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Characteristics of Pc3 pulsations at Great Wall Station, Antarctica*

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Abstract In this paper Pc3 pulsations at Great Wall Station of Antarctica are analyzed statistically from August 16 to November 20, 1990. The occurrence frequency, frequency and polarization are studied for Pc3 pulsation events. The mechanisms of excitation and propagation of Pc3 pulsations at Great Wall Station are discussed theoretically.
Key words Antarctica, Pc3 pulsations.

1 Introduction

The observation of geomagnetic pulsations at Great Wall Station gives us a good chance for investigation of upper atmospheric physics at polar region. At the upper atmosphere above Antarctica the phenomena of pulsations are complicated and active, almost all kinds of pulsations can be observed (Yang, 1992a). They are closely connected with upper atmospheric phenomena such as magnetic storm, polar substorm, auroral and ionospheric storm (Jacobs, 1970). By study of geomagnetic pulsations in Antarctica a lot of information about the electromagnetic environment in polar region can be got. This is of great value in realizing the transport process of solar energy and understanding global space environment.

Great Wall Station is located at 50. 6°S geomagnetic latitude and 7. 4°E longitude. Although its L value isn't large enough, it is the only Chinese station in the West Hemisphere at present and provides directely observations in the Southern Hemisphere and West Hemisphere. Pc3 pulsations are popular phenomena at Great Wall Station of Antarctica. It is very useful to study the characteristics of Pc3 pulsations at Great Wall Station for understanding global variations of Pc3 pulsations.

In this paper the data of geomagnetic pulsations at Great Wall Station are used from August 16 to November 20, 1990. The Pc3 pulsation events are selected in this period. The characteristics of occurrence frequency, frequency and polarization for Pc3 pulsation events are studied. The mechanisms of excitation and propagation of Pc3 pulsations at Great Wall Station are discussed theoretically.

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2 Method of data analysis

Pc3 pulsations are continuous pulsations with the periods from 10 s to 45 s. This kind of pulsations lasts for a long time and displays sinusoidal variation obviously. So they can be easily recognized from the record of geomagnetic pulsations.

Firstly, the Pc3 pulsation events are selected from pulsation record at Great Wall Station. The selecting criterions are as fowllows: (1) the period of continuous pulsations ranges from 10 s to 45 s; (2) the duration is generally more than 20 minutes; (3)the waveform displays sinusoid and peak-peak amplitude is more than 0. 2 nT.

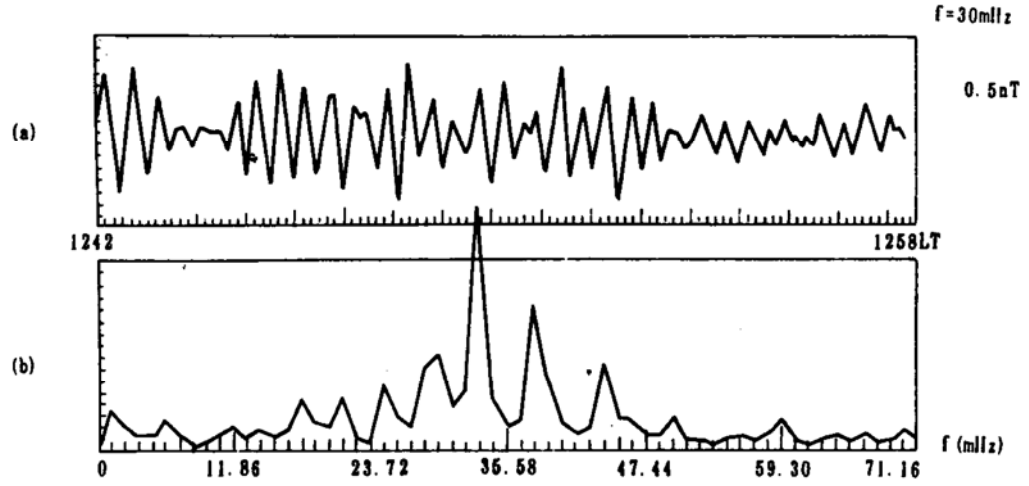

Fig. 1. (a) The typical Pc3 pulsation; (b) The corresponding spectrum.

Secondly, a piece of pulsation record that has good waveform and strong amplitude is chosen as a typical pulsation for each Pc3 pulsation event and FFT Fourier spectrum analysis is made. According to the requirement of digitizing procedure the duration of the selected typical pulsation is 16. 5 minutes. The highest spectrum peak value of the typical pulsation is called the main frequency for the Pc3 pulsation. We emphasize to analyze and study these main frequencies of Pc3 pulsation. Fig1. (a) gives a selected typical Pc3 pulsation and Fig. 1(b) gives the corresponding spectrum for the typical pulsation.

Finally, the selected typical Pc3 pulsations must be filtered by band passing digitized filters in which central frequencies are their main frequencies. Fig. 2(a) gives waveform of a filtered typical Pc3 pulsation. Then the polarization of a typical Pc3 pulsation can be drawn when D component acts as abscissa and H component acts as ordinate. Fig. 2(b) shows the polarization ellipses of the typical Pc3 pulsation.

According to procedure mentioned above, the main frequency, main amplitude, occurrence frequency and polarization ellipses can be got from the Pc3 pulsation events. So we can analyze the characteristics of frequency and polarization for Pc3 pulsations at Great Wall Station.

The selected typical Pc3 pulsations at each hour interval can be compared each other, the one with the great amplitude act as a representative of Pc3 pulsations at this hour

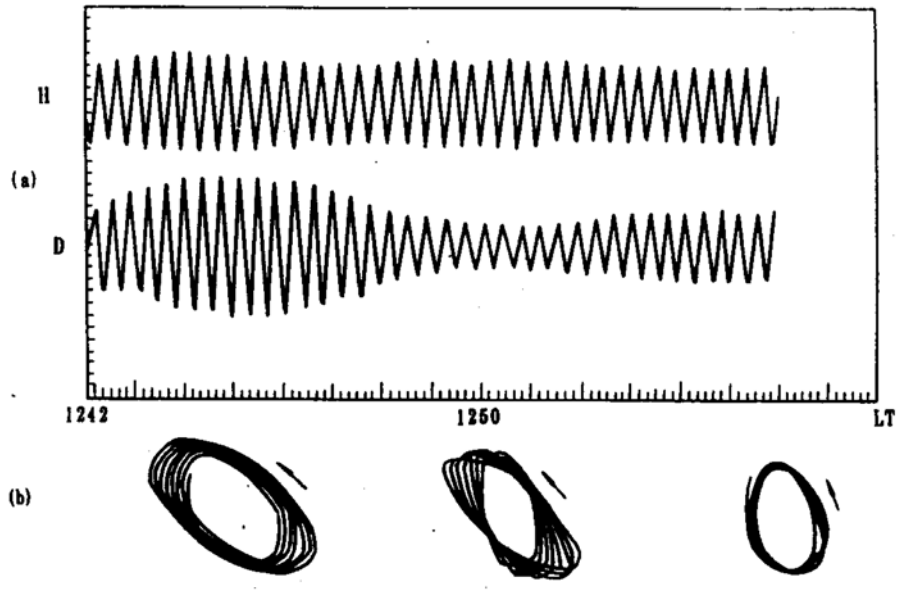

Fig. 2. (a) Filtered waveform of typical Pc3 pulsation; (b) polarization ellipses.

interval, which is called the characteristic Pc3 pulsation. 117 characteristic Pc3 pulsations are totally selected from August 16 to November 20, 1990.

3 Characteristics of occurrence frequency for Pc3 pulsations at Great Wall Station

The characteristics Pc3 pulsations at each interval of an hour are analyzed statistically in local time of Great Wall Station. So the diurnal variation of Pc3 pulsations occurrence frequency at Great Wall Station can be got. Fig. 3 gives the statistical histogram of Pc3 pulsations occurrence frequency at Great Wall Station.

It can be seen from Fig. 3 that Pc3 pulsations occur mainly from 0500 LT to 1800 LT for total occurrence frequency of 117 from August 16 to November 20, 1990. This means that the Pc3 pulsation events are dayside events. There are two obvious peaks at the diurnal variation of occurrence frequency: one is located between 0800 LT and 0900 LT with maximum value of 18/hour, another is located between 1200 LT and 1300 LT with maximum value of 11/hour.

At Great Wall Station of Antarctica more Pc3 pulsations can be observed in the morning from 0600 LT to 1200 LT. Pc3 pulsations occur in 81 intervals of an hour, occupying 69.2% of total number. Pc3 pulsations can be observed obviously from 0400 LT, they are very active in the whole morning. Pc3 pulsations are still active in the noon, but the duration is not long and they are only 9.4% of total number. The occurrence frequency of Pc3 pulsation gradualy becomes lower in the afternoon and obvious Pc3 pulsations can not be observed after 1800 LT.

4 Characteristics of frequency for Pc3 pulsations at Great Wall Station

The main frequency of characteristic Pc3 pulsation in each interval of an hour is

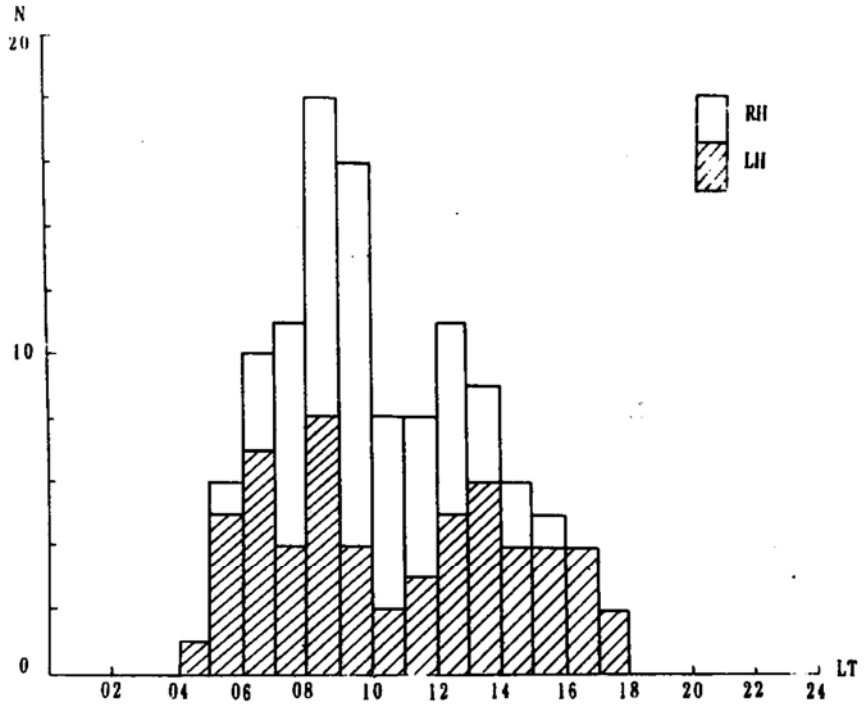

Fig. 3. The diurnal variation of Pc3 occurrence frequency at Great Wall Station.

called the characteristic main frequency of Pc3 pulsations at that interval. The occurrence frequencies of Pc3 pulsations are drawn according to the ranges of frequency so that the characteristics of frequency for Pc3 pulsation can be got.

Fig. 4 gives the frequency distribution histogram of Pc3 pulsation occurrence and the interval unit of frequency is 5 mHz. It can be seen from Fig. 4 that the peak of Pc3 pulsation occurrence frequency is located between 25 mHz and 30 mHz. The peak is obvious and the maximum value is 21 times, 17.9% of total number.

Pc3 pulsations at Great Wall Station occur mainly between 22 mHz and 35 mHz. It is 50 times, 42.7% of total number. In addition, the occurrence frequency of Pc3 pulsations between 40 mHz and 55 mHz is still high. It is 22 times, 18.8% of total number.

The frequency distribution of Pc3 pulsations in the domain of local time is studied when the local time is treated as abscissa and the characteristic main frequency of Pc3 pulsations as ordinate. It can be seen that the range of main frequency for Pc3 pulsations is wide in the morning from 22 mHz to 70 mHz and narrow in the afternoon from 22 mHz to 35 mHz.

5 The characteristics of polarization for Pc3 pulsation at Great Wall Station

Fig. 5 gives the variation of polarization ellipticities versus local time for Pc3 pulsations at Great Wall Station. The positive ellipticities indicate the right-handed polarization and negtive indicate the left-handed polarization. These two kinds of polarizations are plotted with circles and dots respectively in Fig. 5. It can be seen that the right-hand-

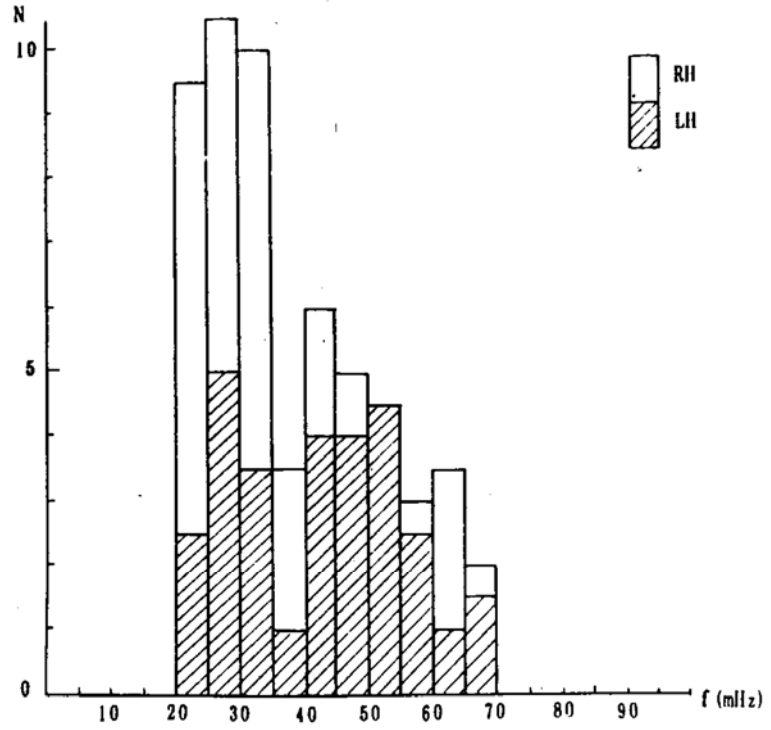

Fig. 4. The frequency distribution of Pc3 pulsations at Great Wall Station.

ed polarizations of Pc3 pulsations are dominant from 0700 LT to 1300 LT of all 72 times, the right-handed polarizations amount to 46 times, 63. 8% of total number. The left-handed polarizations are dominant in the other intervals of local time.

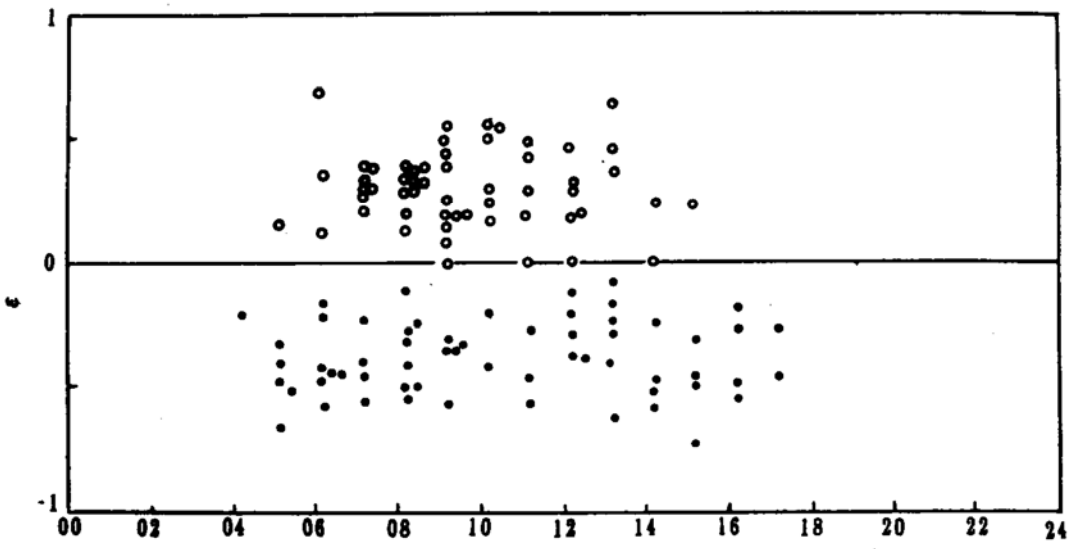

Fig. 5. The variation of polarization ellipticities of Pc3 pulsations in local time at Great Wall Station.

The ellipticities of right-handed polarizations are concentrated between 0. 2 and 0. 4 and the ellipticities of left-handed polarization are concentrated between 0. 4 and 0. 5.

The orientation of major axis of Pc3 polarization ellipses at Great Wall Station varies with local time. It can be seen from statistical results that the NW-SE direction is dominant and the angle between major axis and east is mainly concentrated between $-57°$ and $-58°$.

6 Discussion

According to analysis of Pc3 pulsations at Great Wall Station mentioned above it can be seen that the characteristics of Pc3 pulsations at Great Wall Station are as follows: (1) Pc3 pulsation events are dayside phenomena which occur mainly from 0600 LT to 1800 LT. (2) The frequecy range of Pc3 pulsations is concentrated between 22 mHz and 35 mHz. (3) Right-handed polarizations are dominant from 0700 LT to 1300 LT. In other interval of local time left-handed polarizations are dominant. (4) Ellipticities of right-handed polarizations are between 0.2 and 0.4 generally. (5) The NW-SE drection is dominant for the orientation of major axes of Pc3 polarizations and the angles between orientation and east are generally from $-55°$ to $-60°$.

It can be seen from observations that Pc3 pulsation events at Great Wall Station still have the common characteristics of Pc3 pulsations which are dayside events. It means that the exciting sources of Pc3 pulsations are located in the dayside of the magnetosphere whatever in the Southern Hemisphere or in the Northern Hemisphere. In general Pc3 pulsations are related to some oscillation mechanisms in the magnetosphere because of the quasi-sinusoidal waveform of Pc3 pulsations. The frequency ranges of Pc3 pulsations at Great Wall Station are almost coincident with that at low latitude Pc3 pulsations (Yang, 1992b). This fact reflects that Pc3 pulsations do not have obvious latitude effects. It is well known that there is no obvious latitude effect of Pc3 pulsations because the low frequency MHD waves in front of Earth's bowshock penetrate into the magnetosphere and propagate to low latitudes on the Earth's surface along radial direction. At present it is not clear whether waves propagate directly to low latitudes or indirectly affect low latitudes by some ways.

Polarizations of Pc3 pulsations at Great Wall Station also possess same characteristics at middle latitudes that there is obvious demarcation line in the noon (Lanzerotti *et al.*, 1972). At Great Wall Station right-handed polarizations of Pc3 pulsations are dominant in the morning and left-handed polarizations are dominant in the afternoon. But in the Northern Hemisphere left-handed polarizations are dominant in the morning and right-handed polarizations are dominant in the afternoon. It can be seen that the polarization senses of Pc3 pulsations in the Northern Hemisphere are opposite with that in the Southern Hemisphere. This phenomenon can not be explained by coupling of Kelvin-Helmholtz instability in the magnetopause generated by solar wind and field line oscillation at high and middle latitudes. However it can be expained clearly by our new theory which is called as oscillating field aligned current theory about propagation and exciting mechanism of low latitude Pc3 pulsations (Yang, 1993). It is considered in this theory that the low latitude pulsations can be excited by oscillating field aligned current generated in the field line at middle and low latitudes. Penetrated low frequency MHD waves from Earth's

bow shock can couple with oscillation of some field line and excite Alfven waves reflected between ionospheres so that field aligned currents oscillate. So Pc3 pulsations recorded at middle and low latitudes are results of oscillating field aligned current and its corresponding ionospheric current. According to this theory we simulated low latitude Pc3 pulsations and explained the opposite polarization senses of Pc3 pulsations in Northern and Southern Hemispheres.

How the Pc3 pulsations at Great Wall Station are generated needs further study. Comparison of multistation measurements in Antarctica can be used and the observations at conjugate points of Northern and Southern Hemispheres can also be adapted. These studies are very useful for understanding exciting mechanism and propagation characteristics of Pc3 pulsations at middle and low latitudes.

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