LINK BETWEEN THE SEISMIC EVENTS AND THE DIFFERENT SEISMIC PRECURSOR PHENOMENA

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Abstract: This article presents an analysis of the earthquake prediction methods, highlighting mainly the VLF and LF electromagnetic waves seismic precursors' monitoring method and the correlation among these in order to obtain a more precise result. It is well known the fact that there are lots of links between the seismic events occurrence and different phenomena that predict their occurrence, such as the electromagnetic field, Earth movement, gaseous content of radon and hydrogen within the soil, or within the underground waters. This paper aims to demonstrate the close link between the seismic events and the electromagnetic wave propagation anomalies, which are recorded before the advent of an earthquake.

Keywords: earthquake prediction, VLF and LF electromagnetic waves.

1. INTRODUCTION

The seismic events are natural disasters which cause substantial losses, regarding both human lives and material losses. These huge losses are determining people in a natural way to look for earthquake prediction methods; hence the need for a research study is an urgent issue. The research experience proves the fact that seismic data taken individually are not enough for predicting earthquakes, so this activity should be a close collaboration of the participants in the study, with a correlation of the collected data.

The accuracy of predictions increases as there are considered more events of the future earthquakes. For this reason, earthquakes' prediction turned to different research directions. Electromagnetic emissions may be considered as one of the earthquake's precursors. There are numerous publications that reported findings on the emissions of very low frequency (VLF) and low frequency (LF), taking place during the periods preceding the earthquakes. The regular behavior of electromagnetic VLF emissions can be disrupted, a few days before an earthquake, both in the noise and in the impulse component (usually, the effect is to increase the amplitude of the emission and the rate of the pulses). Satellite observations of the ionosphere- above the rupture zone of future earthquake's location- also revealed the fact that there are changes in the VLF emissions a few days before the event. The effects of the seismic events which affect the ionosphere's parameters are highlighted by observing signals from the VLF and LF radio stations, across the path above the earthquake's epicenter. The effect depends on the signal frequency, the length of the path and the conditions encountered on the way.

2. SEISMIC PREDICTION METHODS

Attempting to predict the earthquakes, people linked the seismic event's prediction with different seismic phenomena. Nowadays we have a variety of methods to warn about the imminence of a seismic event, but still there is not a clear result available yet, that is able to specify the exact area, time, magnitude and the probability of occurrence of an earthquake.

This paper was recommended for publication by Toader Munteanu

Methods used today:

1) *Radon Measurement*: A link was been found between the rare gas called radon and the seismic events, thus by measuring the concentration of radon within groundwater and soil it can be determined the possibility of an earthquake occurrence. For example, researchers have developed special devices, made of plastic tubes, which serve as Alfa type particle detectors for the radon originating in the soil and which is due to the degraded bodies inside it. Data obtained from measurements were studied along with seismic data, such as earthquake’s magnitude while doing the measurements, to find any link between them. This method is still under development and can not be used for an accurate prediction of the earthquakes (Khan, 1990).

2) *Van Method*: it is a method discovered by a group of professors, Varotos, Alexopoulos and Nomicos, their initials also giving the name of the method. This method is based on the detection of the “seismic electric signals” using a telemetric network made of conductive metal rods placed in the ground. Referring to the identification of the seismic electric signals, a permanent noise filtering is being done on the received signal. Researchers claim they can predict an earthquake with a magnitude greater than 5 degrees, from a distance of 100 km from the epicenter, within 0.7 units of magnitude and a prediction interval between 2-hours and 11-days (Lighthill, 1996).

3) *Methods Based On Abnormal Propagation Of Vlf And Lf Signals*:This method is based on the detection of abnormal propagation produced in the low frequency and very low frequency band. Below are presented some of the methods of detection:

a) Ionosondes are devices that use radar technology for examination of the ionosphere. It was proved the fact that there is a deep link between signal propagation in the ionosphere and earthquake prediction. Precisely, the radio waves are attenuated or absorbed, with a few exceptions, which are reflected and deserve a special attention because they give information about different electron concentrations between atmospheric layers. Ionosondes are the equipments that measure the echo of these special 30 MHz waves. There is information about the density of ions in the reflected waves, and the ionized particles are magneto active, and also information about the electron density profile.

b) Microsatellites are devices capable of calculating correlations between low frequency electromagnetic activity and earthquake phenomena, by monitoring a sudden variation of the signal with regards to the electron density in the ionosphere, as well as temperature variations.

The device is made up of four electric transducers capable of measuring three components of the electrical field; the distance between each transducer is 9 meters from one end to another. A magnetometer with three components for measuring the magnetic field will be placed at the far side of a 1 meter pole. A transducer used to measure the following parameters: total plasmatic density (both ions and electrons), temperature, the potential of the satellites and the direction of the ion flux. An ion spectrometer and a particle energy detector. These are associated with two on-board equipments: a high capacity of mass storage (8Gbits) and the telemetry bandwidth transited towards the X band (18 Mbit/s) (Molchanov, 2006).

c) Nanosatellites, as well as the microsatellites, are devices which monitor the electromagnetic signals to create a correlation with an eventual earthquake event. This kind of satellite is designed to collect data from the seismic areas, but data from oceanic areas and the areas of the poles is not monitored. Also, it gives information about the data collected in 5 frequency bandwidths:

- 1st band: 0.5-10 Hz narrow magnetic bandwidth
- 2nd band: 10Hz to 150 Hz wide magnetic bandwidth
- 3rd band: 10Hz to 1000Hz very wide magnetic bandwidth
- 4th band: 130-150Hz narrow magnetic bandwidth
- 5th band: 130-150Hz narrow electrical field bandwidth (Juric, 2003).

d) The VLF/LF receiver is a radio receiver equipment which works in the VLF and LF bandwidths to detect propagation anomalies of the radio waves as well as their correlation with seismic events. This device monitors 10 frequencies distributed along these bandwidths and for each one of them, the power level is stored on a non-volatile memory at a sampled interval of time. The VLF/LF receiver has two standard 4 poles XLR antenna connectors, one for each band. The same connector can provide differential input from the antenna and a double power supply to the preamplifier, both situated near the antenna. The purpose of the preamplifier is to change the high impedance of the low frequency antenna into the low impedance of the cable as well as amplifying the received signal, inducing a very low level of noise. The large quantity of received data collected by the VLF/LF receiver is organized in text files, one file for each day. Apart from the header of the file, the ten values of the samples (one for each frequency) and each time sample (hour, minutes and seconds) can be found on a single line in the text file. The name of the file contains the day of the measurement. The configuration of the equipment and the status of the measured data are possible through an Ethernet interface (Elettronika, 2009).

3. BLOCK DIAGRAM

The main blocks of the VLF/LF receiver presented in Figure 1 are as follows:

-the VLF/LF antenna by which the system receives the data from the propagation environment
-the variable gain preamplifier which, except the fact that it amplifies the power of the received signal, it also has an impedance matching purpose (it converts the high output impedance of the antenna to the impedance of the transmitting cables of the system) in order to assure a better power transmission of the signal to the following circuitry
- the analog front-end, which consists of the following:
- a gain amplifier in order to further amplify the strength of the received signal
-a band pass filter calibrated on the frequency at which the measurement is made; this will reject the spectral components that are not inside the desired measurement bandwidth.
-a 16 bit ADC working with a 200kHz sampling clock for the VLF bandwidth signals respectively 1.25MHz sampling clock for the LF bandwidth signal; this device serves as an interface between the analog circuitry and the digital circuitry (Elettronika, 2009).

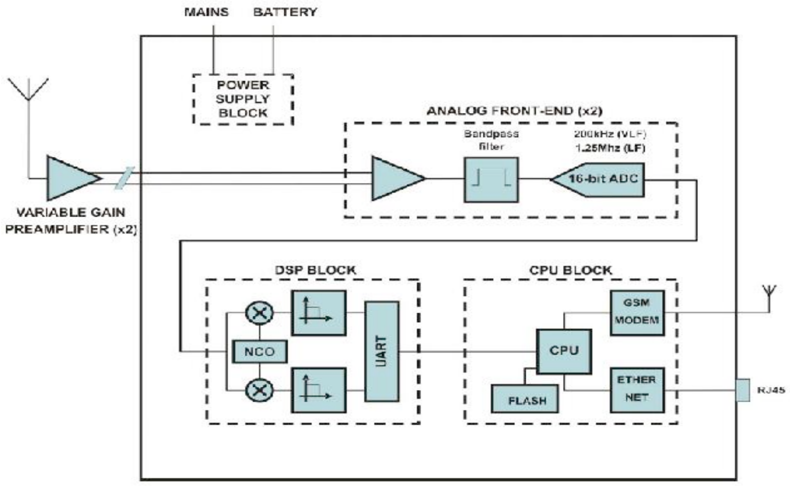

Fig.1. Block diagram of the VLF/LF receiver

4. CONCLUSIONS OF THE RESEARCH STUDY OF VLF/ LF RECEIVER METHOD

With this device were observed anomalies of growth and decrease of the electric field exactly near the analyzed signal, anomalies which have provided hypotheses about earthquake intensity based on its location on the monitories route (Biagi, 2007). Several periods of the anomalies, like 0.5d, 1d, 14d, 28d, 365d, have provided information about atmospheric currents that influenced the propagation of LF waves. Emphasizing them, it is assumed that would be the reason for a local decrease of the gravitational field, as a consequence of pre-seismic fluid diffusion around future epicenter (Biagi, 2002). The proposed model uses the gravitational changing to justify pre-seismic anomalies, observed in LF radio signals. The recorded LF signals are containing information about the Earth wave anomaly related to several variations of Earth parameters and of troposphere, which are influencing the propagation of waves (Biagi, 2004). These variations may be related to pre-seismic phase events that occur in the first Fresnel zone of these radio signals. In this study it was found that there was no connection between anomalies and geomagnetic activity or weather conditions (Biagi, 2005). More specifically, it was verified that the epicenter is located inside the fifth Fresnel zone of an earthquake. A pre-seismic anomaly was observed three days before the Anzio earthquake (M=4.7; 22 August 2005) occurrence, in the VLF signal, so from five registered signal by the receiver, the anomaly appears only in the signal corresponding to the fifth Fresnel zone, which contains the epicenter. This fact provides information about the location of the future earthquake, demonstrated by abnormal propagation of the VLF/LF radio signals (Biagi, 2008).

The following measurements were conducted during an one week monitoring of the VLF (figure 2) and LF (figure 3) signals between the 2^{nd} and 9^{th} of February 2009. The measurements were conducted in the VLF (270 kHz, 216 kHz, 183 kHz, 180 kHz bands) and LF (45.9 kHz, 37.5 kHz, 23.4 kHz, 20.9 kHz, 20.27 kHz, 19.6 kHz) bandwidths. One can see from the diagrams observed on the 6th of February the level of the signal raised abruptly during the 19:00-24:00 time interval (figure 3). Later correlation in the time domain of the data showed that a seismic anomaly was not present in the shape of the received signal. Furthermore, if such an anomaly would have occured, the effect of an possible sesmic precursor would have been present in more than just one bandwidth. The anomalous signal could be associated with a sudden increase of the noise level in the receiving section.

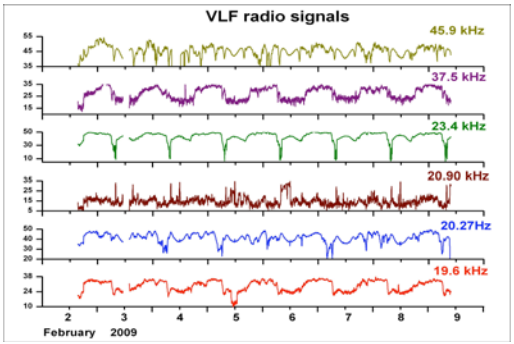

Fig.2. Monitoring of the VLF signal between 2nd and 9th of February 2009 as observed in the Rome receiver

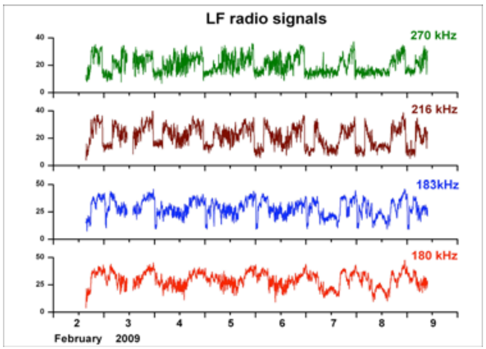

Fig.3. Monitoring of the LF signal between 2nd and 9th of February 2009 as observed in the Rome receiver

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