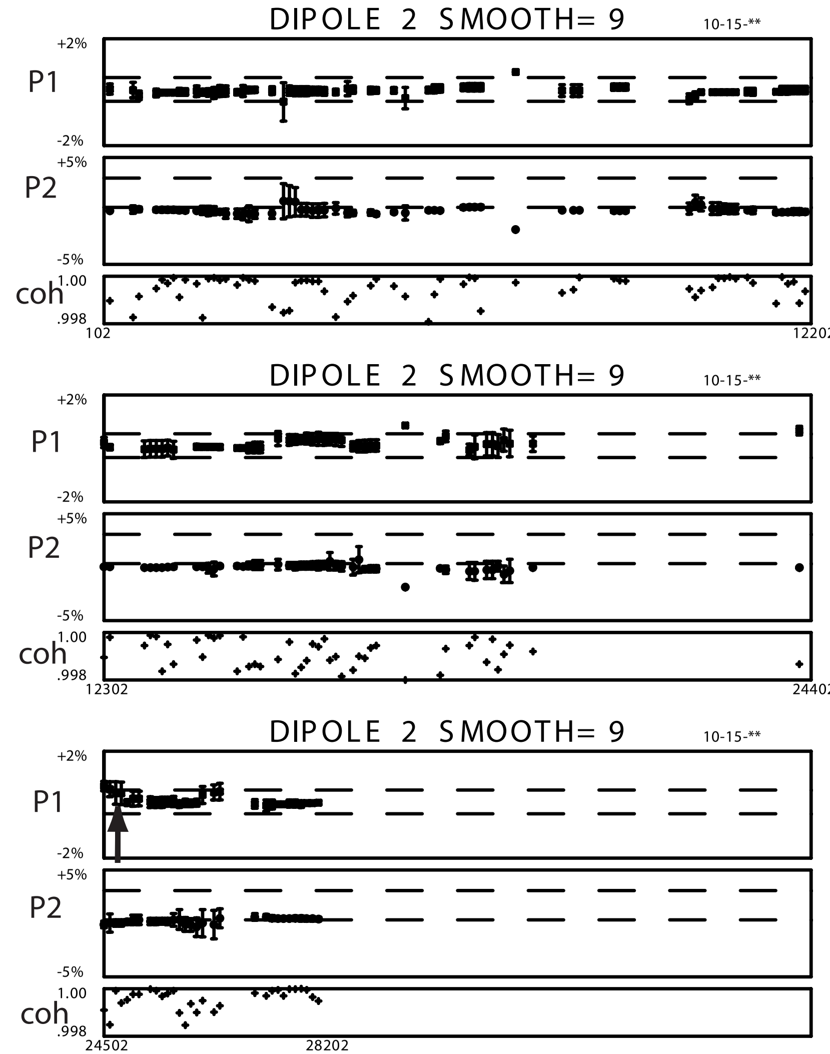


Figure 3- Projections for dipole 2 for 2002. See Figure 2 caption for explanation. Note that this dipole is much noisier than dipole 1, as indicatd by the larger error bars.

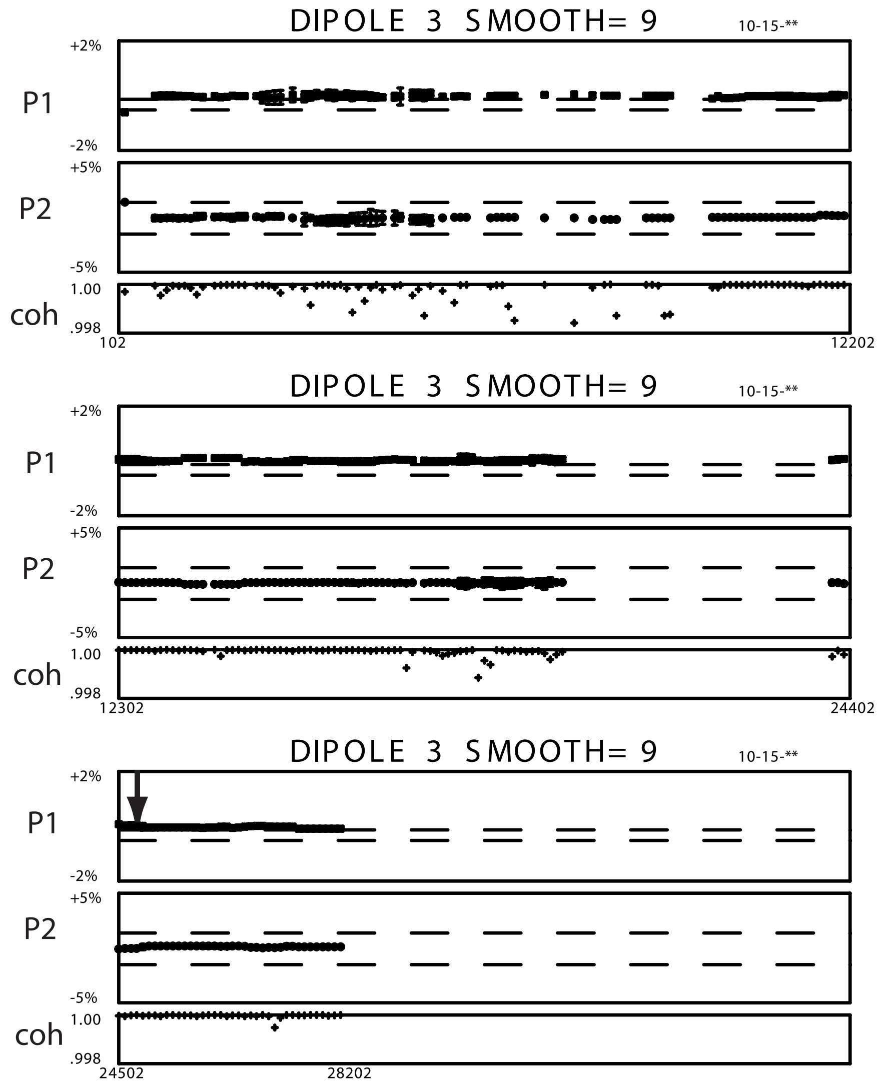


Figure 4- Projections for dipole 3 for 2002. See Figure 2 caption for explanation.

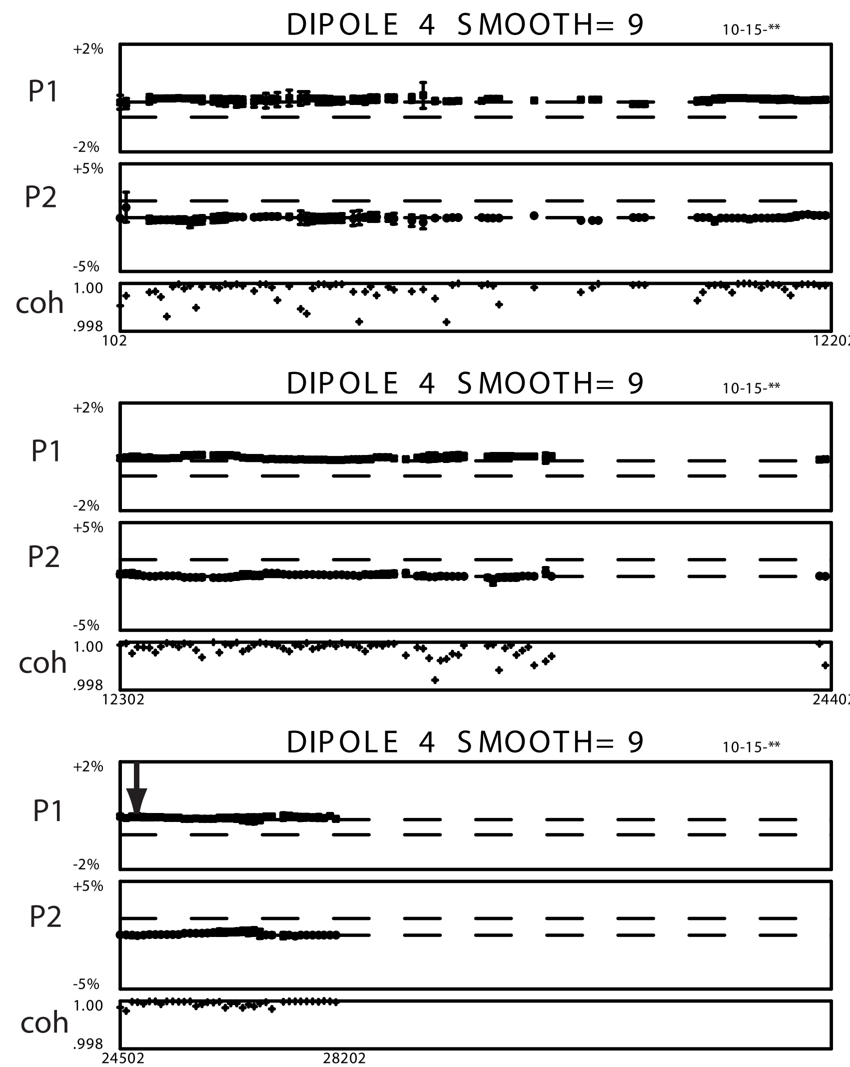


Figure 5- Projections for dipole 4 for 2002. See Figure 2 caption for explanation.

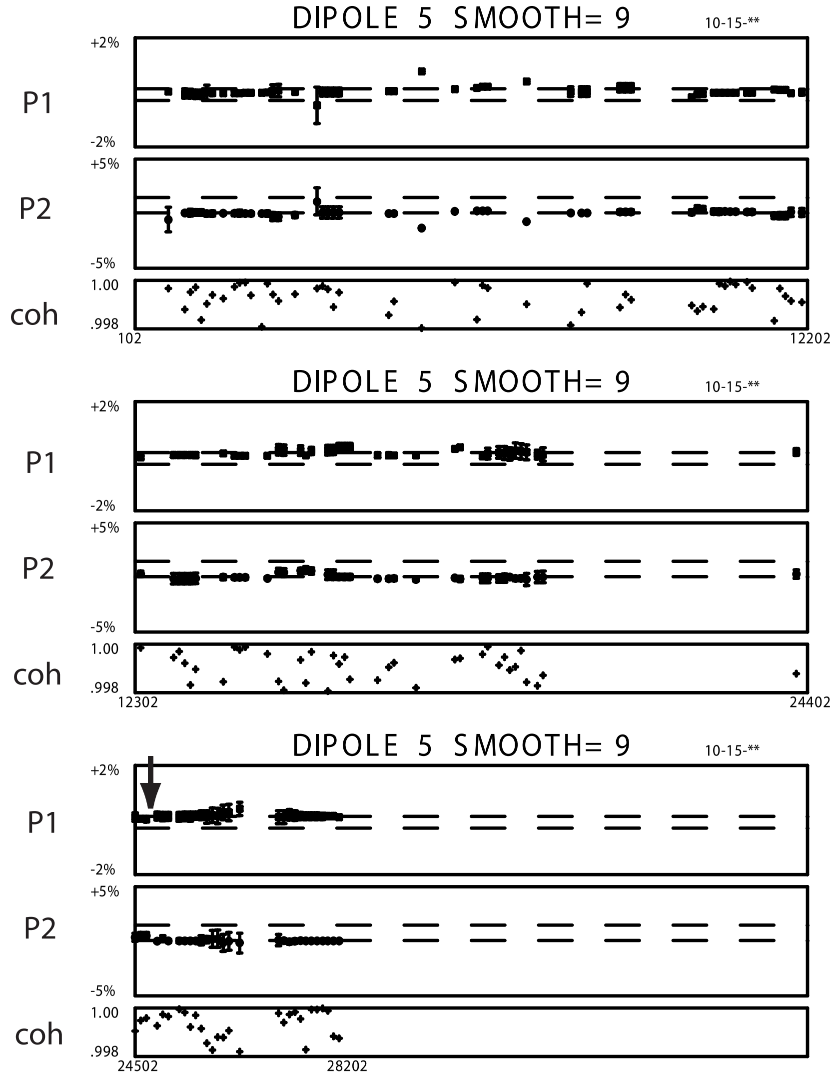


Figure 6- Projections for dipole 5 for 2002. See Figure 2 caption for explanation.

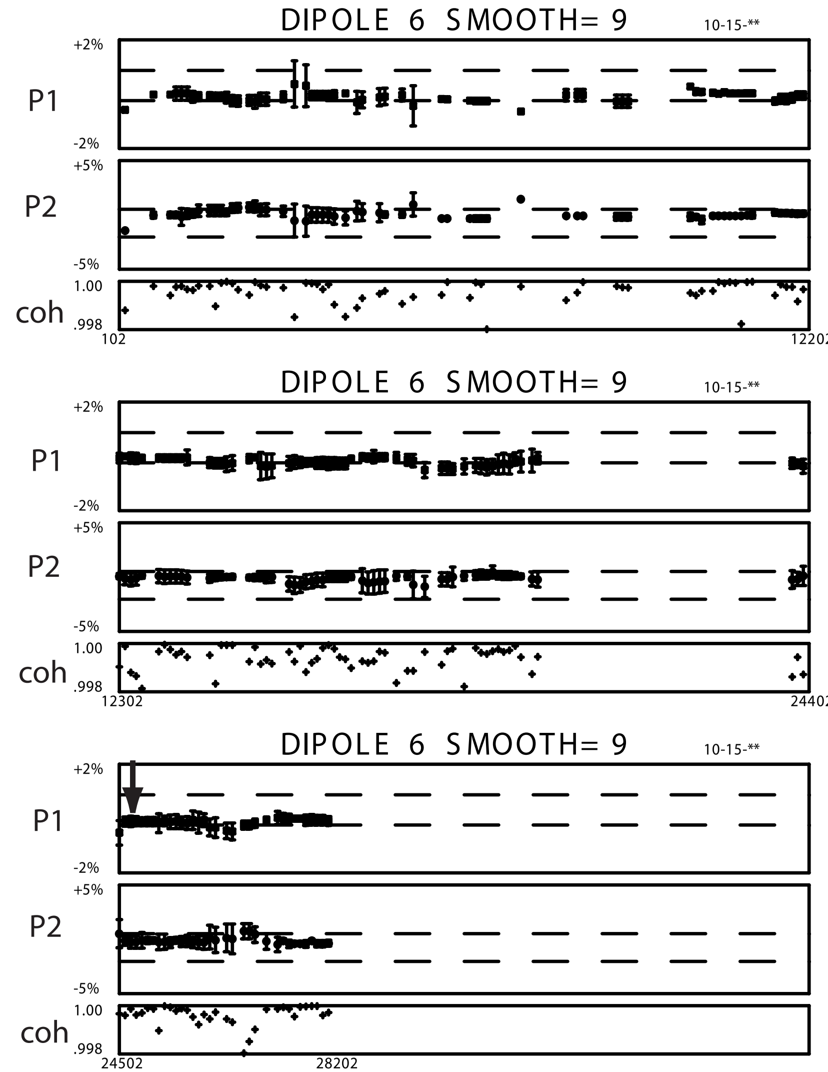


Figure 7-Projections for dipole 6 for 2002. See Figure 2 caption for explanation.