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A COMPARISON OF GROUND ELECTROTELLURIC ACTIVITY BETWEEN TWO REGIONS OF DIFFERENT SEISMICITY

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ABSTRACT

In this work we present a comparative study of the ground electrotelluric behavior of two regions with notorious differences in their seismicity levels. The first one includes electrotelluric monitoring stations at Mexico City and Cholula Puebla. The second one embraces five stations located along the Pacific coast in the Mexican state of Guerrero. The seismic activity in this last region is much larger than that of the first mentioned zone. During long monitoring periods the patterns of ground electric field fluctuations for both zones are remarkably different. In the first region we do not find any structured behavior and the fluctuations are mainly white noise. In the second region we also find predominantly white noise, but there are certain time intervals where the noise is not white-type. These intervals seems to precede seisms with $M \geq 6$. We also analyze the electrotelluric time series by means of the power spectra displayed over the time axis. In this approach we use a frequency band between 0 and 0.015 Hz. This analysis confirms the differences previously mentioned.

KEYWORDS

Electrotelluric activity; seismicity; earthquake precursors; Guerrero State Mexico.

INTRODUCTION

In the last years, a great deal of attention has been devoted to the search of electrotelluric precursors to earthquakes (Varotsos and Lazaridou, 1991; Bernard, 1992; Parrot *et al.*, 1993). A very common way for investigating the electrotelluric field behavior is by means of shallow pairs of unpolarized electrodes buried in the ground. The distance between electrodes is typically between 50 and 2500 m (Varotsos and Lazaridou, 1991) and they are used to measure the electric potential difference over certain time interval generating a voltage time series, V = V(t). Those recordings are analyzed by means of several techniques, as the spectral ones, for example. The aim of this kind of studies is to find some self-potential anomalies that could be correlated with the mechanism of preparation of an impending earthquake. Since 1992, we began a long-term program searching for seismic electrotelluric precursors at the western coast of Guerrero state in southern Mexico. This is a very active seismic zone linked to the Middle American

Trench (Suarez *et al.*, 1990). Our program included two electrotelluric control stations installed deep inland, in a zone of low seismicity more than 300 km away from the trench. Along the Guerrero's coast we have five electrotelluric stations covering approximately 300 km of the coast parallel to the trench. With this network of electrotelluric stations we have found some anomalies that seem to be associated with impending earthquakes with $M_{s,w} \geq 6$ (Yépez *et al.*, 1995). In this work we present a comparative study of the electrotelluric behavior between two control stations [Cholula, Puebla (19.1°N,98.3°W) and Mexico City (19.3°N,99.1°W)] and two coastal stations at Acapulco (16.85°N,99.9°W) and Coyuca de Benítez (17°N,100°W). This study shows that electrotelluric behavior is quite different in both zones.

THE DATA RECORDING

A typical station for monitoring the electrotelluric field consists of two pairs of unpolarized stainless steel electrodes (N-S and E-W oriented) buried 2m into the ground and 50 m apart. We register the voltage between the electrodes by a filter and an amplifier coupled to an analog to digital converter driven by a personal computer. Voltage values are stored in a magnetic disk every 2 sec (we also used a 3 and 4 sec sampling interval). The frequency cutoff of the filter was set at 5 Hz (we also used 0.1 and 10 Hz frequency cutoffs). The filters were designed in such a way that their response was flat up to 5 Hz and falling to a negligible value at 10 Hz. The power supply for filter/amplifier was a stable 12 V battery providing long periods of operation. The computer was supplied by a regulated backup system that could work up to 12 hrs during a blackout; a station could work for a few days without human assistance. Nevertheless, each station is driven by an operator who through few and short interventions maintains the station at operation and send the data toward Mexico City, where those are analyzed.

COMPARATIVE ELECTROTELLURIC STUDY

The first considered region is located at the state of Puebla Mexico. We installed a station at Cholula (19.1°N,98.3°W). Recently, González-Pomposo and Valdés-González, (1995) have reported seismicity measurements in this region, which is characterized by seisms with $M_c \leq 4$. The number of microseisms in this zone is in the order of one hundred per year. This microseismicity level is remarkably lesser than that of Guerrero State (Singh *et al.*, 1983). Moreover, in Guerrero State there are very common seisms with $M_c \geq 4$, which are quite infrequent in the Puebla region. Both considered regions have similar surfaces (in the order of 3-6 x 10^4 km^2). In our comparative study we take two Guerrero's stations at Acapulco (16.85°N,99.9°W) and Coyuca (17°N,100°W) as representative stations of the Guerrero's coast.

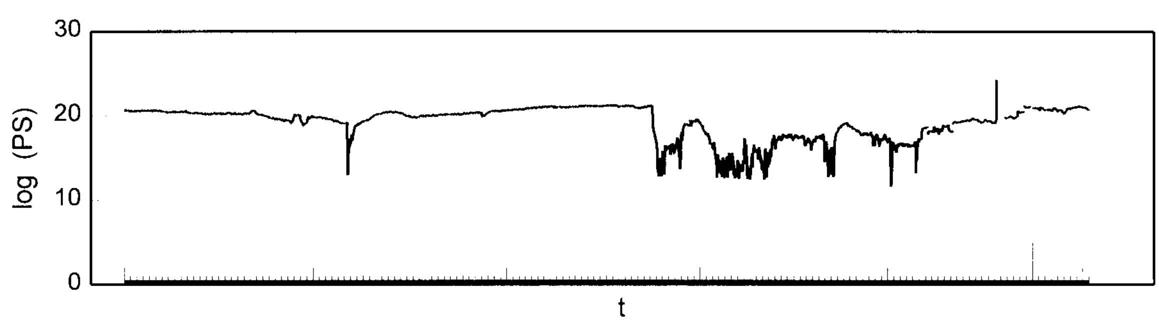

Fig. 1. Log of the Power spectrum versus time over five months of voltage registers from Acapulco station. A seism with $M_w = 6.5$ occurred at October 24, 1993. (marked with the arrow).

Our study is by means of Fourier analysis. We made time charts of the power spectra of voltage time series by using the fast Fourier transform (FFT) method. The details of our procedure are in Yépez *et al.*, (1995). In the present paper we only discuss the electrotelluric behavior in the range of ultra low frequencies (ULF) (0-0.015 Hz),that is in the range of quasielectrostatic phenomena. In Fig. 1 and Fig. 2 are depicted the log of the power spectra (PS) versus time of five months of voltage registers from Acapulco station and two months from Coyuca station, respectively. The typical ULF-behavior at these two stations consist in the presence of a stable basal line from which there are departures that can last from a few days up to several weeks. The short-lasting departures seemingly have not seismic relevance, but the large lasting departures would be related with the mechanism of preparation of seisms with $M \geq 6$ (Yépez *et al.*, 1995). For example, the PS-fluctuations observed in figures 1 and 2 occurred before seisms with $M_{s,w} \geq 6$, at the dates marked with arrows. A more detailed discussion of this fact was reported by Yépez *et al.*, (1995).

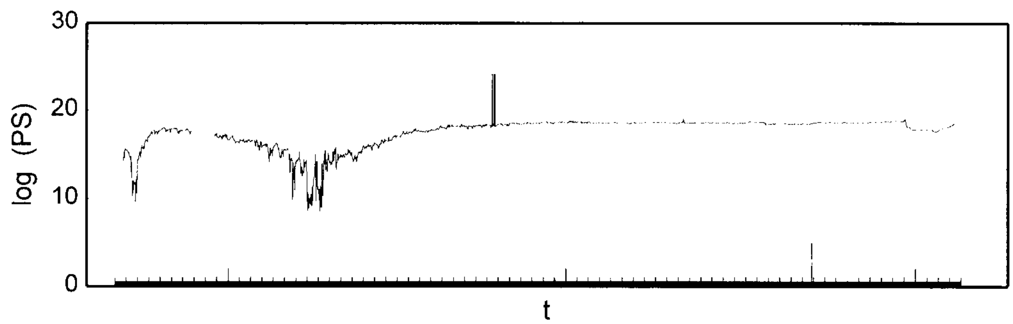

Fig 2. Log of the power spectrum versus time over two months of voltage registers from Coyuca station. A seism with $M_w = 6.3$ occurred at May 22, 1994. (marked with the arrow).

In Fig. 3, we show the ULF-behavior at Cholula station during about three and a half months. This station is also characterized by a stable basal line, but with only short lasting departures from the basal line. In the another control station at Mexico City this same behavior was observed (see Fig. 4). Thus, in the context of the ULF-frequency range the contrast between control stations and Guerrero stations consists in the fact that only the second ones show large-lasting departures from their basal lines. This difference in the electrotelluric behavior could be correlated with the remarkable differences in the seismic activity between the two considered regions. In fact, the large-lasting anomalies are seemingly correlated with the mechanism of preparation of large seisms with $M_{s,w} \geq 6$ (Yépez *et al.*, 1995).

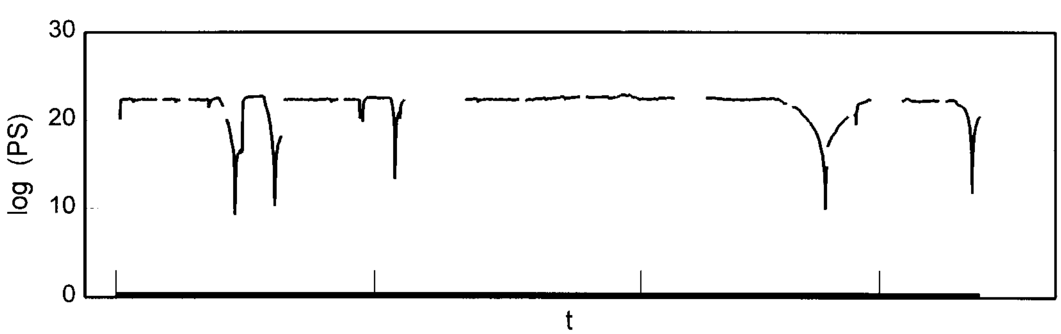

Fig. 3. Log of the power spectrum versus time over three and a half months of voltage registers from Cholula station.

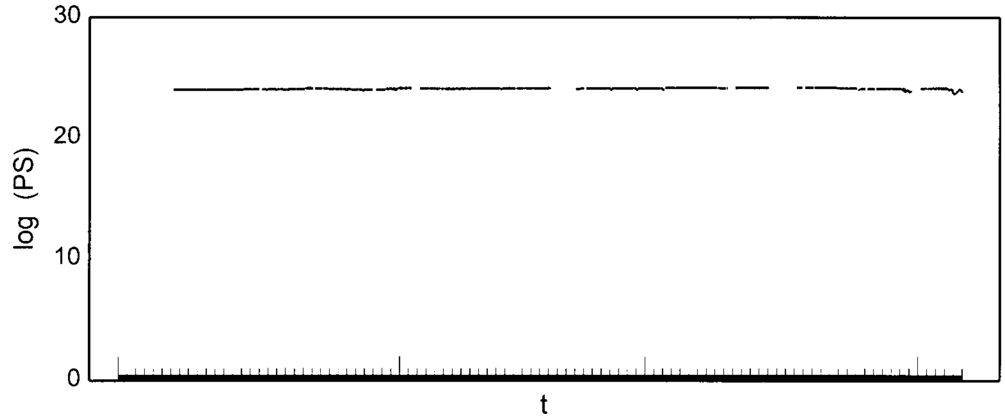

Fig. 4. Log of the power spectrum versus time over three months of voltage registers from Mexico City station. A great stability in the basal line is observed.

The another analysis we present is in the context of a noise study (Plotnick and Prestegaard, 1993). A series of independent random numbers generated from a Gaussian distribution form a white noise. If these numbers are used as the increments of a random walk, a Brownian motion is produced. In Fig. 5, we show the plot of successive values of V(t) taken from Cholula station. This graph has the characteristic behavior of a zero-mean-valued Gaussian noise, which is concomitant with a typical Brownian motion.

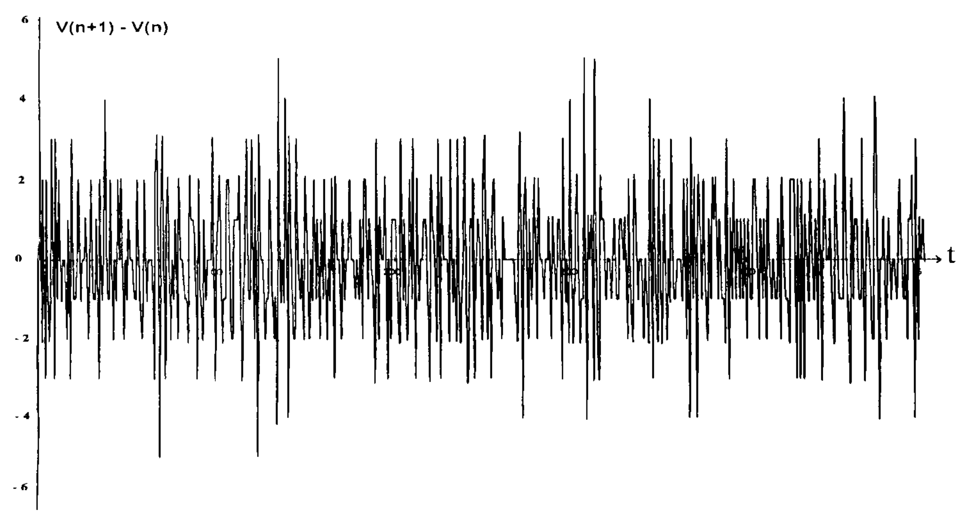

Fig. 5. Voltage increments versus time for a segment taken from a Cholula voltge time series.

The equivalent plot from Coyuca station is depicted in Fig. 6, where a fractional Gaussian noise is observed, which corresponds with a fractional Brownian motion (Plotnick and Prestegaard, 1993). Even though this analysis is only qualitative, it shows also evident differences between the both considered zones. In what concerns to possible physical explanations for the observed electrotelluric behavior, we can make the conjecture that we are observing electrokinetic effects (Jouniaux and Pozzi, 1995), that in the first case (Cholula) do not reach the failure stage, and in the second case (Guerrero) this stage is reached in some processes ($M_{s,w} \geq 6$).

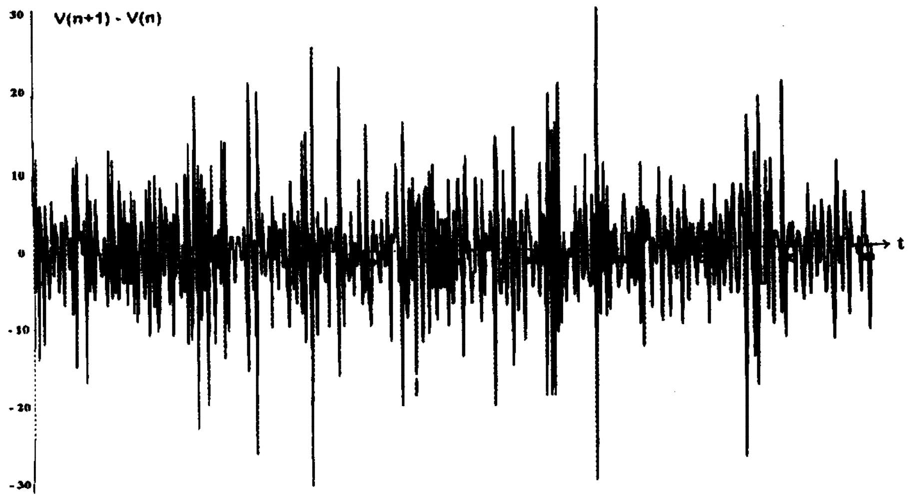

Fig. 6. Voltage increments versus time for a segment taken from a Coyuca voltage times series.

CONCLUSIONS

Our preliminary results suggest that electrotelluric activity depends on seismic activity. The two compared zones in our study have remarkable differences in their seismicity levels, and seemingly this difference is translated to remarkable differences in electrotelluric behavior. This fact is observed through both the ULF-behavior and a brief noise analysis. However, further studies are necessary to confirm our observations. A possible physical explanation of our electrotelluric study would arise from the electrokinetic effect.

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REFERENCES

Bernard, P. (1992). Plausibility of long distance electrotelluric precursors to earthquakes. *J. Geophys. Res.*, **17**, 17531-17546.

González-Pomposo, G.J. and C. Valdés-González (1995). Seismicity of the State of Puebla, Mexico, 1986-1989. *Geofi. Int.*, **34**, 221-231.

Jouniaux, L. and J.P. Pozzi (1995). Streaming potential and permeability of satured sandstones under triaxial stress: Consequences for electrotelluric anomalies prior to earthquakes, *J. Geophys. Res.*, **100**, 10197-10209.

Parrot, M., J. Archache, T.J. Berthelier, E. Blanc, A. Deschamps, F. Lefeuuvre, M. Menvielle, J.L. Plantet, P. Tarits and J.L. Villain (1993). High-frequency seismo-electromagnetic effects, *Phys. Earth. Planet. Inter*, 77, 65-83.

Plotnick E.R. and K. Prestegaard (1993). *Fractal analysis of geological time series in Fractals in geography*, (Nina Siu-Ngan Lam and Lee De Cola Ed.), Prentice Hall, N.J.

Singh, S.K., M. Rodríguez and L. Esteva (1983). Statistics of small earthquakes and frequency of occurrence of large earthquakes along the Mexican subduction zone, *Bull. Seism. Soc. Am.*, **73**, 1779-1796.

Suárez, G., T. Monfret, G. Wittlinger and C. David (1990). Geometry of subduction and seismogenic zone in the Guerrero gap, Mexico, *Nature,* **345**, 336-338.

Varotsos, P. and M. Lazaridou (1991). Latest aspects of earthquake prediction in Greece based on seismic electric signals, *Tectonophysics,* **188**, 321-347.

Yépez, E., F. Angulo-Brown, J.A. Peralta, C.G. Pavía and G. González-Santos (1995). Electric field patterns as seismic precursors, *Geophys. Res. Lett.,* **22**, 3087-3090