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Some Characteristics of Large Amplitude Pc5 Pulsations

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Abstract

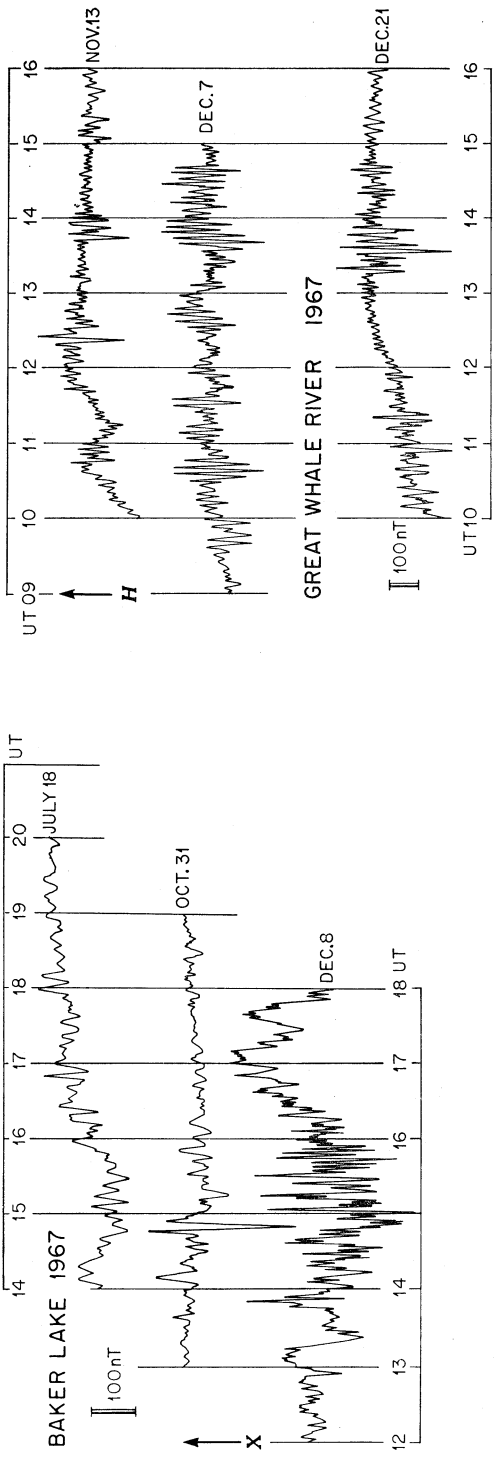
An analysis of the 1967 geomagnetic data from five Canadian observatories reveals that Pc5 pulsations of amplitude $\geqslant 40$ nT occur most often within geomagnetic latitudes 65°–74°. The occurrences peak during morning hours in the auroral zone but during later hours of the day at higher latitudes, while a strong midnight occurrence peak is also noted at the auroral zone stations. The occurrences and amplitudes in general are found to be largest near the central line of the auroral zone, while the periods are found to increase with increasing latitudes. Stronger magnetic activity seems to generate a larger number of Pc5 pulsations with large amplitudes. With increasing activity, there seems to take place a continuous decrease in the level at which instability develops. This may be inferred from the Baker Lake data, where the period of pulsations decreases continuously with increasing activity. The results of the present investigation seem to fit a model in which the auroral zone ionosphere acts as an amplifier of the amplitude of hydromagnetic waves which arrive along the lines of force from the magnetopause.

Introduction

Giant pulsations belonging to the Pc5 group were first discovered by Rolf (1931). Several authors have studied these pulsations since then (Harang 1936; Sucksdorff 1939; Kato and Watanabe 1954, 1956; Obyashi and Jacobs 1958; Whitham and Loomer 1958; Ol' 1963; Kokubun and Nagata 1965; Hirasawa 1970). This work as well as that of others has been reviewed by Campbell (1967), Saito (1969), Jacobs (1970) and Orr (1973). Recently, spectrum analysis techniques have been applied by Samson (1972) and by Morgan and Lanzerotti (1973) to study the characteristics of Pc5 pulsations from data obtained from separate chains of stations that were spread over a wide range of latitudes along nearly the same geomagnetic longitude.

Pc5 pulsations are low frequency oscillations of the geomagnetic field having sinusoidal waveforms with a period in the range 150–600 s. Frequently their amplitudes have exceeded several hundred nanoteslas (1 nT $= 1\gamma = 10^{-5}$ G) in the magnetically active auroral zone. Theoretical considerations suggest that hydromagnetic oscillations of the field lines may give rise to these pulsations whenever, under suitable conditions, a Kelvin–Helmholtz instability arises at or near the magnetopause. However, some characteristics of these pulsations remain to be explained, and it is hoped that the analysis of both ground and satellite observations will lead to a better understanding of this phenomenon.

The purpose of the present investigation is to study morphological features of the large amplitude pulsations that occurred in and around the auroral zone during 1967.



[Fig. 1 continued below]

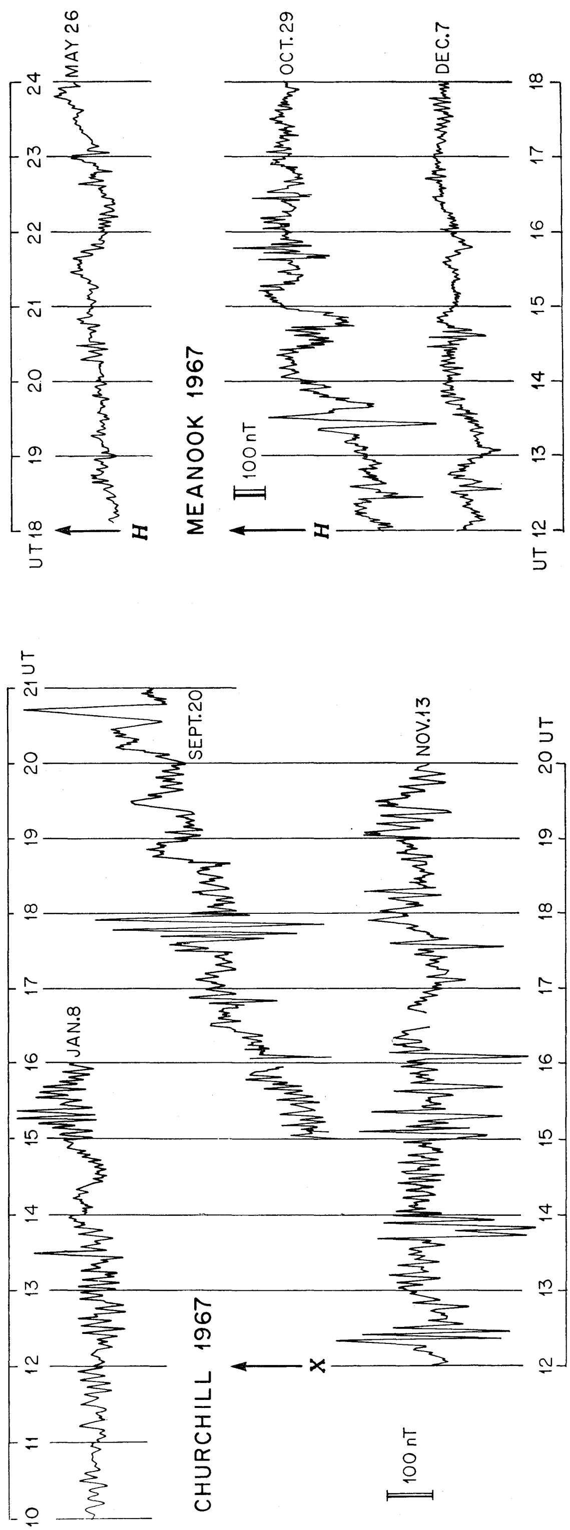


Fig. 1. Some examples of LAP received at the indicated stations in 1967.

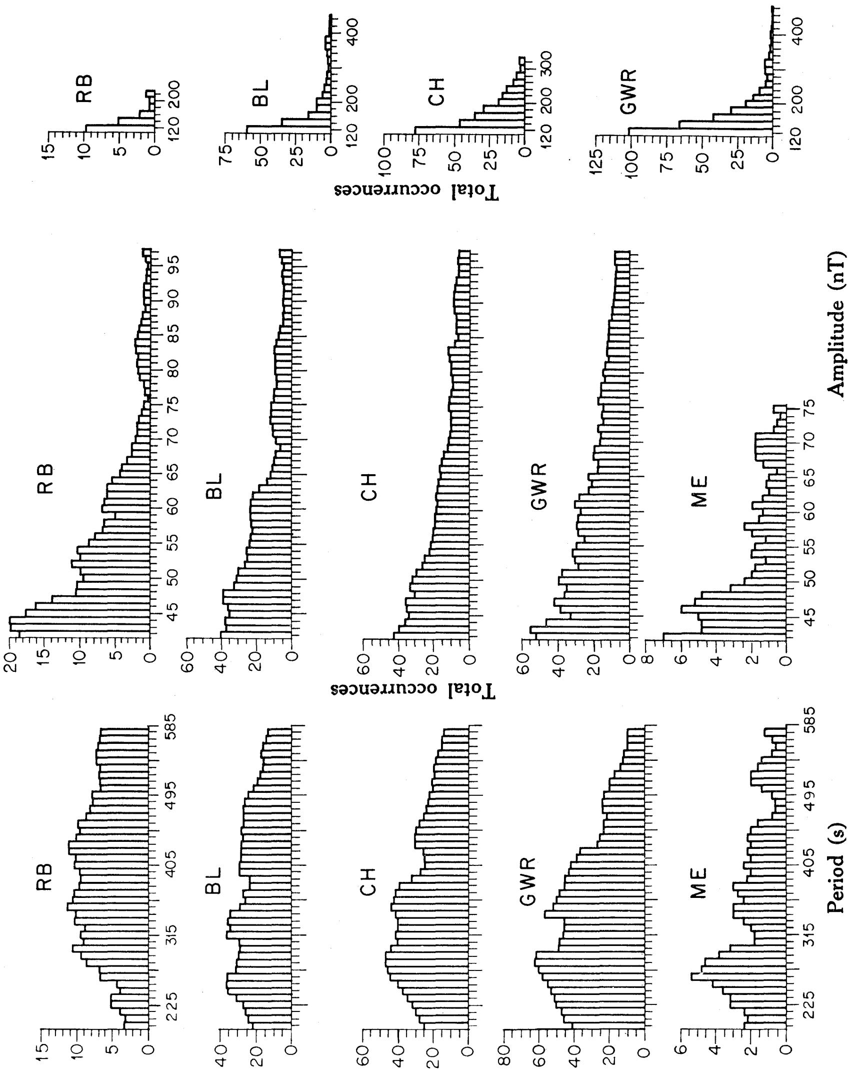


Fig. 2. Total occurrences of LAP received at the indicated stations in different period and amplitude intervals. Note that the vertical scales for Meanook (ME) and Resolute Bay (RB) are different from those for Great Whale River (GWR), Churchill (CH) and Baker Lake (BL).

Those pulsations which possessed a peak-to-peak range (denoted hereafter by 'amplitude') of 40 nT or more are included in the analysis. This limit on the amplitude was dictated by the absence of pulsations of such large amplitudes at the mid-latitude observatories of Victoria and Agincourt while, with a cutoff of 40 nT, the volume of data is still sufficient for statistical work. A few examples of these large amplitude pulsations (denoted hereafter by LAP) are shown in Fig. 1. Often they occurred at times of magnetic disturbance, a significant number appearing on the magnetograms after a bay at the station.

Analysis

The data analysed here include scaled values of LAP from standard-run Ruska magnetograms ($\sim$20 mm h^{-1}) for 1967 from the Canadian observatories listed in Table 1. For each station the average instrumental sensitivity in 1967 and the total number N of LAP used in the analysis (where N is the number of pulsations with amplitudes $\geqslant$40 nT) are also given.

Table 1. Properties of stations and data

Station	Geomagnetic Lat.	Geomagnetic Long.	Geographic Lat.	Geographic Long.	Component analysed	Sensitivity (nT mm^{-1})	N
Resolute Bay (RB)	83·1° N.	287·7° E.	74·7° N.	94·9° W.	X	7·1	365
Baker Lake (BL)	73·9° N.	314·8° E.	64·3° N.	96·0° W.	X	8·4	1252
Churchill (CH)	68·8° N.	322·5° E.	58·8° N.	94·1° W.	X	7·8	1426
Great Whale River (GWR)	66·8° N.	347·2° E.	55·3° N.	77·8° W.	H	13·8	1776
Meanook (ME)	61·9° N.	300·7° E.	54·6° N.	113·3° W.	H	11·6	107

The scaling of the magnetograms involved measurement of the amplitude and period of the best-defined sinusoidal cycle in any hour when pulsations were present on the records. The measurements were made with a microscope of 0·1 mm resolution. Details of the selection criterion and the method of measurement have been given in earlier reports (Gupta 1973, 1974). The basic reduction of the data consists of computing (1) the mean and standard deviation, and (2) the median and 25th and 75th percentiles for both the amplitude and the period. The latter set (2) has in general been used because the interquartile range about a median value is immune to extreme values. The data analysis was done for the whole year 1967; for its subdivision into three Lloyd's seasons: j, May to August; e, March, April, September, October; d, November to February; and for its subdivision into International Quiet (Q days) and Disturbed (D days) days.

The distribution of LAP in different period and different amplitude intervals is displayed in Fig. 2. These graphs have been smoothed by performing a running average over five points. To keep the diagrams a reasonable size, the Y scales are different for different stations. By inspecting the graphs at individual stations, one may note that the LAP of shorter period are more frequent at a lower latitude station (e.g. Meanook) and that, as the latitude increases, more LAP are found with longer periods. It is also clear that the occurrences become less and less frequent as the amplitude of the pulsations increases. Stations in the auroral zone, especially Great Whale River near the central line of the zone, have the largest number of LAP with amplitude $\geqslant$100 nT.

Results

A few examples of the variations in the occurrence, amplitude and period of the LAP received at different stations are illustrated in Fig. 3. The largest number of LAP almost always occurred at Great Whale River except for Q days when they occurred most frequently at Baker Lake. On D days the occurrences of LAP increased by a factor of over 10 compared with those on Q days. The occurrences dropped more sharply towards latitudes south of Great Whale River than towards higher latitudes. Thus, within the five degrees of geomagnetic latitude from Great Whale River to Meanook, the number of LAP occurrences decreased by a factor of over 16, while they decreased by a factor of only about 5 within the 16° from Great Whale River to Resolute Bay.

In general, the amplitudes also decreased at a sharper rate towards the lower latitudes than towards the higher latitudes from near the central line of the auroral zone. Only on Q days was the median amplitude of LAP largest at Baker Lake, while on D days it was largest at Great Whale River. For a seasonal grouping of days, the amplitude was largest at Churchill in the winter and equinoxes but was largest at Great Whale River in summer.

The period T of the LAP was found to increase linearly with geomagnetic latitude Φ, with a correlation coefficient of $r \approx 0 \cdot 75$, which is significant at the 95% confidence limit. The equations of the straight lines which fit the data at different seasons and for the whole year are:

Summer	Equinox	Winter	Whole year
$T_j = 2 \cdot 0\Phi + 216$	$T_e = 4 \cdot 3\Phi + 51$	$T_d = 5 \cdot 0\Phi - 15$	$T_y = 3 \cdot 9\Phi + 75$
$r = 0 \cdot 83$	$r = 0 \cdot 93$	$r = 0 \cdot 95$	$r = 0 \cdot 95$

The whole-year relation (dashed line) is shown in the upper right-hand corner of Fig. 3.

The period–latitude profiles for Q and D days do not show any such simple variation. However, the period of LAP was in general larger on Q days than on D days. Also, on D days, the LAP occurred with much smaller periods at Baker Lake than at adjacent stations. This was probably due to the movement of the cleft of the geomagnetic field towards a lower latitude and to a lower altitude as the level of disturbance increased. This question is explored in more detail in a parallel study (Gupta 1975).

Diurnal Variation

The diurnal changes in the occurrence, amplitude and period of LAP are demonstrated in Fig. 4, in which geomagnetic noon is marked by an arrow. The daily occurrence pattern of LAP is significantly different from that of all the Pc5 pulsations observed in 1967 at these stations (Gupta 1973) and that of long period ($T \geqslant 300$ s) Pc5 pulsations (Gupta 1976*a*). The main difference is the absence of the afternoon peak at all stations except Resolute Bay. Several other studies of sinusoidal Pc5 pulsations have found that an evening peak was either absent or very weak (e.g. Saito 1964; Ol' 1963; Hirasawa 1970). LAP seem to occur dominantly near geomagnetic noon at very high latitudes but earlier in the day as the latitude decreases. This systematic change with latitude may well be evidence of a systematic change in the location of the region at which the driving source couples with the local field line to produce resonance (personal communication from L. J. Lanzerotti).

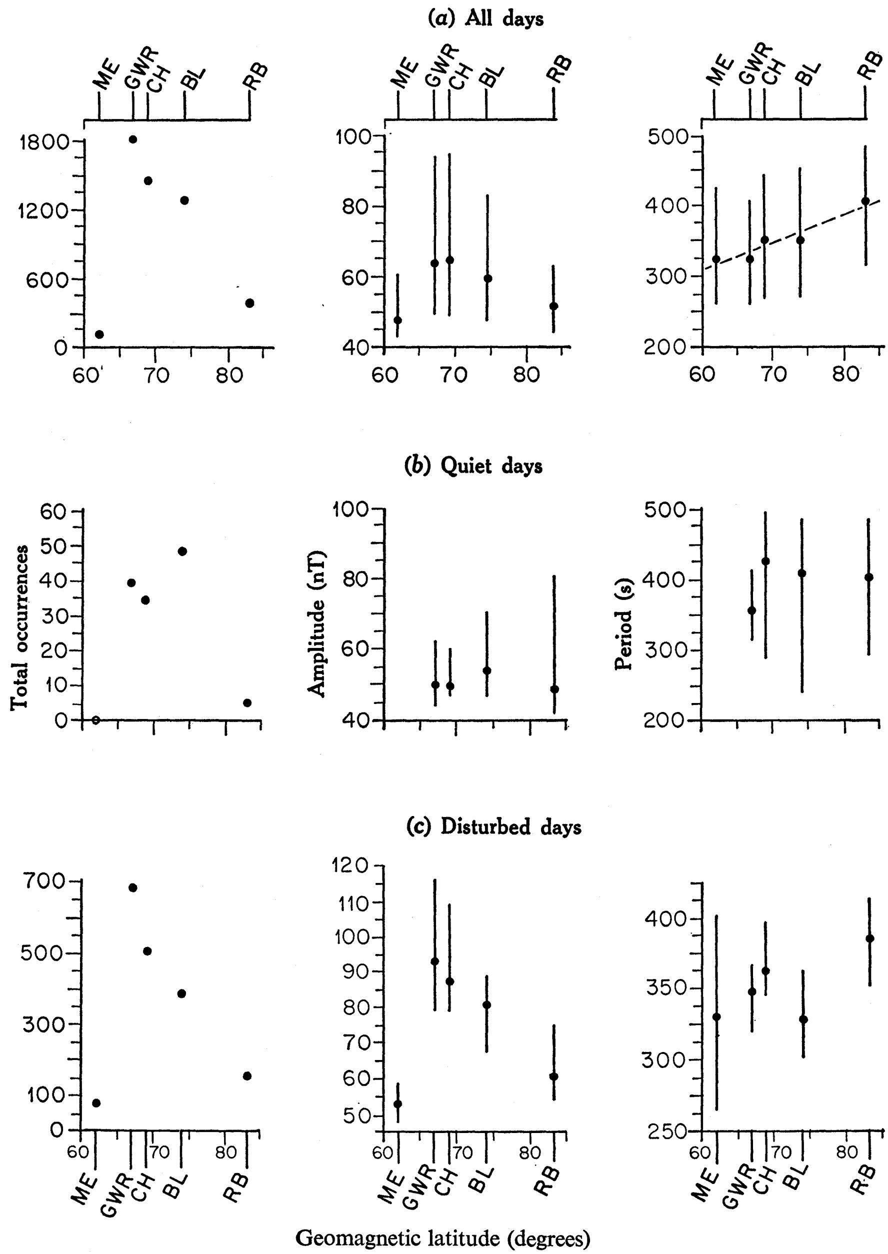


Fig. 3. Variation of total occurrences, amplitude and period of the LAP received at the indicated stations for (*a*) all, (*b*) quiet and (*c*) disturbed days of 1967. Note the differences in ordinate scales.

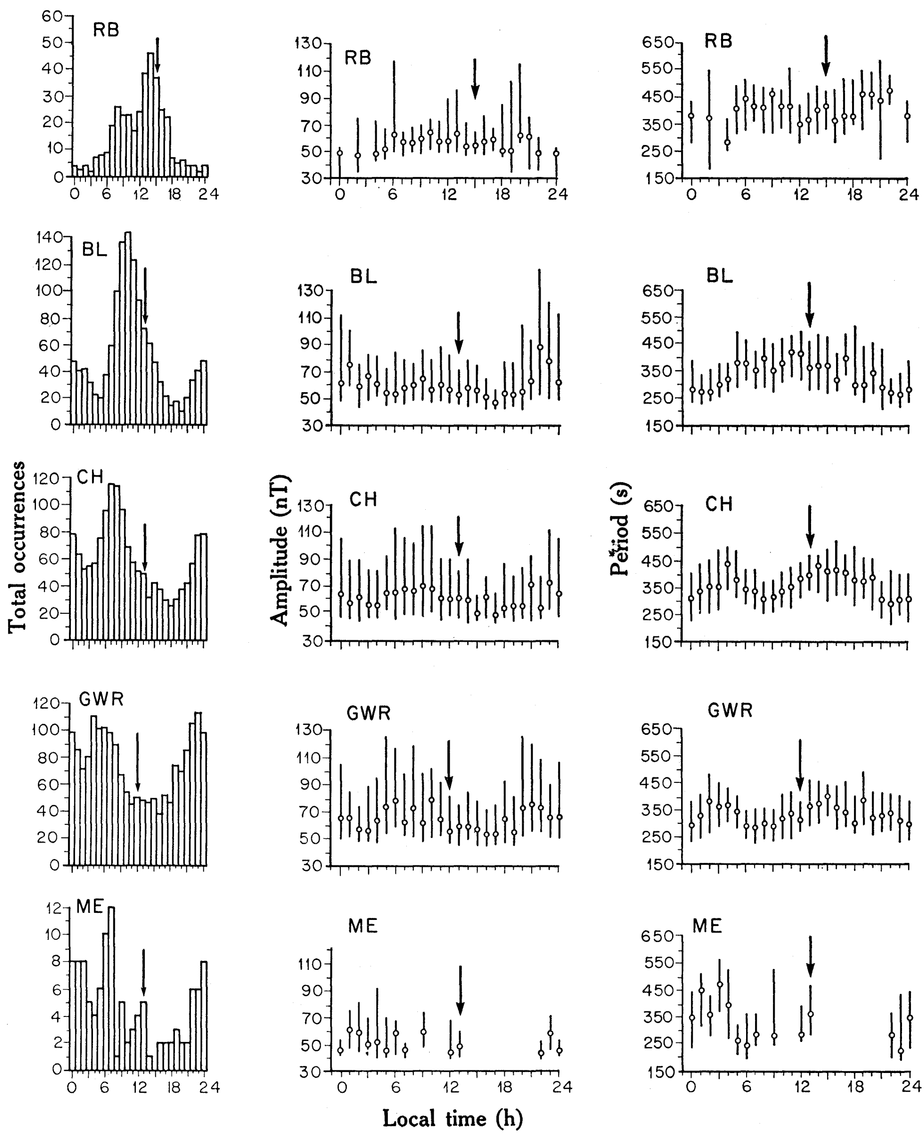


Fig. 4. Diurnal variation (local time) of total occurrences, amplitude and period of LAP, with geomagnetic noon indicated by an arrow. Note the differences in ordinate scales.

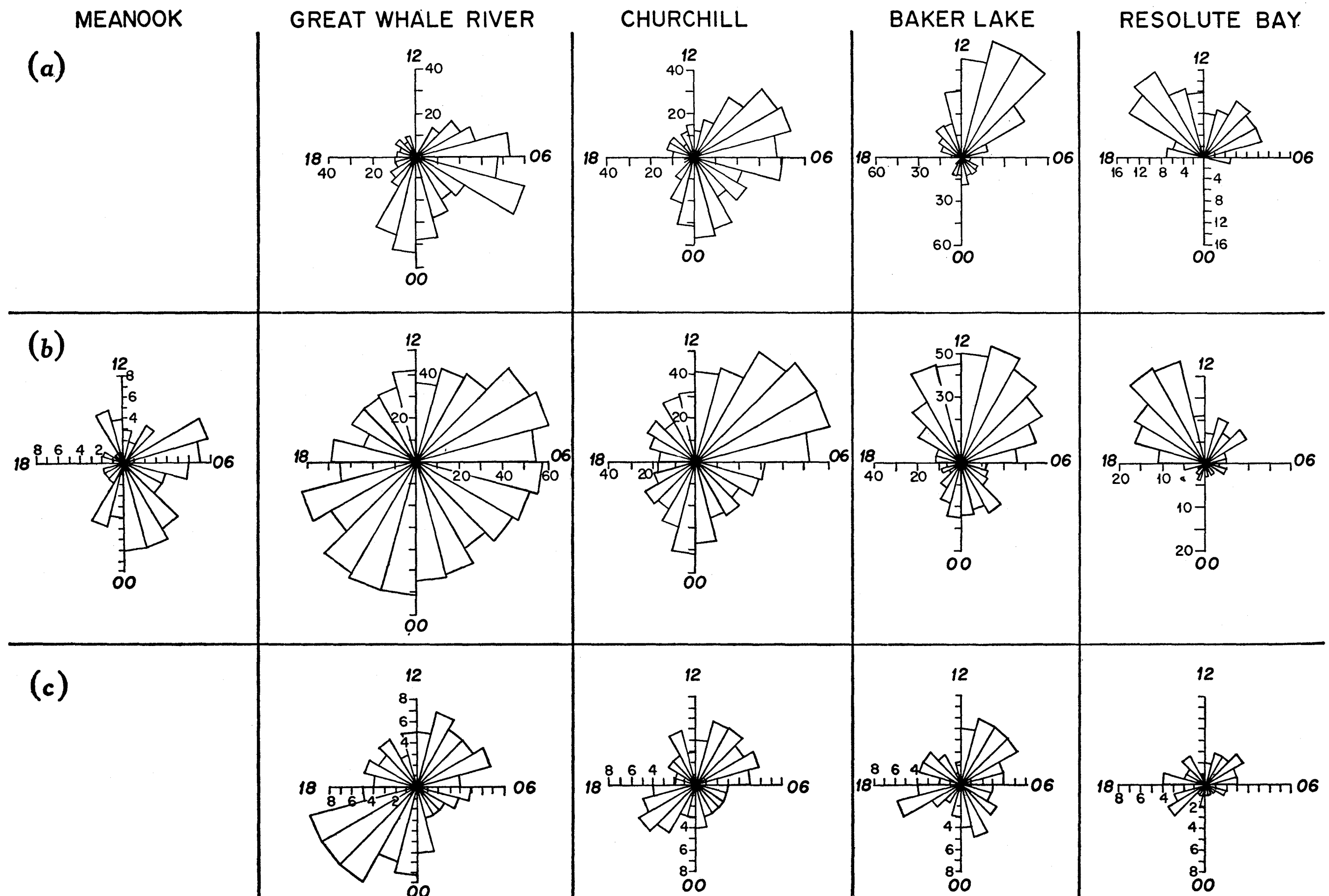


Fig. 5. Diurnal variation (local time) of total occurrences of LAP in the three magnetic activity groups (*a*) $Kp \leqslant 2_+$, (*b*) $3_- \leqslant Kp \leqslant 5_+$, (*c*) $Kp \geqslant 6_-$. Scales are variable.

Some light on this view has been shed by Fukunishi *et al.* (1975). In the auroral zone, LAP occurred frequently near midnight as well, i.e. during the hours when substorms dominate magnetic activity in this region. More LAP occur during the midnight hours on the north side of the auroral zone (at Baker Lake) than to the south (e.g. Meanook).

The data were further subdivided into the following three groups according to the level of magnetic activity: $Kp \leqslant 2_+$, relatively quiet intervals; $3_- \leqslant Kp \leqslant 5_+$, moderately disturbed intervals; $Kp \geqslant 6_-$, severely disturbed intervals. The occurrence patterns for each of these groups having sufficient data are drawn in Fig. 5.

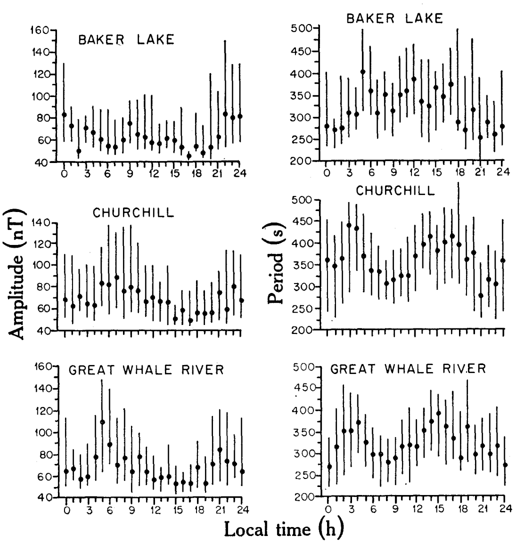


Fig. 6. Diurnal variation of amplitude and period of LAP for moderately active intervals ($3_- \leqslant Kp \leqslant 5_-$) of 1967.

Clearly, most of the LAP occurred during moderately active intervals. The midnight occurrence peak at Great Whale River and Churchill tends to appear earlier in the premidnight hours as the magnetic activity increases. The morning occurrence peak is relatively stable but tends to be wider on moderately disturbed days ($3_- \leqslant Kp \leqslant 5_+$) than on quiet days. At Resolute Bay the afternoon peak is strong during relatively quiet and moderately disturbed intervals but, for severely active intervals, this afternoon occurrence peak is no longer prominent. These results show that there are significant changes in the diurnal variation of LAP occurrence with changing magnetic activity.

Turning once more to the amplitude and period distributions (Fig. 4) one finds in general that when the amplitude of LAP is larger its period is smaller. The morning LAP seem to have a larger amplitude than those in the evening. At Baker Lake, amplitudes during the day are smaller than those during the night, while the reverse is true for the periods. One may assume that the LAP observed at Baker Lake originate in the vicinity of the cleft region on the day side of the magnetopause and in the region of open and closed field lines on the night side. In such a case the observed period of Pc5s would be considerably affected by the altitudes of these regions.

To return to the groupings by magnetic activity, Fig. 6 shows the diurnal variation of amplitude and period at Great Whale River, Churchill and Baker Lake for moderately disturbed magnetic conditions. Plots for quiet and severely disturbed groupings are not presented because of lack of data points. Data grouped this way according to level of magnetic activity show no significant deviations in diurnal variation patterns from those given in Fig. 4, where data at all activity levels have been averaged together.

Two possible sources of the dawn–dusk asymmetry at the magnetopause are now considered. To some extent, at least, these effects may influence the development of instability and give rise to the observed asymmetry in the occurrence of Pc5s.

Friction

One may assume the average solar wind velocity to be nearly 500 km s^{-1} and the velocity of rotation at $10\,R_E$ to be nearly $4{\cdot}6$ km s^{-1}. In the morning sector, the motion of the lines of force rotating with the Earth would be in the direction opposite to the oncoming solar wind while, in the evening sector, the motion would be in the same direction as the solar wind. The velocity difference of about $\pm 1\%$ may give rise to somewhat larger frictional forces in the morning sector than in the evening. As a result, one may expect a greater chance for the development of instability-producing MHD waves in the morning than in the evening. However, because of a very small difference in the magnitude of the frictional forces, their importance as a significant source of the dawn–dusk asymmetry is questionable and needs further examination.

Particle Dynamics

The IMP-7 satellite was in a nearly circular orbit at a distance of about $35\,R_E$. As part of its mission, it collected particle data from the magnetosheath and the magnetotail. Results of the data analysis by Keath *et al.* (1976) have shown considerable dawn–dusk sector asymmetry in the dynamics of protons (energy 30–90 keV) and of electrons (energy 50–200 keV). According to these authors:

(1) The protons show a dawn–dusk asymmetry in the intensity of the events, while the electrons show little evidence of asymmetry.

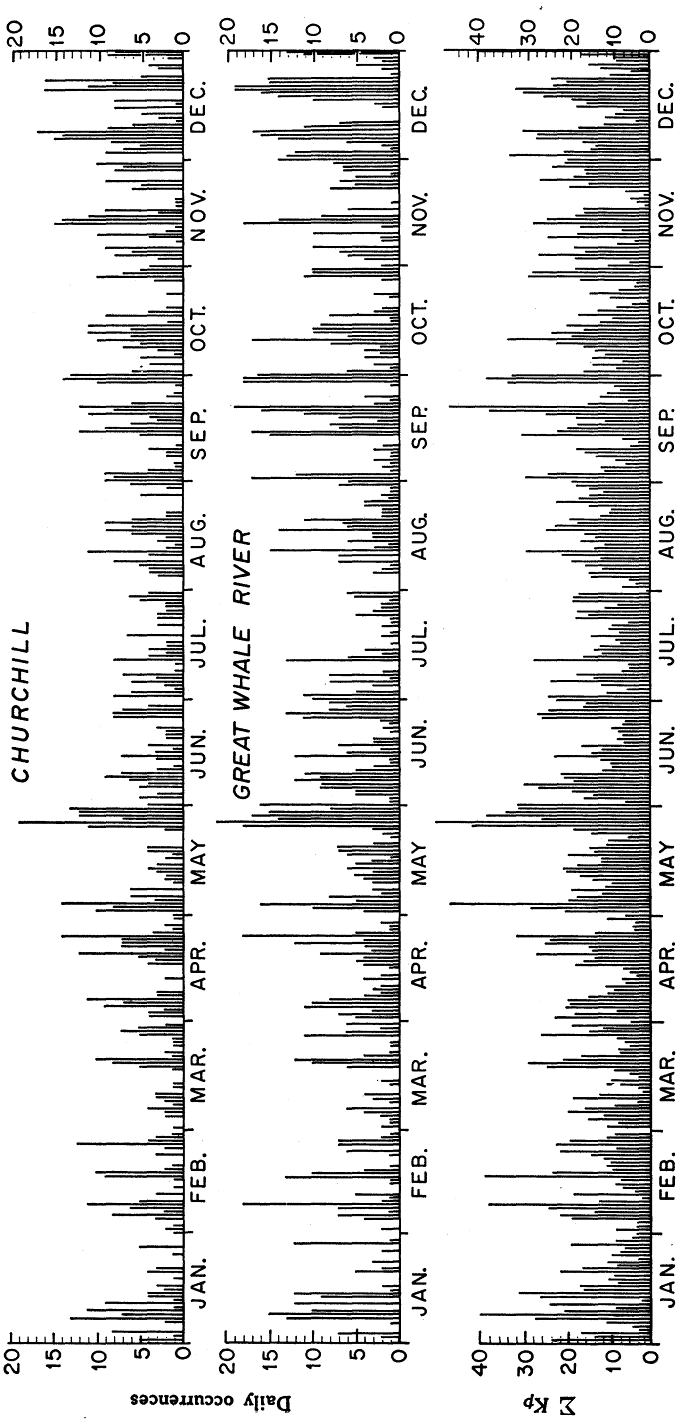
(2) The correlation of the electron and proton events in the magnetotail was found to be highest in the dawn sector.

(3) The event probabilities for the protons show a positive correlation with *Kp* only in the dawn sector. These, along with the additional asymmetries in the particle morphology of the magnetotail, indicate that the manifestation of geomagnetic activity is substantially different in the dawn and dusk sectors of the magnetotail.

It is quite conceivable that a similar dawn–dusk asymmetry in the particle dynamics prevails near the flanks of the magnetopause under varying magnetic conditions. In such a case the instability giving rise to the MHD waves near the flanks of the magnetopause may not always develop simultaneously near the dawn and dusk meridians.

Magnetic Activity Effects

The level of geomagnetic activity is conveniently represented for short intervals by *Kp* and for intervals as long as a day by $\sum Kp$. In Fig. 7, $\sum Kp$ is plotted together with the total daily occurrences and the average amplitude of LAP for each day of 1967.



[*Fig. 7 continued below*]

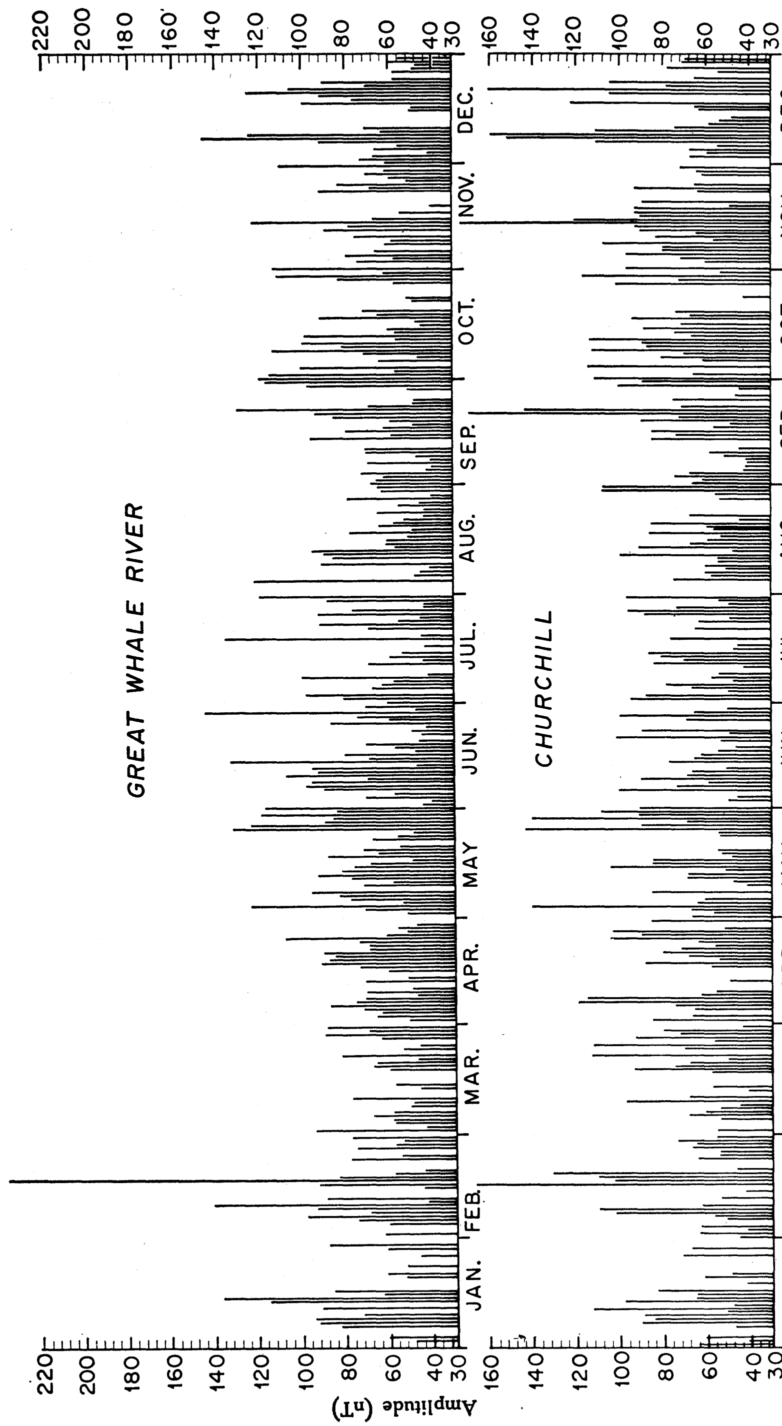


Fig. 7. Comparison of the total daily occurrences, $\sum Kp$ and average amplitude of the LAP received at Churchill and Great Whale River for the year 1967.

It is quite clear from Fig. 7 that the prevailing magnetic activity has a strong bearing on both the occurrences and the amplitudes of LAP. This is further demonstrated in Fig. 8, which is drawn by the method of superposed epochs (Chapman and Bartels 1962). It can be seen that the occurrences as well as the amplitudes of LAP were largest on the day when $\sum Kp$ was largest. This observation differs from that of Ol' (1963; see his Fig. 6) who found that long period gigantic pulsations occurred about three days after the magnetic activity attained its highest value. The conclusions drawn from Fig. 8 are further substantiated by the annual correlation coefficients r_O between $\sum Kp$ and the daily total occurrence, and the annual correlation coefficients r_A between $\sum Kp$ and the daily average amplitude of LAP, as given in Table 2. The correlations are largest at Great Whale River and decrease towards both higher and lower latitudes. Similarly, the Q and D day correlations (not listed) were found to be significant only at Great Whale River and Churchill on Q days, but at all stations except Resolute Bay on D days. Also noted, but only for Baker Lake, was a negative but significant correlation between the period of LAP and $\sum Kp$.

Table 2. Comparison of r_O and r_A from different stations

	RB	BL	CH	GWR	ME	95% conf. limit
r_O	0·61	0·72	0·81	0·87	0·53	0·11
r_A	0·52	0·55	0·62	0·68	0·52	0·11

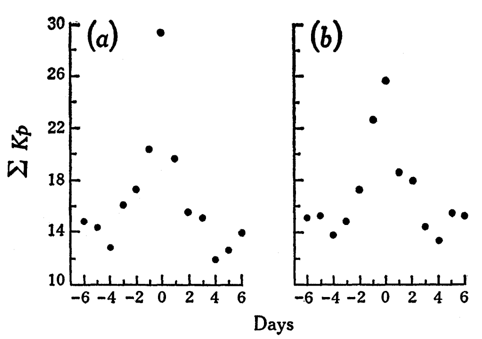


Fig. 8. Effect of $\sum Kp$ on (*a*) occurrences and (*b*) amplitudes of LAP at Great Whale River, drawn by the method of superposed epochs. The greatest number of occurrences and the largest amplitude occur on day 0 in (*a*) and (*b*) respectively.

The occurrences of LAP in 3 h intervals were further tested for cross-correlation with *Kp*. Eight successive lags of 3 h each were used. For zero lag the correlations were significant but they dropped sharply as the lags increased.

The effects of magnetic activity on the occurrence, amplitude and period of LAP are examined in more detail in Fig. 9 (*Kp*) and Fig. 10 ($\sum Kp$). We define the percentage rate of occurrence in this case to be the number of LAP at a given *Kp* level, expressed as a percentage of the total number of occurrences of this *Kp* level. This helps to remove the effect of the nonuniform distribution of *Kp* or $\sum Kp$ levels within a given time interval. The percentage rate of occurrence appears to vary linearly for the entire range of the two magnetic-activity indices (see Figs 9*a* and 10*a*).

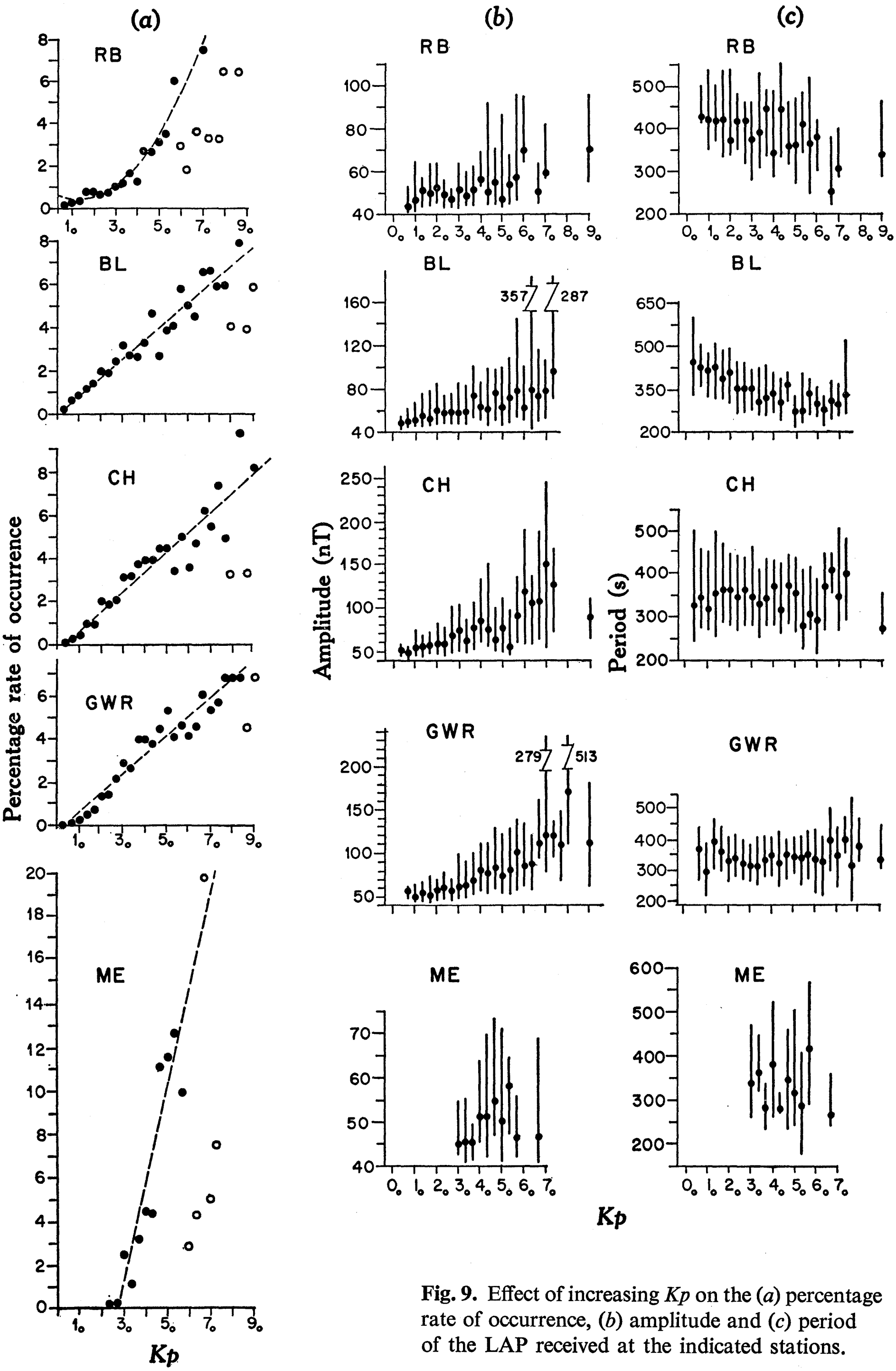


Fig. 9. Effect of increasing *Kp* on the (*a*) percentage rate of occurrence, (*b*) amplitude and (*c*) period of the LAP received at the indicated stations.

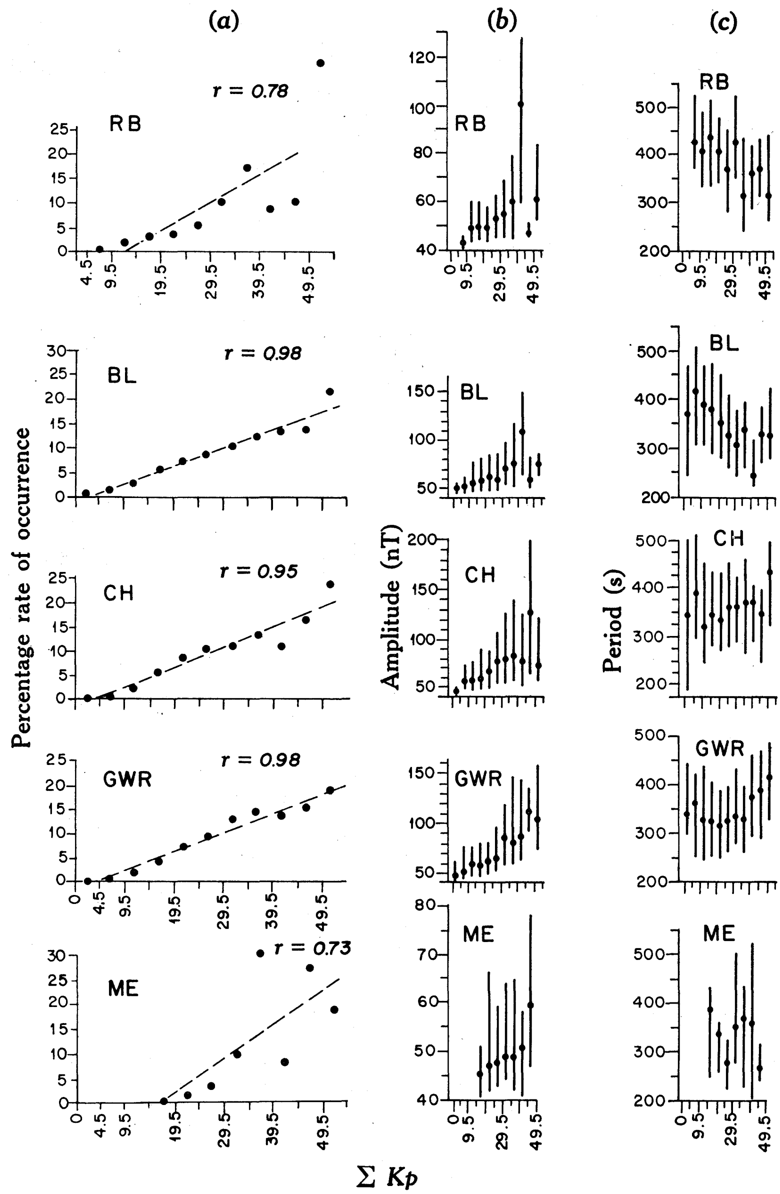


Fig. 10. Effect of increasing $\sum$ *Kp* on the (*a*) percentage rate of occurrence, (*b*) amplitude and (*c*) period of the LAP received at the indicated stations.

This implies that, the larger the activity, the greater is the chance that LAP will occur at these high latitudes, which could not be said so clearly for other forms of Pc5s that the author has analysed by a similar process (Gupta 1973). The equations which approximately represent the relationships between the percentage rates of occurrence R and R' between Kp and $\sum Kp$ respectively are given in Table 3.

Table 3. Comparison of $R(Kp)$ and $R'(\sum Kp)$ from different stations

Station	$R(Kp)$	$R'(\sum Kp)$
Resolute Bay	$R_{RB} = 0\cdot78 - 0\cdot62(Kp) + 0\cdot23(Kp)^2$	$R'_{RB} = 0\cdot59(\sum Kp) - 7\cdot31$
Baker Lake	$R_{BL} = 0\cdot88(Kp) - 0\cdot07$	$R'_{BL} = 0\cdot37(\sum Kp) - 0\cdot99$
Churchill	$R_{CH} = 0\cdot92(Kp) - 0\cdot26$	$R'_{CH} = 0\cdot39(\sum Kp) - 1\cdot51$
Great Whale River	$R_{GWR} = 0\cdot89(Kp) - 0\cdot30$	$R'_{GWR} = 0\cdot39(\sum Kp) - 1\cdot46$
Meanook	$R_{ME} = 4\cdot46(Kp) - 12\cdot10$	$R'_{ME} = 0\cdot68(\sum Kp) - 11\cdot09$

The amplitudes of LAP at all stations (Figs 9*b* and 10*b*) increase gradually with increasing magnetic activity. However, for very large activities (say $Kp \geqslant 7_0$) the results are relatively uncertain, mostly because of insufficient data. The effects of the magnetic activity on the periods of LAP are demonstrated in Figs 9*c* and 10*c*. North of the auroral zone (at Baker Lake and Resolute Bay) one may notice a gradual decrease in the period as the activity increases, but within the auroral zone the periods initially decrease and then increase after the magnetic activity reaches a certain level.

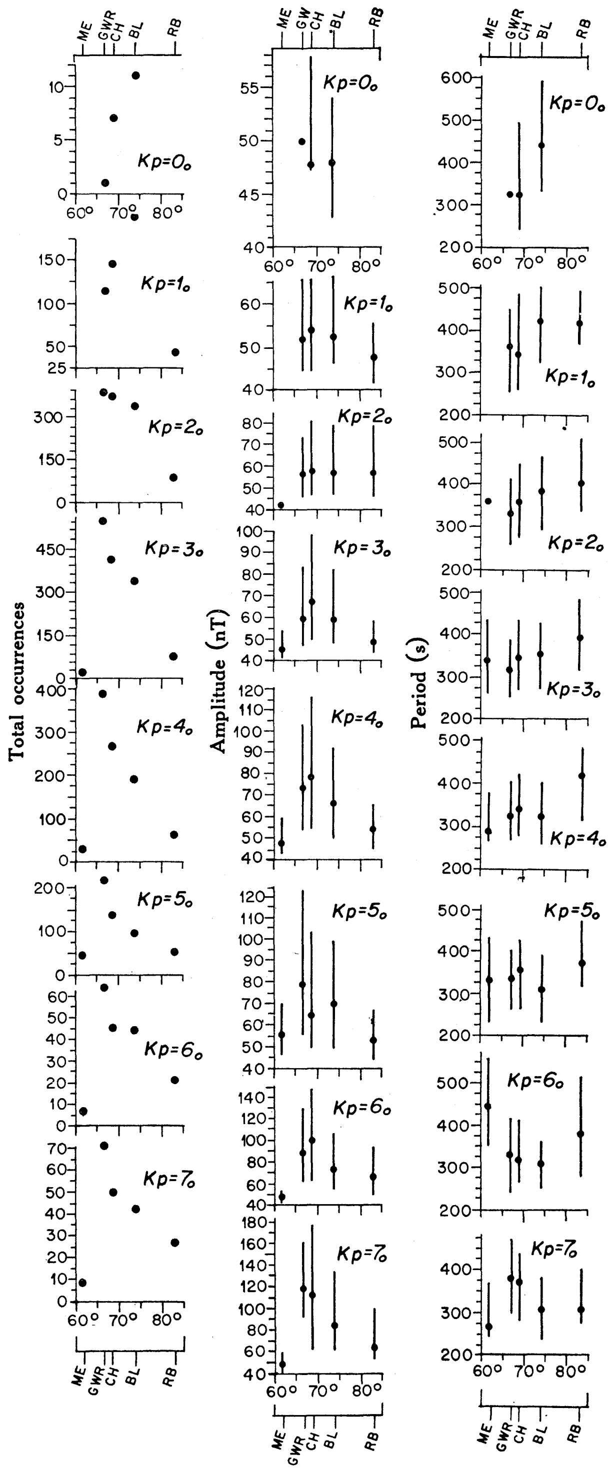
In order to investigate the behaviour of latitude profiles of LAP characteristics, the data were divided into *eight* Kp groups (a group designated $Kp = 3_0$ implies $3_- \leqslant Kp \leqslant 3_+$). The latitude profiles are drawn in Fig. 11.

For quiet intervals ($0 < Kp \leqslant 2_+$) LAP occurred at Great Whale River, Churchill and Baker Lake (between 66°–74° geomagnetic latitudes) and only occasionally at Resolute Bay. The amplitudes of these LAP were slightly greater than 50 nT and their periods seemed to increase with increasing latitude.

For more active intervals ($3_- \leqslant Kp \leqslant 5_+$) some LAP were found to occur in the subauroral zone at Meanook and in the polar zone at Resolute Bay. However, they occurred very frequently in the auroral zone at Great Whale River and Churchill, and in the cusp region at Baker Lake. The average amplitude was nearly 60 nT, and peak values were found at Great Whale River or Churchill. The periods were found to increase with latitude, although the periods at Baker Lake were in general smaller than the value predicted by a straight line fit to the periods at the other stations.

During very active intervals ($Kp \geqslant 6_-$), of which there were not many in 1967, there were fewer occurrences of LAP than for other intervals. The amplitudes of the LAP were in the vicinity of 80 nT except at Meanook where they were much smaller. For $Kp = 6_0$ the periods decreased from Meanook to Baker Lake and then increased. For $Kp > 7_0$ they decreased from Great Whale River to Baker Lake and possibly to higher latitudes.

These occurrence and amplitude results support the results of Hirasawa (1970) since, as magnetic activity increases, they show a shift towards the equator of the region where LAP occur most frequently and with largest amplitude.



[*Fig. 11. See caption opposite*]

For Baker Lake, the amplitude–period profile is drawn in Fig. 12. Notice that at this station, as the magnetic activity increases, LAP of smaller period and of larger amplitude became more frequent. Such a clear relationship between amplitude and period is not evident at other stations, where more complicated relations seem to prevail with changing magnetic weather. This amplitude–period variation of LAP at Baker Lake and adjacent stations with increasing magnetic activity may possibly be used to study the latitudinal movement of the cleft region, as suggested by Rostoker *et al.* (1972), and also the variations in the altitude at which the instability that gives rise to LAP develops.

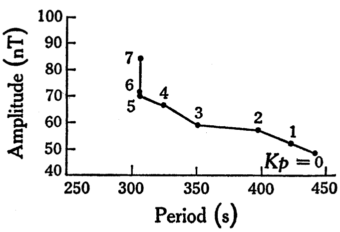


Fig. 12. Variation of amplitude as a function of the period of the LAP received at Baker Lake for the indicated magnetic activity levels.

Discussion and Conclusions

On the basis of past work, it has now generally become accepted that hydromagnetic waves in the Pc5 period range may be produced by the interaction of the solar wind with the magnetosphere. The turbulent solar wind moving away from the subsolar point within the magnetosheath produces tangential stresses at the flanks of the magnetopause near the dawn and dusk meridians, and this can give rise to waves generated by the Kelvin–Helmholtz instability. The waves so produced are guided towards the Earth along the magnetic field lines, which intersect the ionosphere in the auroral oval region (Fairfield 1968; Frank 1971).

On the other hand, on the night side of the magnetosphere when the lines of force reconnect, a large amount of energy is released. This accelerates the plasma-sheet particles which pass through the region of open and closed field lines (near the inner boundary of the plasma sheet) and which ultimately precipitate in the auroral ionosphere. An instability developing in this region may give rise to hydromagnetic waves (Saito and Sakurai 1970) which will travel to the Earth along the auroral oval field lines (Vasyliunas 1968). The polarization properties of night-time Pc5s need to be investigated extensively to determine whether the instability developed in this region is also of the Kelvin–Helmholtz type.

The propagation within the ionosphere of the waves to a reasonable distance towards higher and lower latitudes can explain the morning and evening occurrence peaks (Gupta 1973), which are noted on average days at a wide range of latitudes, as well as the midnight occurrence peak seen mainly at the auroral zone stations.

However, LAP show only one occurrence peak in the morning and one near midnight at the auroral zone stations. At the polar station Resolute Bay, the occurrences maximize in the post-noon hours, while a relatively smaller occurrence

Fig. 11 (*opposite*). Variation of total occurrences, amplitude and period of the LAP received at the indicated stations for different levels of magnetic activity. Note that $Kp = 2$ implies the range $2_- \leqslant Kp \leqslant 2_+$, etc.

maximum is seen in the morning hours. An attempt is made here to understand these observations.

We have noted that LAP occur abundantly in the northern half of the auroral zones (Fig. 3), a region which mostly coincides with the auroral oval. This observation supports Samson (1972) who has shown that, except near local noon, the region of the intensity maximum of Pc5s overlaps the auroral oval. Both the occurrence and amplitude for LAP are found to be large when the magnetic activity is rather strong (Figs 7 and 8) and this implies that a stronger conduction in the auroral oval is almost a necessity for the appearance of LAP. This conclusion is borne out by the observation that most LAP occur during the recovery phase of the bays and during the following few hours. At high latitudes bays generally occur during the post-midnight hours due to a westward electrojet which is considered to flow along the auroral oval. The strength of the electrojet is largest in the midnight–morning sector (Akasofu 1968; see his Figs 31*a* and 31*b*) and decreases rather rapidly towards the other sectors. The return currents seem to produce eastward electrojets, and these flow both in the polar cap and at lower latitudes; the strength of the former being larger. The present author (Gupta 1976*b*) has recently performed a cross-spectral analysis between the Pc5 amplitude and the *H*-component data from Great Whale River for 1967. The results of this investigation seem to imply that the overhead ionosphere acts as an amplifier for the amplitude of Pc5 pulsations.

On the basis of the information given above, one notices that, whenever the auroral oval strength is large (i.e. there is a strong westward electrojet giving rise to bays) and there is also hydromagnetic activity near the dawn meridian at the magnetopause, the generated waves which travel along the lines of force meet the ionosphere in the auroral oval region and undergo an amplification of their amplitudes which depends upon the level of conduction in the oval. This amplification is enhanced by the increase in the conductivity due to the fresh ionization in the morning, which is caused by the oncoming solar ultraviolet radiation. Geometrically, it is not inconceivable that the optimum condition for wave propagation and for conduction is arrived at in the vicinity of 8 h LT. If this is the case, one can expect to receive LAP at about this time at some auroral zone station. As the auroral oval conductivity is large near midnight hours (when bays occur), whenever an instability gives rise to hydromagnetic waves in the region of open and closed field lines, the waves arriving in the oval region undergo amplification (on our assumption that the ionosphere acts as an amplifier) and this gives rise to the LAP. This explanation of the LAP seen in the auroral zone would apply as well for the afternoon peak of the LAP noted at Resolute Bay. The strength of the eastward electrojet in the polar cap is large (whenever the westward electrojet is strong in the oval) during the afternoon to midnight hours. If at such times the hydromagnetic waves are generated near the dusk meridian at the magnetopause, they would travel along field lines, arrive at the auroral ionosphere and spread within the ionosphere to higher and lower latitudes. Because of the presence of the eastward electrojet, the conductivity in the polar cap is large and this helps in amplifying the amplitudes of the waves, thus leading to LAP.

In summary, if it can be assumed that the auroral zone ionosphere acts as an amplifier for the amplitude of the hydromagnetic waves and as a bed (medium) for their propagation towards higher and lower latitudes, it seems plausible to explain the occurrence characteristics of the LAP with the help of the Kelvin–Helmholtz instability theory. However, it is well realized that more work on Pc5 pulsations needs to be carried out in order to understand the mechanism of their generation and propagation, and that the simple explanation given above for the LAP occurrence characteristics needs further examination.

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