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# Preliminary analysis of the geomagnetic pulsations observed at Teoloyucan, Mexico

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**RESUMEN**

Desde febrero de 1993, se han estado registrando casi en forma continua micropulsaciones en el Observatorio Magnético de Teoloyucan, Edo. de México, en la banda de frecuencias de 0.01 a 0.20 Hz, que corresponde a periodos entre 5 y 100 segundos. En este trabajo presentamos un análisis preliminar de los datos en el que se muestra la distribución de la frecuencia de ocurrencia de todos los eventos con respecto al tiempo local y a lo largo del año. Encontramos un máximo de ocurrencia alrededor del medio día y un mínimo de ocurrencia cerca de la medianoche. Parece haber también una variación estacional que muestra dos máximos, en marzo y en diciembre, y un mínimo en julio.

**PALABRAS CLAVE:** Micropulsaciones, física magnetosférica.

**ABSTRACT**

Geomagnetic micropulsations have been observed almost continuously since February 1993 at the Geomagnetic Observatory in Teoloyucan, Mexico, in the frequency band 0.01-0.20 Hz (5 - 100 seconds in period). In this paper we present a preliminary analysis of the data showing the frequency distribution of all the events with respect to local time and along the year. We find the maximum occurrence of micropulsations around noon and the minimum around midnight. A seasonal variation seems to be present with maxima in March and December and a minimum in July.

**KEY WORDS:** Micropulsations, magnetospheric physics

## INTRODUCTION

Low-latitude micropulsation observations have been recently started at Teoloyucan, Mexico. This paper is a preliminary report on the first observations from Teoloyucan.

The Earth's magnetosphere is filled with plasma which may become unstable for many reasons. These instabilities generate electromagnetic or electrostatic waves which propagate in the conducting medium. Geomagnetic pulsations correspond to the lowest-frequency waves in the electromagnetic spectrum and may be continuous (Pc 1,2,3,4,5) or irregular (Pi 1, 2). Among the Pc1 pulsations, there are some with a clearly diminishing period classified as IPDP (Jacobs, 1970). Pulsations can occur as stationary waves in the magnetic field. The wavelength can be as large as the magnetosphere; this is the case of the Pi2 and Pc3, 4, and 5 pulsations. Other kind of waves occur in the magnetosphere usually in the form of travelling waves. This is the case of Pi1, Pc1 and IPDP pulsations, whose wavelength is small compared with the magnetospheric dimensions. These are packets of waves or impulses travelling along the geomagnetic field lines. For details concerning the morphology and sources of geomagnetic pulsations, see Troitskaya (1967), Troitskaya and Gul'Elmi (1967), Saito (1969), Gendrin (1970), Jacobs (1970), Orr (1973), and Samson (1991).

The study of the propagation of pulsations in the magnetosphere requires observations made at different latitudes on the Earth and at different altitudes above the surface. The micropulsation observatory at Teoloyucan, near Mexico City (geographic coordinates: 19°N, 99°W) provides low latitude (L=1.3) recordings of geomagnetic micropulsations in order to contribute to the study of the propagation of pulsations in different regions of the magnetosphere. It features a two-axis search coil magnetometer system and records pulsations with frequencies as low as 0.0016 up to 2.0 Hz. The observatory has been in almost continuous operation since February 1993.

## DESCRIPTION OF THE EQUIPMENT

The geomagnetic pulsation detector consists of two orthogonal high-permeability-core search coils, oriented N-S and E-W connected to a system of digital recording controlled by a computer. The search coils are 200,000 turn coils of 0.12 mm-diameter copper wire wound on a 90 cm-long and 10.0 cm-diameter cylinder with a permalloy core. The output of the sensor coils feeds a current preamplifier which amplifies the signal by $10^4$. From there, the signal goes through 2-Hz low-pass filters and through a variable-gain voltage amplifier.

The next stage consists of three different band pass filters which separate the signals into three different bands: 0.20-2.00 Hz (HF band), 0.01-0.20 Hz (LF band), and 0.0016-0.01 Hz (SLF band). However, the system is calibrated to receive only the low frequency band between 0.01 and 0.20 Hz (corresponding to Pc3, Pc4, Pc5, and Pi2 pulsations) because most pulsations at this latitude are expected to be in this range. We do not expect to observe Pc1, Pi1, and IPDP pulsations because they propagate mainly along the field lines connecting the magnetospheric tail, which enter the Earth at much higher latitudes.

There is an option of an additional adjusted voltage amplification. The final amplification yields a signal in the dynamic range of ±8 volts. Finally, the signal feeds a digital acquisition system controlled by a personal computer using an intelligent program. The system is adjusted to an attenuation of 6 db and is calibrated every month with a sinusoidal signal of frequency 0.05 Hz and amplitude of 0.4 Vpp. This amplitude is equivalent to a magnetic field of 4 γ. The signal is fed into the calibration coil which is inside the sensor.

## DATA ACQUISITION AND PROCESSING

The digital acquisition system consists of a 16-channel acquisition card which has a 12 bit resolution and a dynamic range of ±10 volts. We are using two channels, one for each sensor. The sampling rate is 1 Hz which ensures recording all signals with frequencies up to 0.5 Hz. Data are recorded onto a hard disk by means of a program that records only when the signal amplitude exceeds a threshold of 0.04 Vpp, which is equivalent to a magnetic field of 0.4 γ. The data are recorded in files of 1024 pairs of data points per channel. The files are coded by date and time of the event.

## THE OBSERVATIONS

Some examples of pulsations observed at Teoloyucan are shown in Figure 1. We may distinguish Pc5, Pc4, Pc3, and Pi2 pulsations. In this paper we present a preliminary analysis of one year of data, from February 1993 to January 1994. A detailed analysis of the different kinds of pulsations will be presented in future papers. We recorded a total of 4701 events, or about 12 per day, and we obtained their frequency distribution with respect to local time and month of the year.

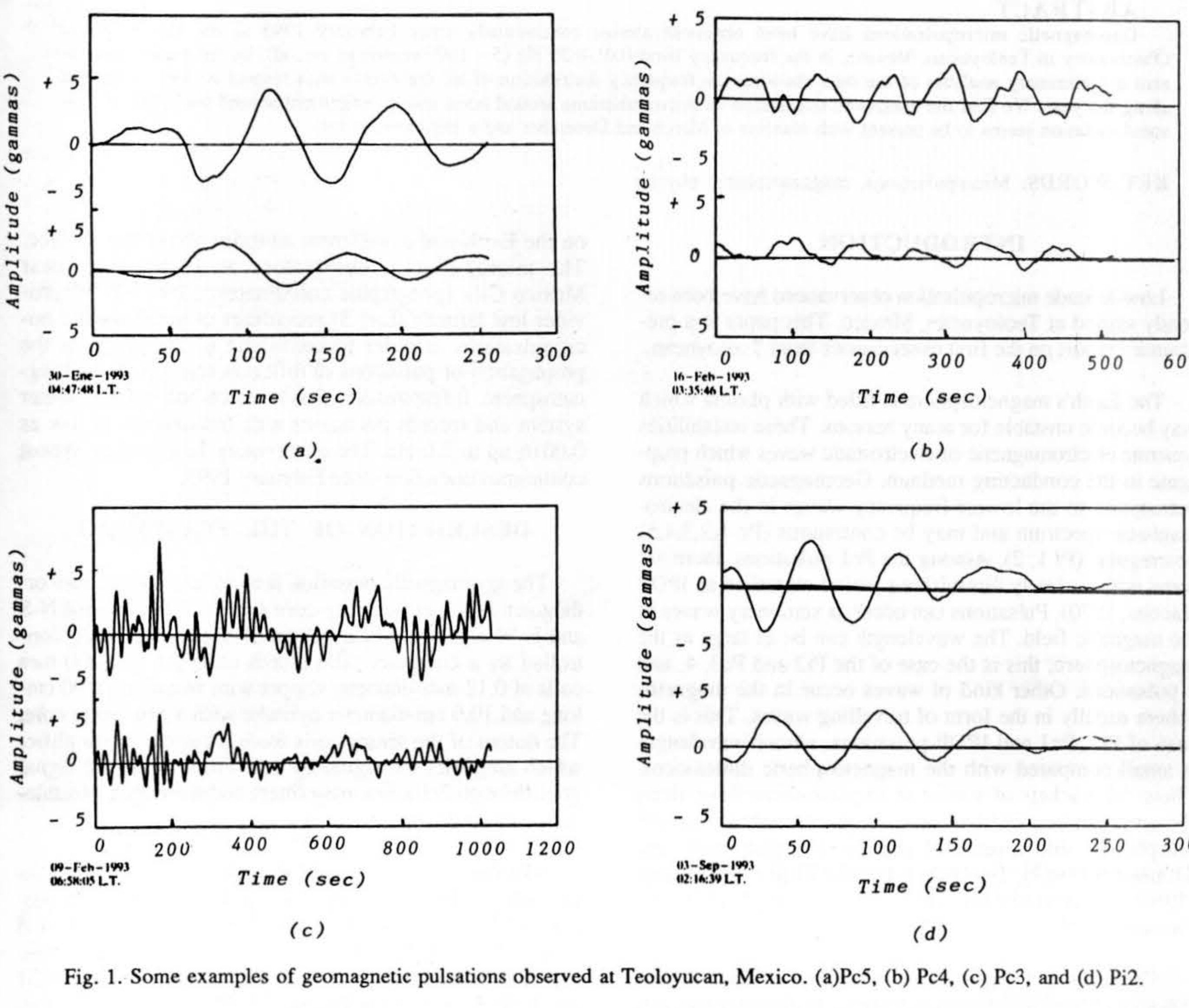


Fig. 1. Some examples of geomagnetic pulsations observed at Teoloyucan, Mexico. (a)Pc5, (b) Pc4, (c) Pc3, and (d) Pi2.

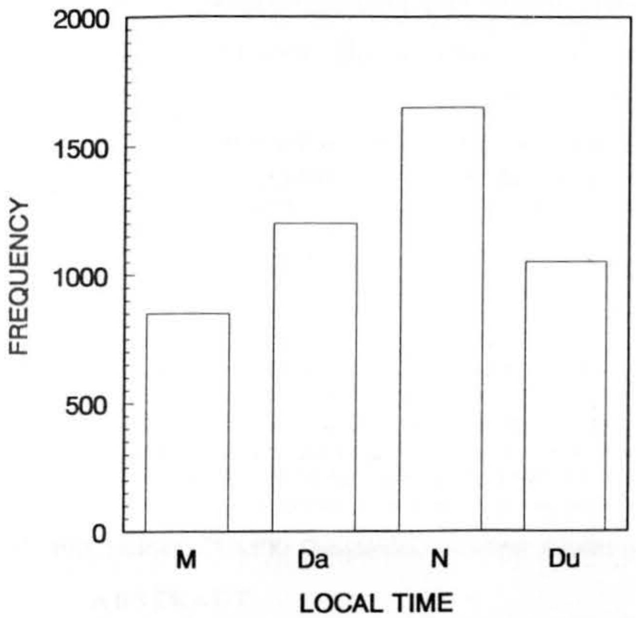


Fig. 2. Total frequency distribution versus local time of the geomagnetic pulsations observed at Teoloyucan from February 1993 to January 1994. Six hour intervals were used, around midnight (M), dawn (Da), noon (N), and dusk (Du).

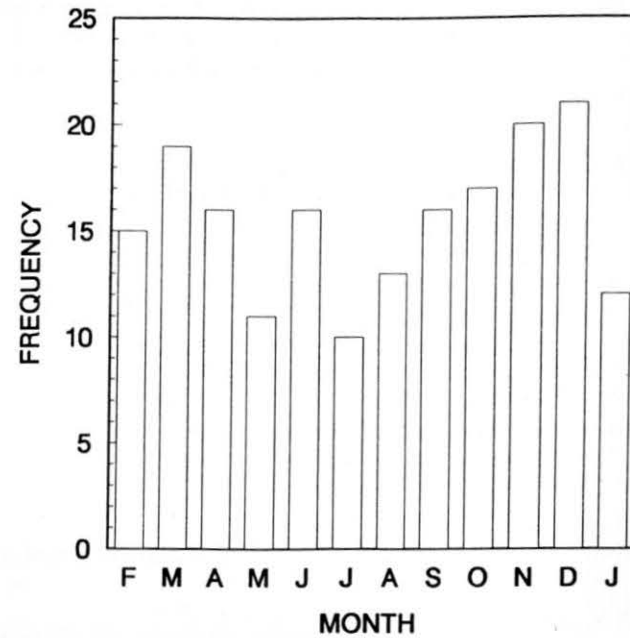


Fig. 3. Monthly frequency of occurrence of geomagnetic pulsations at Teoloyucan from February 1993 to January 1994, normalized by the number of days of observation per month.

Figure 2 shows the frequency distribution of micropulsations at Teoloyucan with local time. The distribution peaks about noon and has a minimum around midnight. This behaviour is similar to that reported for Pc1 pulsations (e.g. Campbell, 1967; Taylor *et al.*, 1975) and for Pc2 and 3 (Jacobs and Sinno, 1960). It differs from the temporal behaviour of Pi2 pulsations, which present a maximum of occurrence around midnight (Lester and Orr, 1981). Clearly, even if we do observe Pi2 pulsations, which are global pulsations, we do not receive them very frequently.

The monthly distribution of pulsations is shown in Figure 3, where the frequency has been normalized by the number of days of observation per month. A seasonal effect seems to be present, with maxima in March and December and a minimum in July.

## DISCUSSION

From a preliminary analysis of geomagnetic pulsations observed at Teoloyucan, we find that they appear very frequently for a geomagnetic latitude as low as 29° (L=1.3), considering that the solar activity is now going toward a minimum. Our observations suggest a predominance of Pc 1, 2, and 3 pulsations, but a more detailed analysis, separating each type of pulsations, is required before we can tell which pulsations we are actually observing and how their frequencies distribute along the day and the year.

## ACKNOWLEDGEMENTS

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