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Study of Ultra Low Frequency signals (0.01-10 Hz) associated with moderate Earthquake occurred in Koyna region using induction type magnetic sensor

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ABSTRACT

Study of magnetic field fluctuations due to earthquakes have been started at Shivaji University, Kolhapur (India) using three axis ULF/VLF induction type magnetic sensors, since March 2006. We have considered one event of moderate earthquake (4.0<M<5.0) for the present study. This earthquake occurred in Koyna region on 14th November 2009 at 13:03:35 UT (M=4.8). For study of these signals we have taken the frequency band ranging from 0.01 Hz to 10 Hz which is one of the most promising candidates for short term earthquake prediction. Suitable Data analysis methods like power spectral density, fractal analysis etc. are used. This analysis gives the detailed information about the possibilities of precursory signals due to moderate seismic activities near the observation site. A variation in the polarization parameter during seismic events is discussed in the present paper in the light of geomagnetic activities.

Keywords: - ULF/VLF waves; Earthquake precursors; Power Spectral Density; Polarization parameter: Fractal Analysis

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INTRODUCTION

The seismic hazard forecast has been the most urgent scientific problem for all time. Especially earthquake and their prediction, because of their high destructive force and undetermined location is important. Among different types of observed earthquake precursors the electromagnetic one seems to be the most reliable and the most frequently observed. For earthquake prediction, changes in the electromagnetic field before earthquake occurrence have been thought as one of the possible methods.

There are many practical evidences of the magnetic field fluctuations occurring before earthquake [1, 2, and 3]. These fluctuations occur mostly in the ULF-VLF frequency band. Our paper intends to discuss a ground based methodology (using search coil magnetometer) to determine the magnetic field variations of the ULF electromagnetic emission occurring prior to seismic activities. Our instrument is installed near the earthquake prone regions called- Koyna - Warna region. We discuss here one moderate event, which gives some preliminary results of magnetic field variations before, during & after the activity.

MATERIALS AND METHODS

2. Experimental Set Up:-
Induction coil magnetometer with data processing system is intended for the measurement of the magnetic field variations in low-noise areas. It consists of three induction coil magnetic sensors. Signals received from the sensors

are amplified and filtered using communication and data processing system CAM-Unit. GPS antenna serves the purpose of recording the three dimensional position of the observatory & the time information. The magnetometer works in the frequency band 0.001-32 Hz. The system is installed at remote place in the university campus to avoid the artificial interferences. The effect of magnetic storms on the ULF data is examined in terms of variation in geomagnetic indices. We have taken the data of Kp index of Nov. 2009 from world data centre (website-http://swdcwww.kugi.kyoto-u.ac.jp/index.html) to study the geomagnetic activities for the comparison with that of the seismic activities.

3. Data Analysis:-

We have considered one case of moderate earthquake (M=4.8) near Koyna reservoir which is earthquake prone region. Position of this earthquake from observation site is as shown in fig.1. We have analyzed two month's data from 01 Oct-30 Nov 2009 by using power spectral density, polarization parameter and fractal analysis method. We have selected shot term analysis i.e. response of different frequency channels few days and few weeks before of earthquakes In the case of power spectral density method, we have checked response of different frequency i.e. enhancement in the power before earthquake First of all we derive the power spectral density for 06 different frequency bands (Channel 01-06) ranging from 0.01-10 Hz. Frequency range for each band is given in table 1

Figure. 01 Location of epicenter of the earthquake.

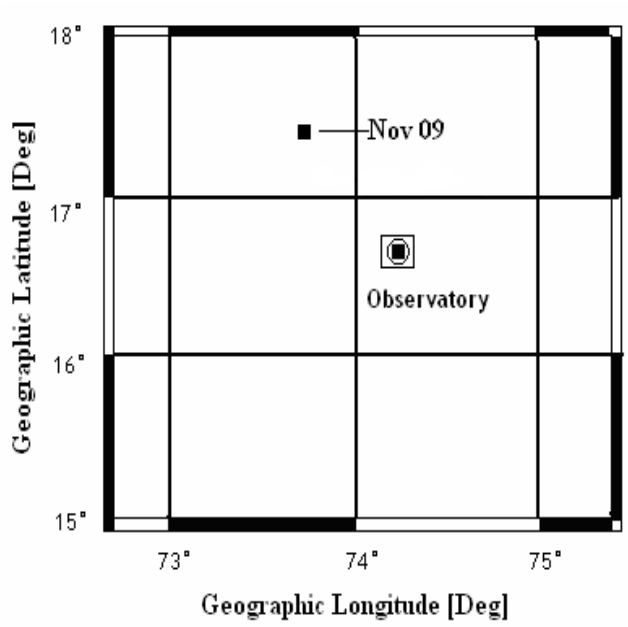

Table 01- Frequency Range

Frequency Channels	Frequency Range
Channel 01	**0.01-0.05 Hz**
Channel 02	**0.06-0.1 Hz**
Channel 03	**0.1-0.5 Hz**
Channel 04	**0.6-01 Hz**
Channel 05	**01-05 Hz**
Channel 06	**06-10 Hz**

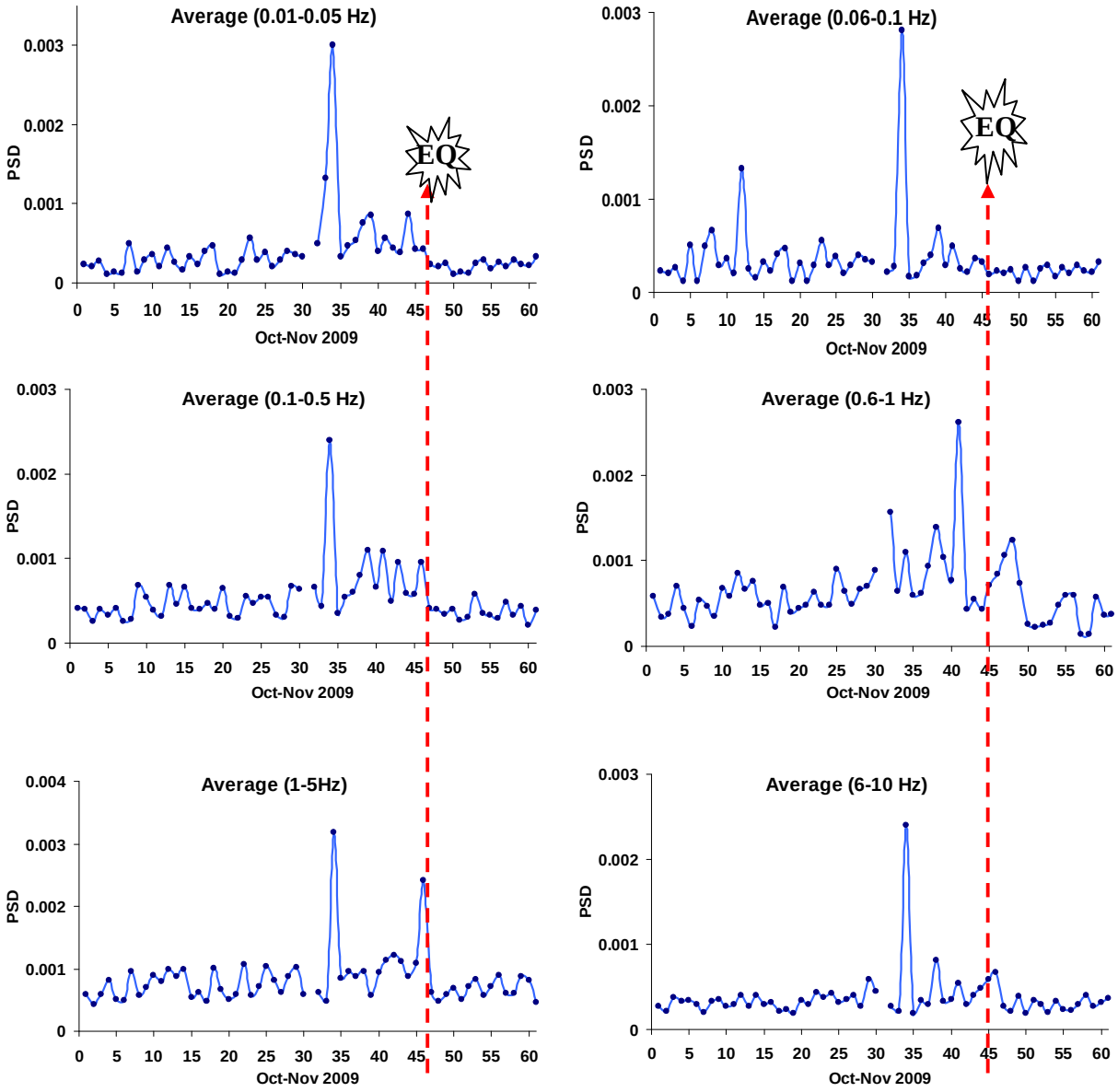

Figure 02 -Power Spectral Density for Z component (01 October – 30 November 2009)

Power spectral analysis for Z component is shown in fig.2, which gives us idea of change in the power of particular frequency channel before earthquake. In second method i.e. polarization parameter, we have considered 3 channels i.e. Ch-1 (0.01-0.1 Hz), Ch-2 (0.1-01 Hz) and Ch-3 (01-10 Hz). Polarization is the ratio between the amplitude of the vertical magnetic component and that of the horizontal one i.e. $Z/Sq(X^2+Y^2)$. This factor allows us to distinguish between the geomagnetic pulsation (predominantly having a horizontal component) and seismo-magnetic emissions (having vertical component larger than the horizontal component). We expect an increase in polarization ratio when seismo-magnetic emission is intensive, whereas it might decrease during magnetic storm time [3, 4, 5]. Polarization parameter ($Z/Sq(X^2+Y^2)$) for channel 01, 02 and 03 is shown in figure 3.

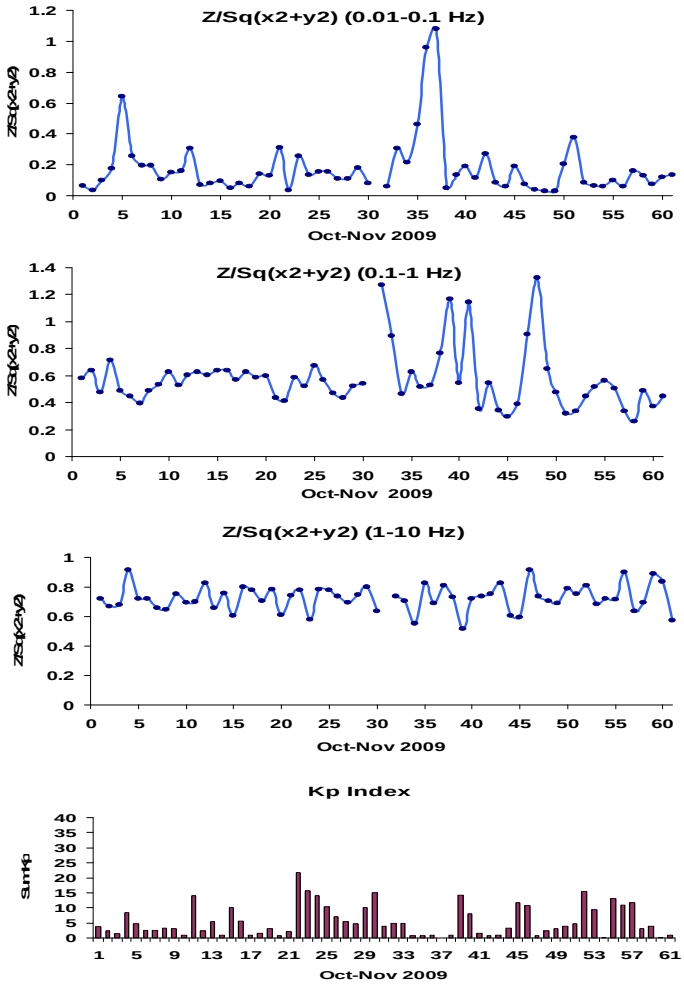

Figure 03 Polarization Parameter Z/Sq(X^2+Y^2) (01 October – 30 November 2009)

Third method i.e. fractal analysis gives us fractal exponent (β) and from this we calculated the fractal dimension D by using the relation D = (5-β)/2 [6]. We have used data of daytime (11:30 am-12:30 pm, local time) and night time (23:30 pm-00:30 am, local time) fractal analysis for X, Y and Z component. In both the cases we got some response before earthquake, which is shown in fig.04.

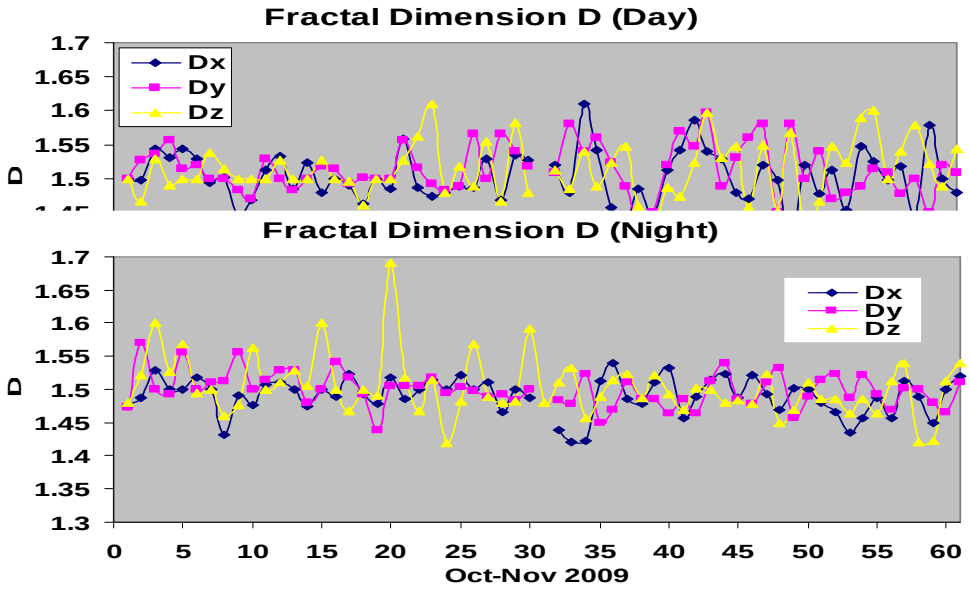

Figure. 04- Fractal Analysis

RESULTS AND CONCLUSION

We have analyzed one moderate earthquake which occurred on 14th Nov. 2009. Fig 02 shows power spectral density analysis of given data. Ch-1 and Ch-2 show enhancement on 03rd and 08th Nov. Ch-3 and Ch-4 give good enhancement which started 10 days before of seismic activity.Ch-5 and Ch-6 show response only on 3rd Nov. Polarization analysis (Fig. 03) clears the fact that increase in the power of particular frequencies are due to lithospheric activities[7]. Fig. 03 shows that few weeks before (04-05 Oct) we got poor enhancement in the polarization parameter for Ch-1 and Ch-2 we got good enhancement in the polarization ratio few days before (06-10 Nov) . During this period the geomagnetic activity was low ($\Sigma Kp<02$). We have analyzed the data by Fractal analysis method also. In this we have checked response of Fractal dimension (D) few weeks before of seismic activity. We got enhancement few days before (11-12 Nov) in noon time data and increment of D in Z component especially on 20th October i.e. near about 03 weeks before the event. Its value was 1.7 which was high enough as compared to other values.

In conclusion ultra low frequency emission observation at Shivaji University Site has shown that enhancement in ULF wave activity was observed few days before the Koyna earthquake. Fractal dimension increased before earthquake. This indicates the frequency fluctuation in the ULF emission before the earthquake. Fractal dimension, calculated from the Berry's expression, has a tendency to increase toward D=2 prior to the earthquake [8]. Frequency channel 02 i.e. 0.06-0.1 Hz shows good results in the case of polarization parameter study.

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