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 detail 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 investigation in the light of geomagnetic activities.

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

1. Introduction:-

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

There are many practical evidences of the magnetic field fluctuations occurring before earthquake [1,2]. 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 discussed here one moderate event, which gives some preliminary results of magnetic field variations before, during & after activity.

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 for recording the three dimensional position of the observatory & for the time recording. The magnetometer works in the frequency band 0.001-32 Hz. System was installed at remote place far from 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 months 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 before few days and few weeks of earthquakes In case of power spectral density method we 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 described in table 1

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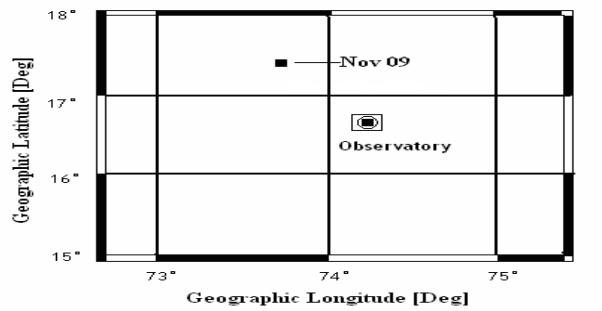

Figure. 01

Table. 01

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

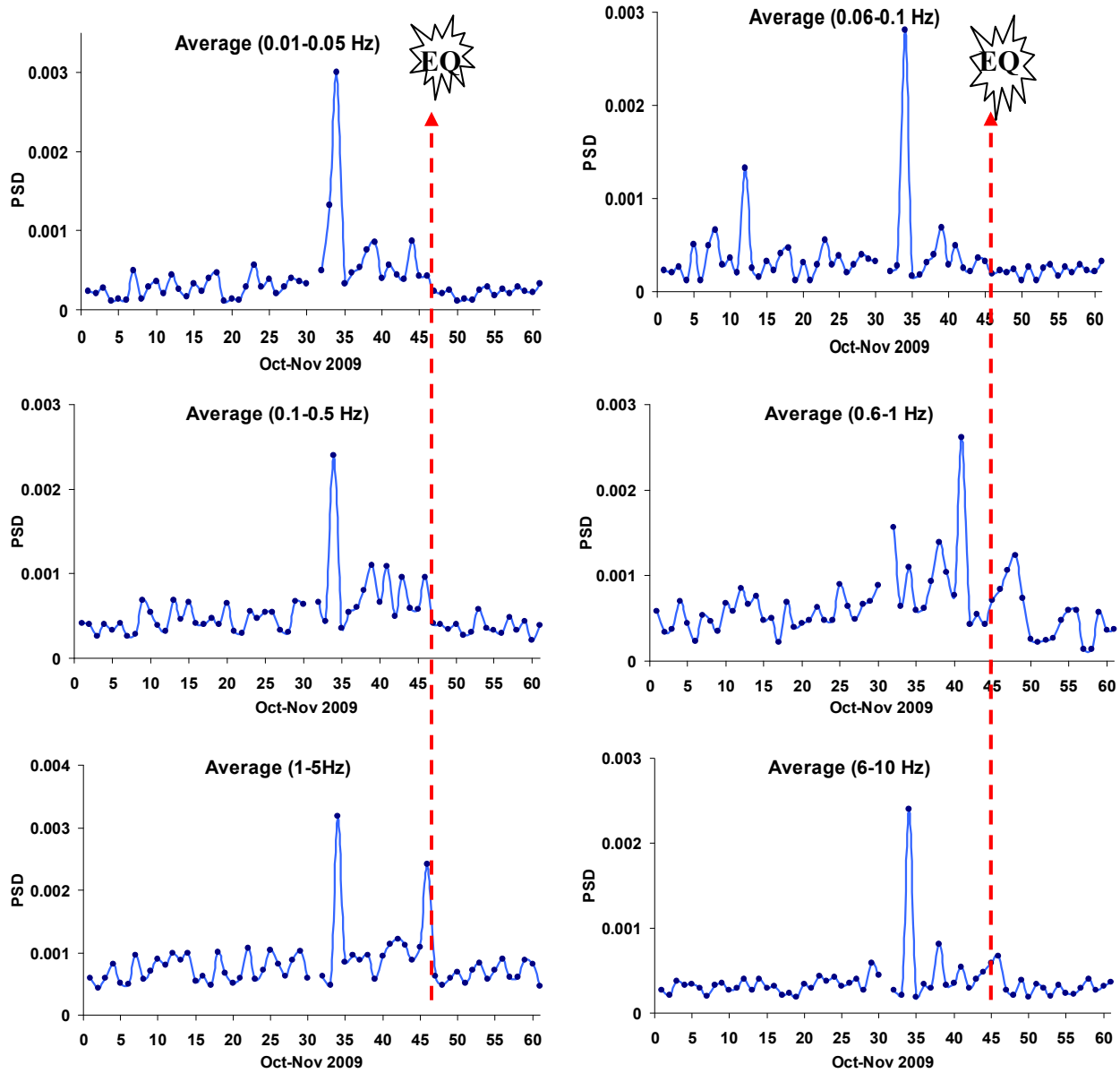

Figure. 02 -Power Spectral Density for Z component (01 October – 30 November 2009)

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 channel i.e. C-1(0.01-0.1 Hz), C-(0.1-01 Hz) and C-3(01-10 Hz) polarization parameter 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 of polarization ratio when seismo-magnetic emission is intensive, whereas it might decrease during magnetic storm time [3,4]. Polarization parameter ($Z/Sq(X^2+Y^2)$) for 03 channels is shown in figure 3.

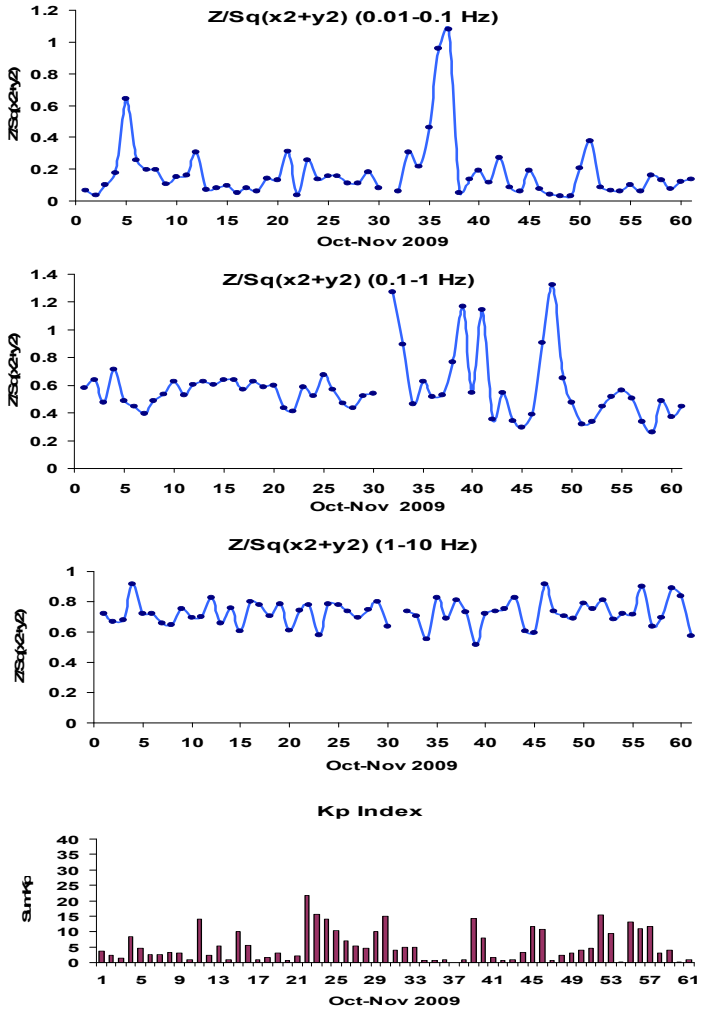

Figure. 03 Polarization Parameter $Z/Sq(X^2+Y^2)$ (01 October – 30 November 2009)

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

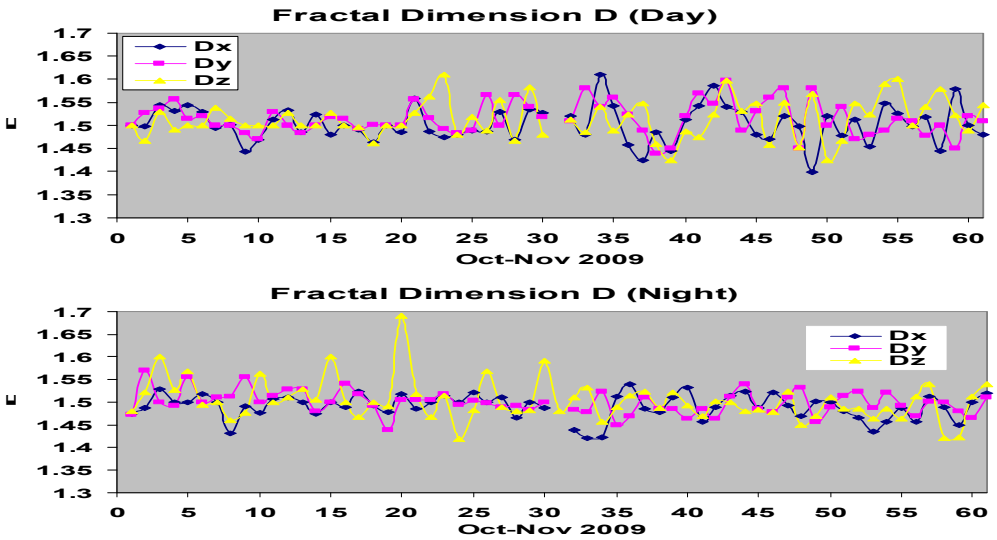

Figure. 04- Fractal Analysis

4. Results and Conclusions:-

We have analyzed one moderate earthquake which is occurred on 14th Nov. 2009. Fig 02 shows power spectral density analysis of given data. In case of different frequency channels Ch-1 and Ch-2 shows enhancement on 03rd and 08th Nov. Ch-3 and Ch-4 gives good enhancement which was started before 10 days of seismic activity.Ch-5 and Ch-6 shows 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[7,8]. Fig. 03 shows that before few weeks(04-05 Oct) we got poor enhancement in the polarization parameter but in case of Ch-1 and Ch-2 we got good enhancement in the polarization ratio before few days(06-10 Nov). During this period geomagnetic activity is low ($\Sigma Kp<02$). We have analyzed the data by Fractal analysis method in that we have checked response of Fractal dimension (D) before few weeks of seismic activity. We got enhancement before few days (11-12 Nov) in noon data and increment of D in Z component especially on 20th October i.e. near about 03 weeks before the event. Its value is 1.7 which is 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 increases before earthquake. Frequency channel 02 i.e. 0.06-0.1 Hz shows good results in case of polarization parameter study.

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