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OBSERVED PERIODIC VARIATIONS OF THE EARTHS ELECTRIC FIELD PRIOR TO TWO EARTHQUAKES IN N.GREECE

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SUMMARY

This paper describes the results of an extensive investigation of the variations of the earth's electric field at two site areas in Greece and their relation to the occurrence of earthquakes.

A microprocessor controlled sampling device connected to a 50m dipole was installed and the obtained data were extensively analyzed and revealed the existence of a periodic variation of the electric field prior to two main shocks.

Finally, some physical processes which could explain the above phenomenon are proposed.

INTRODUCTION

The development of methods of earthquake prediction, proceed from the assumption that some variations of different geophysical and geochemical fields occure before any strong earthquake due to the accumulation of geotectonic stresses in its focal area.

The summarized data of precursors (1) shows the presence of a wide range of precursor times, from several minutes to several years, for different geophysical fields, indicating the existance of an almost uninterrupted frequency spectrum of precursors that reflects the fracturing of different size blocks of rock.

Recordings of changes of the natural electric field of the earth in search of precursors of strong earthquakes have been reported by many researchers in the literature, starting in 1966 by the Pioneering work of Sobolev and co-workers (2,3,4).

These researchers, installed a network of coastal stations in the tectonically active area of Kamchatka, and reported the existence of some characteristic anomalous changes of the earth's electric field which started 3-16 days before the main shock and had a bay form with a duration of a few days.

Electric field anomalies have been observed also prior to many strong earthquakes in China (5). These anomalies are expressed by an abrupt drop of the electric field, a few hours prior to the earthquake and its subsequent recover after the occurrence of the shock.

The successful prediction of the Heicheng earthquake in 1975 was based on such a phenomenon (6).

Similar anomalies have also being reported by researchers in Japan (7).

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In Greece, a systematic observation of the changes of the earth's electric field as earthquake precursors has started since 1981 from a network of eighteen stations [8,9]. The systematic analysis of the data revealed that in many cases a transient change of the electric field of the order of several mV for a 50m dipole and a duration between 1 and 60 minutes occured several days prior to the shock.

Although the stress acumulation in a tectonically active area last for a long period, it is well understood that the rate of change of the various physical parameters characterizing the epicentral area (i.e. natural potential, resistivity, etch.), increases just prior to the occurence of the main event. For that reason we focused our attention to physical variations of one day period.

The purpose of the present paper is to examine a different kind of electric field periodic variations which were observed prior to two earthquakes in Greece.

Two possible generating mechanisms of the phenomenon are discussed:

a) Induction of periodic electric currents due to the one day's period oscillations of the earth's magnetic field.

b) Large scale piezoelectric phenomena due to earth tides.

1. THE LESVOS EXPERIMENT

The area of N.Agean sea is an area with a relatively high seismic activity [10]. During the years 1978-1983 a considerable increase in this activity has been observed. A main shock of Ms=7.0 occured at the northeastern part of the Sporades trough to the west of the island of Limnos. Statistical investigations showed that a second earthquake with magnitude not less than 4 was expected from the same focal area [11].

Hence, we decided the installation of an experimental SP recording device to study the variations of the earths electric field of a few days period, as earthquake precursors (Fig.1).

1a. The Experimental Device

The experimental device consists of the following parts.

a) A 50m dipole in the NW-SE direction

b) A self potential back up system

c) A low pass filter with a 5 min time constant

d) An analog recording device equiped with an RS232C port for direct communication with a microcomputer.

Since the tectonicaly active area was known, the dipole was directed in such a way as to bisect orthogonally the expected equipotential surfaces, of the anomalous SP field originating from the hypothetical focal area.

1b. Data Processing

As all background values of geophysical fields are subject to considerable fluctuation, the problem of forecasting is methodically reduced to the separation of the signal from the background of noises, with all the difficulties this entails.

The raw data, were separated in their long and short period components of less and greater than one day respectively (Fig.2a,b). This was achieved by using a moving average technique. The existence of a 24h period oscillation of the electric field is revealed on the data.

The statistically expected earthquake occured on 9-2-1982 and is shown on Fig.2a by an arrow. The good correlation between the maximum rate of variation of the amplitude of the oscillation and the time of occurence of the earthquake is obvious (Fig.2b).

In order to study the possible correlation between the variation of the earth's magnetic and electric field, a spectral analysis of the magnetic and electric recordings, was carried out for two distinct periods.

The first period 29-1-1982 until 3-2-1982, which is long before from the event, shows a very small correlation between the two fields (Fig.3).

During the second period 4-2-1982 until 9-2-1982, the high degree of correlation between the two fields in both diagrams is evident (Fig.4). The dominant oscillation is clearly shown in both diagrams with a 24 hours period.

2. THE EPANOMI EXPERIMENT

During the summer of next year (1983), the experiment was repeated in the Epanomi area (Fig.1).

The recordings were performed during three separate intervals of about ten days duration each.

The earthquake activity of the area under investigation was relativelly small during the first period 24-7-1983 until 2-8-1983 [12]. Fig.5, shows the data obtained and their subsequent treatment while Fig.6, shows the corresponding power spectra. Judging from the above diagrams, we see that the power spectra of the magnetic field is concentrated in the 24h period band. On the other hand, the SP power spectra is wide, characterized by very long periods, greater than 24h and there is a difference ΔT between the two peacks.

During the second period 3-8-1983 until 11-8-1983, an increase in the seismic activity of the area is observed [12]. Fig.7, shows the data obtained while Fig.8, shows the corresponding power spectra.

In contrast to the first period, a periodic oscillation of the electric field builds up and on 6-8-1983 an earthquake with Ms=6.6 occured expressed by a sudden decrease in the amplitude of the periodic oscillations.

As one can easily deduce from the power spectra curves, there is a concentration of the energy in the 24h and the 12h period band for both the magnetic and the electric field.

Finally, there is a considerable increase in the seismicity of the area, during the third recording period. This is also expressed by a continuous increase of the variation of the amplitudes (Fig.9). Fig.10, shows the corresponding power spectra. A characteristic coupling for the 24 hour peak is obvious.

3.POSSIBLE EXPLANATIONS OF THE PHENOMENON

In the following, two possible mechanisms have been considered for the explanation of the observed oscillation of the earths electric field prior to an earthquake.

a) Change of electromagnetic induction on the earth's surface due to variation of the various physical parameters of the focal area (resistivity,magnetic susceptibility, porosity, etc.), which govern the coupling parameter between the oscillations of the Earth's magnetic field and the ground [13]].

As far as this model is concerned, the oscillating magnetic field induces secondary currents in the ground. The amplitude of the induced currents is determined by the various physical parameters of the ground which in their turn, depent upon the existing stress field in the area. More generally, this is expressed as a variation in the coupling coefficient between the ground and the ionosphere.

b) Large scale piezoelectric phenomena. The stress field of the area, during its increase with time due to various tectonic processes, is modulated by a 24 hour oscillation due to earth tides [14]. Fig.11, shows a possible explanation of the mechanism that we propose, according to which the amplitude of the 24 hour period oscillation depends upon the position of the stress level in the area.

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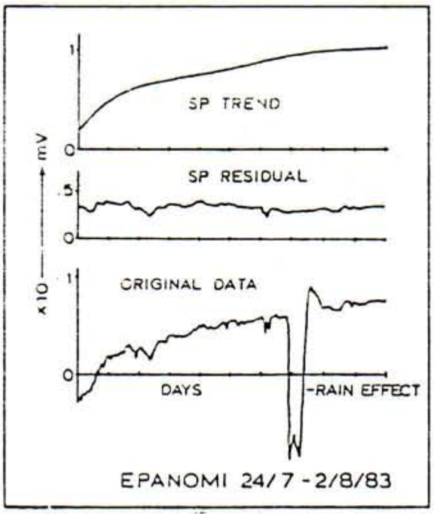

Fig.5 Recorded, regional and residual data for the period 24/7-2/8/83.

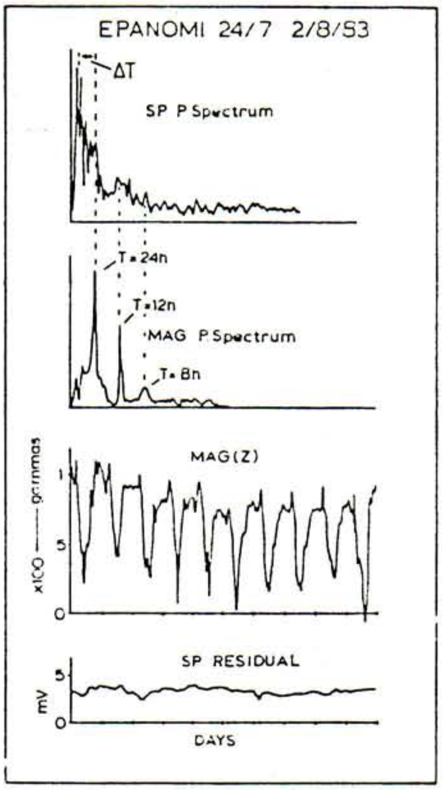

Fig.6 Comparison between SP and magnetic data and their spectra for the period 24/7-2/8/83.

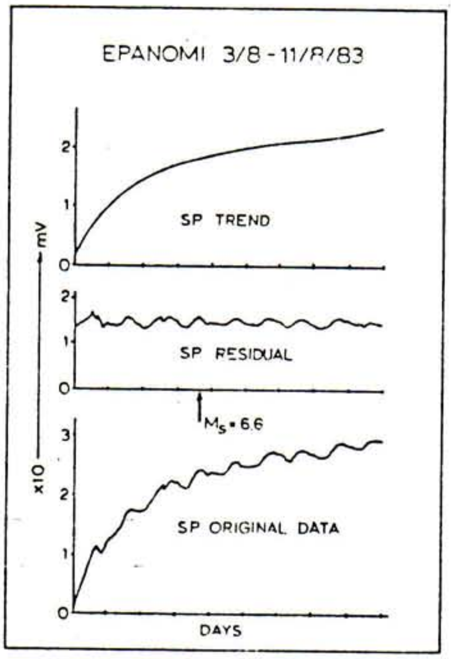

Fig.7 Recorded, regional and residual data for the period 3/8-11/8/83.

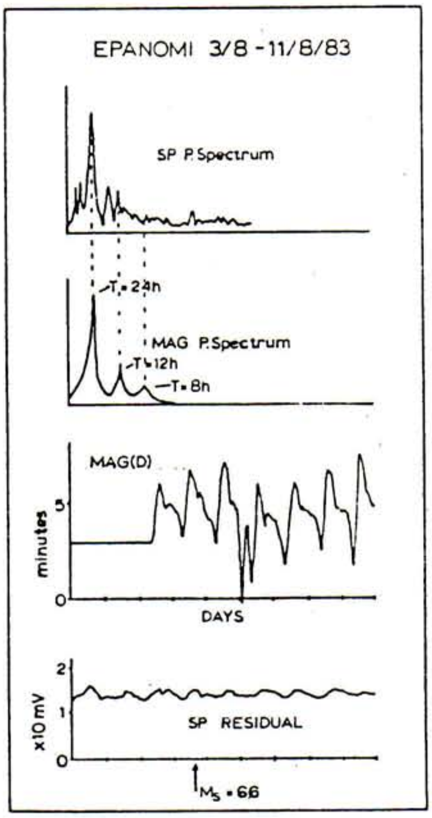

Fig.8 Comparison between SP and magnetic data and their spectra for the period 3/8-11/8/83.

Fig.1 Location of the tworecording sites and the focal area.

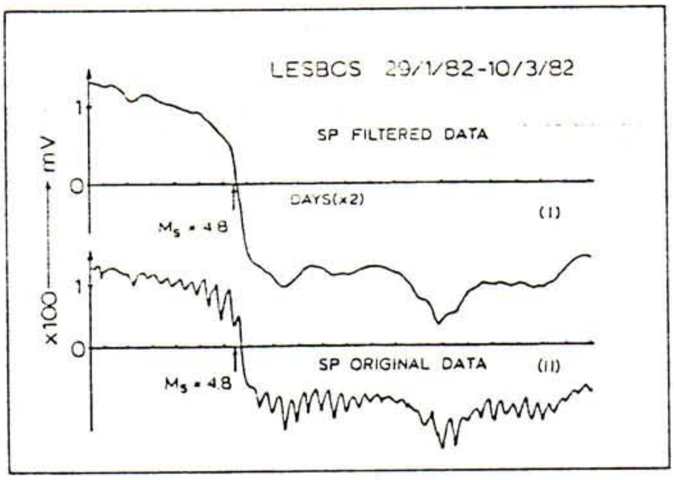

Fig.2$_a$ Original and low pass filtered data.

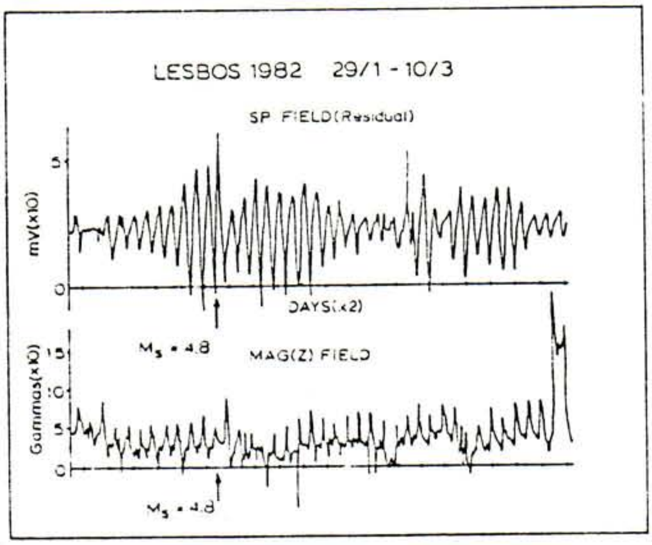

Fig.2$_b$ Variations of the residual {II-I} electric field and the earth's magnetic field between 29/1/82-10/3/82.

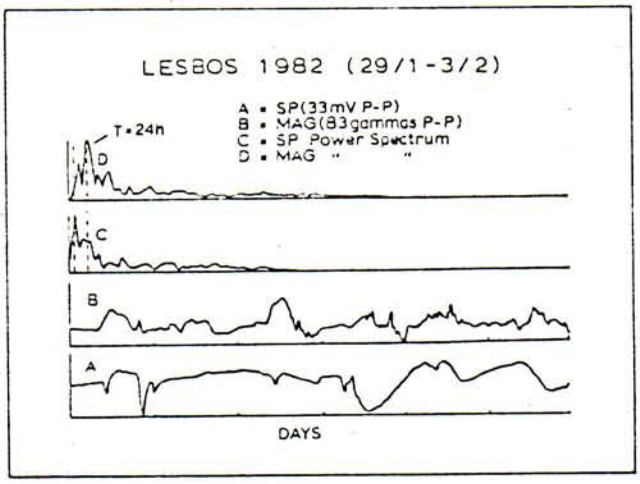

Fig.3 Comparison between the variations of the electric and magnenetic fields and their power spectra between 29/1/82-3/2/82.

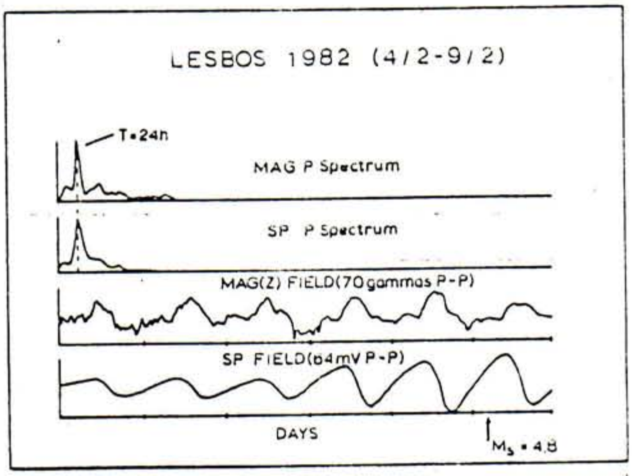

Fig.4 Comparison between the variations of the electric and magnetic fields and their spectra between 4/2/82-9/2/82.

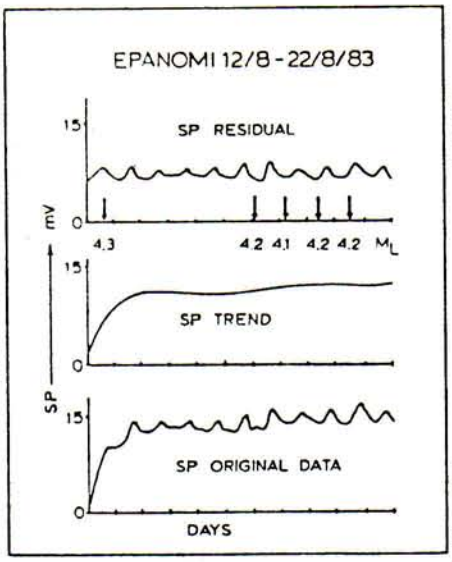

Fig.9 Recorded, regional and residual data for the period 12/8-22/8/83.

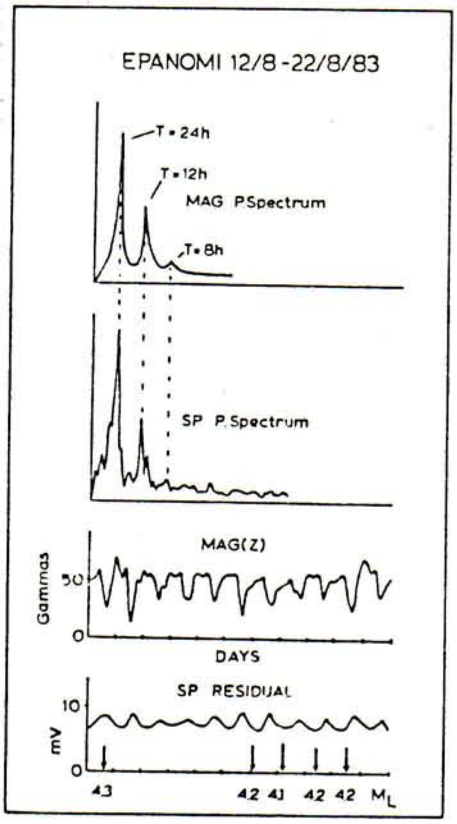

Fig.10 Comparison between SP and magnetic data and their spectra for the period 12/8-22/8/83.

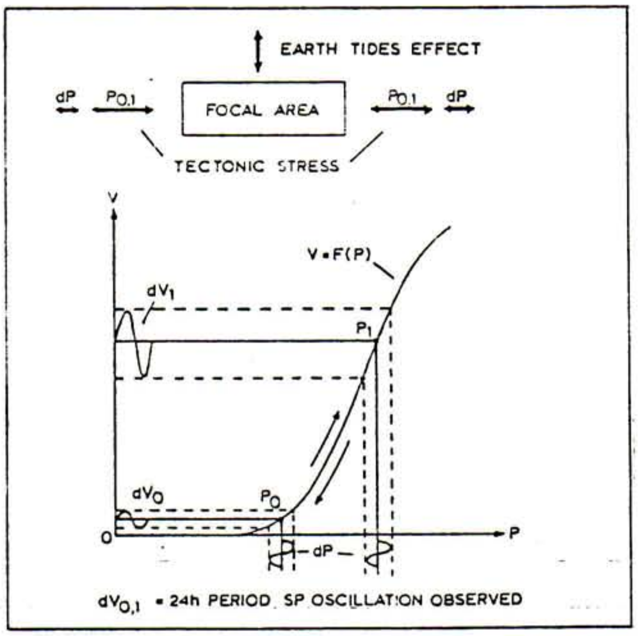

Fig.11 Proposed model.