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# Study of ULF magnetic field variation for identification of earthquake precursor before a moderate Earthquake at Kachchh, Gujarat, India

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**ABSTRACT**

*In this paper we applied the polarization ratio and power spectral density analysis at different frequency ranges to magnetic data in the ULF band to study the seismo-electromagnetic emissions associated with a moderate event (Sept 27 2014, Mw 3.8) that occurred at Kachchh region, Gujarat. To discriminate the effect of geomagnetic storm activity, the planetary index (Kp) is also analyzed in the corresponding period. Here we found an enhancement in the power spectral density at different frequency range prior to the occurrence of event. Moreover, the polarization ratio (Z/G) for the ULF range is also showing a value which is nearly equal to 1. The Kp value is less than 30 which shows a quiet activity during the corresponding period. We may conclude less influence of global magnetic field during this period. Fractal analysis is also applied to observe the fractal nature of the ULF signal by studying the variation of the fractal dimension prior to the occurrence of the event. We found enhancement of fractal dimension before the earthquake.*

**Key words:** ULF Magnetic Field, Earthquake, Precursor, Kp Value

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## INTRODUCTION

Recently the forecast of natural disaster has been shown a special attention and specially the earthquakes. There are many approaches have been put forward by different authors in world- wide to study the short-term prediction of earthquake and seismo-electromagnetic method is one of them. There are many practical evidences of magnetic field fluctuations occurring before earthquakes and these fluctuations occur mostly in the ULF-VLF frequency band (Sharma et.al. 2012). In this study, we have taken all the three components of earth's magnetic field in the ULF (0.01-10 Hz) to perform the polarization ratio and power spectral density analysis. A search coil magnetometer has been installed to measure the magnetic field in real time basis at Desalpar, Kachchh region, Gujarat. The magnetometer is working with the Faraday's law of electromagnetic induction.

**Instrumental setup:**
Institute of Seismological Research (ISR) established one observatory at Desalpar, Kachchh region of Gujarat and this region is a highly active region in terms of seismicity. There are many active faults passing most of Kachchh region and our observatory is situated on an active fault known as the Gedi fault. To discriminate the effect of any man-made noise and the electric field, the instruments are installed at remote places, i.e. away from the habitation area. An induction coil magnetometer with three sensors, each sensor is oriented in three directions, i.e. east-west(X), north-south(Y) and vertical (Z), are installed at this observatory. Signals received from the sensors are amplified and filtered using the communication and processing CAM-unit. Global Positioning System (GPS) has

been attached with the instrument to provide the position and time information. The magnetometer is working with the frequency range of 0.01-32 Hz. The data have been recorded with a sampling frequency of 64 Hz.

**Data Analysis:**

An earthquake of Magnitude 3.8 occurred on 27th September 2014 at a distance of 14 km NNW from Desalpar, Kachchh region, which is within 60 km from Desalpar magnetic observatory. The locations of the earthquake and the magnetic observatory are shown in fig.1. We have considered the datasets of two months, i.e. August and September 2014 for analysis. Polarization ratio and power spectral density have been estimated for the magnetic data to check the variation of the magnetic field before the occurrence of earthquake on short-term basis. Again to discriminate the effect of the geomagnetic storm activity, we have also calculated the planetary index (Kp) value for this particular period by taking the data from world data centre, Kyoto, Japan (website-http://swdcwww.kugi.kyoto-u.ac.jp/index.html).

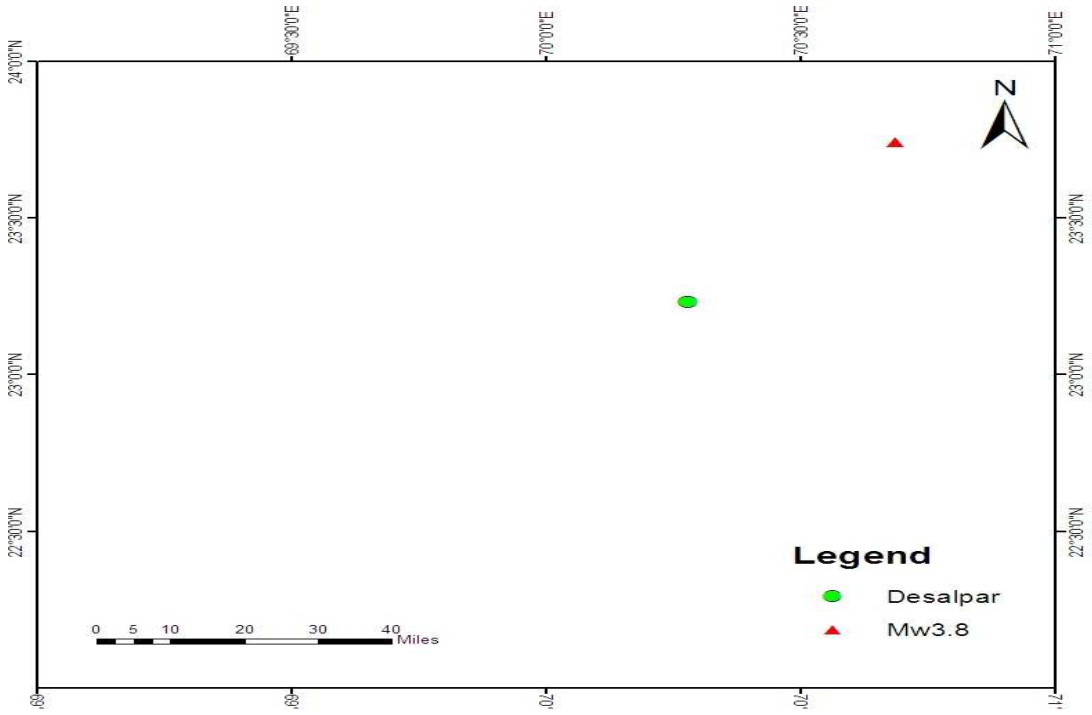



**Fig.1 Location map showing the earthquake**

**1. Power Spectral Density Analysis:**

For power spectral density analysis, we have checked the variation in six different frequency bands i.e

| | |
|---|---|
| F1 | 0.01-0.05 Hz |
| F2 | 0.06-0.1 Hz |
| F3 | 0.1-0.5 Hz |
| F4 | 0.6-1 Hz |
| F5 | 1-5 Hz |
| F6 | 5-10 Hz |

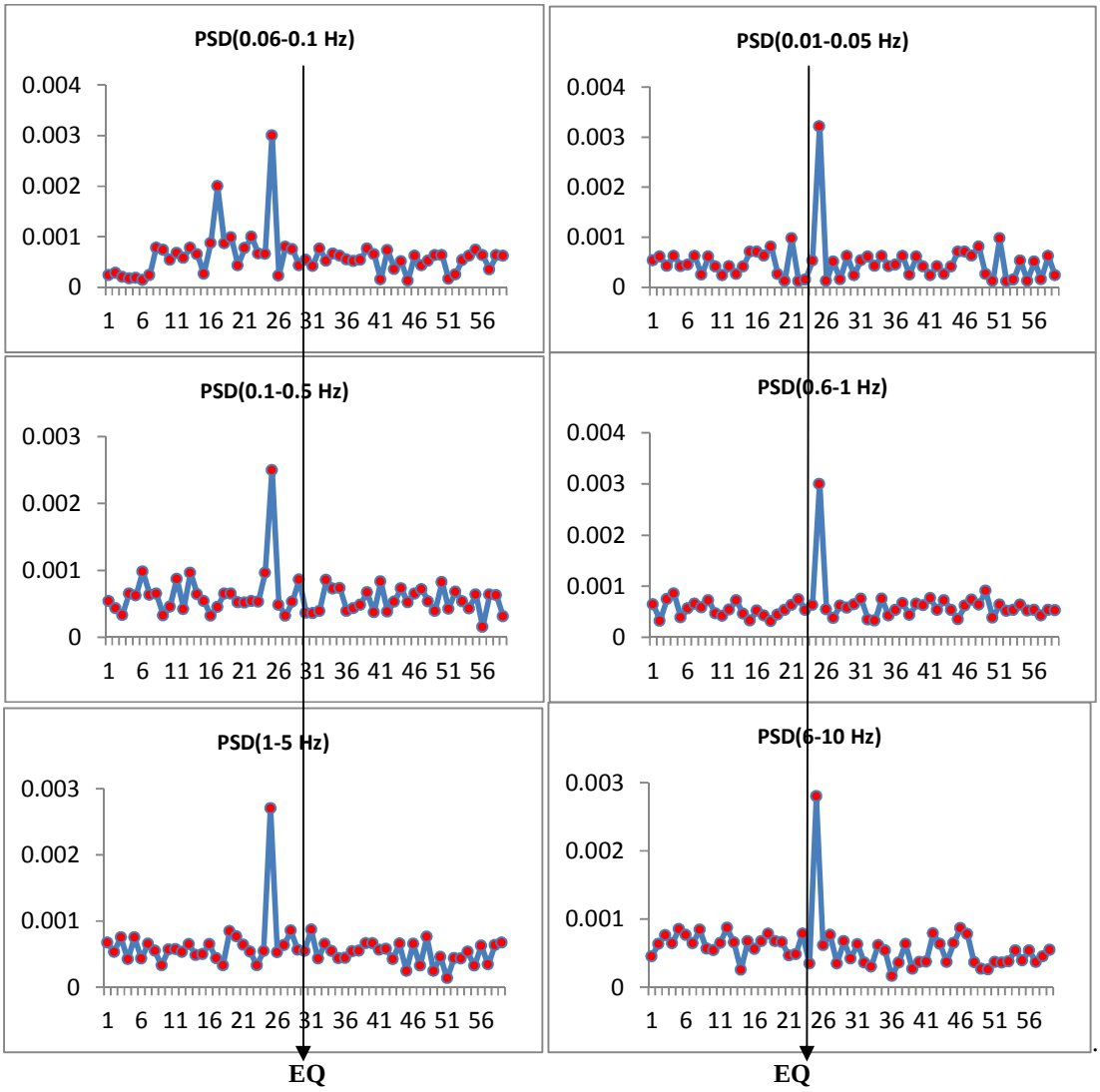



**Fig.2 Power Spectral Density for Z-component (1st August-30th September)**

## 2. Polarization Ratio Analysis:

Polarization ratio is defined as the ratio between Z and G, where Z is the vertical magnetic field and G= $\sqrt{(X^2 + Y^2)}$. Z/G is calculated to distinguish between the seismogenic emissions from other noises (Hayakawa et.al, 1999). We expect an increase in polarization ratio when seismo-magnetic emission is intensive, whereas it might decrease during magnetic storm time (Sharma et.al. 2012). In this study, we calculated the Z/G for three frequency bands (i.e. 0.01-0.1 Hz,0.1-1 Hz and 1-10 Hz) in the ULF range and at each range, we got some enhancement in the value for a particular period prior to the occurrence of the event (fig.3).

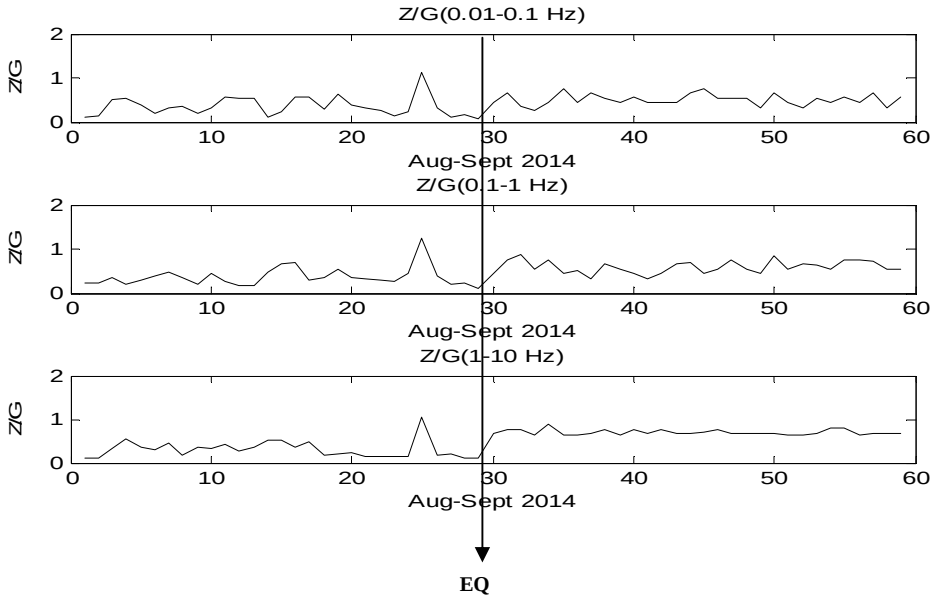



**Fig.3 Polarization parameter Z/G (1st August- 30th September, 2014)**

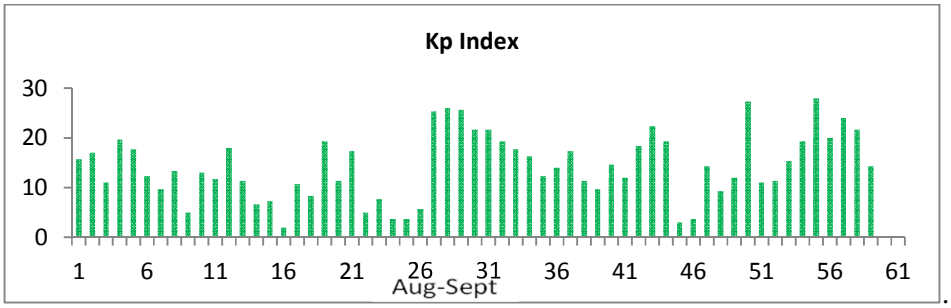
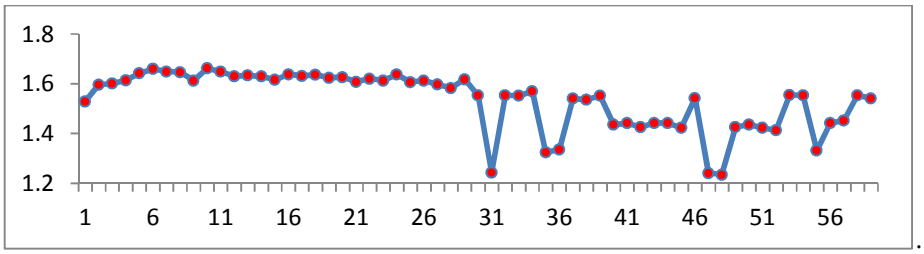



**Fig.4 Planetary Index (Kp) value(1st August-30th September 2014)**

## 3. Fractal Analysis:

Earthquake dynamics can be studied by the self organized criticality (SOC) concept, where earthquake occurrence is regarded as a critical stage (Rawat et.al, 2014). Since the dynamics of such a system reflects the power law distributions, we have calculated the slope of the power spectrum (β) by the relation, S(f)= $f^{-\beta}$ and it is linked with the fractal dimension by the Berry's Equation: D= $(5-\beta)/2$. Fractal dimension is obtained for all the three components(X, Y and Z) of the magnetic field and shown in the fig.5 below:



X-component

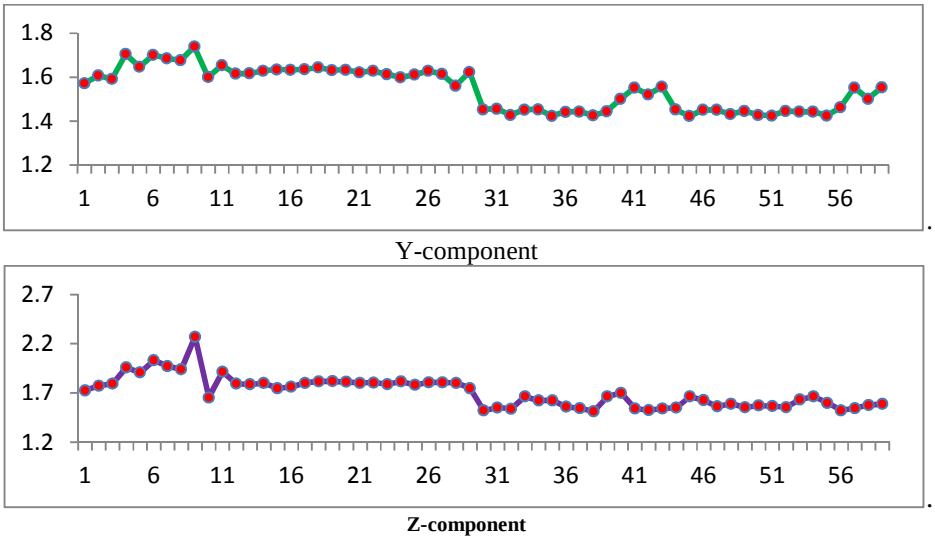



**Fig.5 Fractal Dimensions for X, Y and Z-components (1st August-30th September)**

## RESULTS AND CONCLUSION

We have applied different methods to the magnetic datasets to correlate with the occurrence of a moderate earthquake and the result is discussed below:

- In fig.2, we got an enhancement of PSD value on 16th and 25th August for F1, whereas for other frequency ranges, there is a sharp increase on 25th August.
- In fig.3, there is also an increase in the polarization ratio for all the frequency ranges on 25th August.
- In fig.5, there is a sharp increase in the fractal dimension of the Z-component on 8th August.

From all the observation we conclude that that enhancement of ULF wave activity was observed before the Kachchh earthquake and during this period there was no geomagnetic storm and the planetary index was in a quiet condition (Kp < 30) (fig.4). Again there was also increase in the fractal dimension of the Z-component. Hence, it may be regarded as all the enhancement is due to the seismogenic activity.

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