centre frequency of the burst changes erratically with time, and the sinusoid suffers both amplitude and phase distortion, as observed in the case of *CP* 0950. This can probably be attributed to the large value of $|df/dt|$, leading to a value for Δf_i greater than 1·0 MHz.

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Investigation of Quasi-periodic VLF Emissions and their relation to Geomagnetic Micropulsations

VLF emissions the signal strength of which changes with time with a period longer than the two hop whistler group delay are called long period VLF emission pulsations[1] or quasi-periodic (QP) VLF emissions[2]. About 400 QP events were observed in the VLF emission data recorded on chart at Byrd Station in Antarctica during 6 months (February April, September November 1964). VLF emissions were recorded in the frequency range 1–2·4 kHz and in a narrow band centred on 8 kHz. Additional observations were occasionally made at 400 Hz. QPs have been observed on the two lower frequency channels, though not necessarily simultaneously. They have never appeared on the 8 kHz channel. QPs were observed mostly when Byrd Station was on the daylight side of the Earth. Periods of QPs range from 10 s (the lowest limit resolvable) to about 2 min and occasionally up to 10 min. A QP event usually lasts for several tens of minutes. Sometimes it lasts for only a few minutes and sometimes for a few hours.

A QP event is often found to be associated with geomagnetic micropulsation (GP) activity in the sense that the GP period is comparable with the QP period. Such QPs will here be called GP-associated QPs. Not all QPs are associated with GP activity, however. Some QPs take place with no simultaneous GP activity. Even when there is simultaneous GP activity, the period of a QP can be very different from that of the GP. When a GP-associated QP appears, VLF emission activity is usually already at a certain level before the breakoff of a QP event. In such a case, no VLF curve on the chart approaches zero. These observations are clearly seen in Fig. 1, which shows a typical example of a GP-associated QP. In a GP-associated QP, the VLF signal appears not to be generated by, but only to be modulated by, the GP activity.

Spectral structures of QPs have been examined for twenty-two events which were observed at either of the following three Antarctic stations during 1964–1966; Eights, Byrd and Polar Plateau. Seven cases were found to be GP-associated QP events, and ten cases were non-associated. For the remaining five cases, it is difficult to determine whether there is any association with GP activity or not. Among the spectra of the twenty-two events, two extreme types have been separated. One type, which is typical of non GP-associated QPs, is characterized by a peculiar time variation of the emission frequency—the frequency continues to increase during one quasi-period. The spectrum is of either the diffuse or discrete type, or even a combination of both. Eight out of the ten non GP-associated events belong to this type. Some examples of this type are shown in Figs. 7-42 and 7-44 in the text by Helliwell[3]. There is a strong indication that for this type of QP the QP period is dependent on the VLF signal strength, being shorter (longer) for stronger (weaker) emissions. The other extreme spectral type, which is typical of GP-associated QPs, is a diffuse emission which is here called "lower frequency hiss". The emission frequency of this type lies approximately between 0·3 and 1·5 kHz, whereas the emission frequency of non GP-associated QPs lies between about 1·5–6 kHz. In GP-associated QPs, chorus or periodic emissions often overlap emissions of low frequency hiss. The upper frequency limit of the emission band of low frequency hiss (and of overlapping chorus

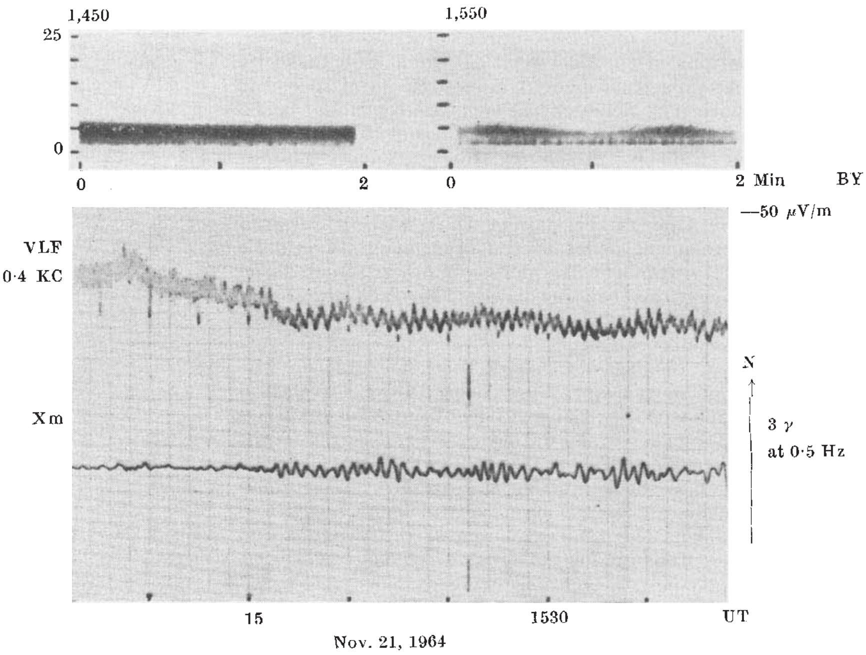

Fig. 1. A GP-associated QP event observed at Byrd Station, Antarctica. The middle curve represents the strength of VLF emission observed at 400 Hz, the width of the frequency window being about 40 Hz. The lower curve shows the micropulsation activity in the horizontal component of the Earth's magnetic field (taken positive in the direction of magnetic north). Note that the quasi-period of the VLF emission is comparable with the period of the micropulsation activity. Note also that the quasi-periodicity in the VLF emission starts at almost the same time as the micropulsation activity is enhanced. Tape recording of VLF emissions, which made spectral analysis feasible, was made once every hour, starting at the fiftieth minute in universal time and lasting 2 min. The VLF emission is of the type of "low frequency hiss" overlapped by "chorus". In the spectrogram starting at 1450 UT (upper left hand curve), there is no indication of quasi-periodicity, whereas it is clearly seen in the spectrogram beginning at 1550 UT (upper right hand curve).

and/or periodic emissions if they exist) often changes with time during one quasi-period, increasing and decreasing in synchronism with the change in signal strength (Fig. 1). This is not always the case, however. In some GP-associated QPs, only the VLF signal strength changes with time. For one GP-associated QP event observed at Polar Plateau, the chart speed was high enough to allow a phase comparison between the QP and GP activity. It was found that a peak in the QP curve often corresponds to either a peak or a trough in the GP curve. The peak to peak or peak to trough correspondence does not last long but only for a few oscillations. An interval of peak to peak correspondence tends to alternate with that of peak to trough correspondence and vice versa. The spectra of the five events for which it is difficult to determine whether there is any GP-association or not are much more complicated compared with the cases mentioned here. The spectrum of every one of these five cases is different. Despite the variety in their spectral types, however, it seems that everyone of them could fit in somewhere between the two extreme types already described.

GPs can affect VLF emissions not only as in the case of GP-associated QPs. GP activity occasionally lowers the general level of VLF emission activity, as seen in Fig. 1. Such suppression can occur in every spectral type of VLF emission whether GP-associated or not. Suppression begins at the higher frequency end of the emission band and extends towards lower frequencies. As the GP activity decays, VLF emission activity begins to recover. The recovery proceeds in the opposite direction, beginning first at the lowest emission frequency.

The magneto-conjugacy of GP-associated QPs has been examined using data from the Great Whale River (Quebec) and Byrd (Antarctica) pair of stations. Nine events have been investigated—more than half lack conjugacy in QP activity. Of four QP events which were observed to be GP-associated at Byrd Station, only one event was magneto-conjugate. With regard to the other three events, GP activity was found at Great Whale River but lower frequency hiss was inactive and not quasi-periodic. The investigation of quasi-periodic emissions is continuing and results will be published in detail later.

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Height of the Twilight Sodium Layer: Evening–Morning Effect observed at Victoria, British Columbia, from February 1967 to February 1968

AN interesting variation in the height of maximum density of the twilight sodium layer was observed at Victoria, British Columbia, during a year long series of observations, between February 4, 1967, and February 29, 1968, using a birefringent photometer directed towards the zenith sky. It has been found that, in general, the height of the sodium layer during the morning twilight period is lower than the evening twilight layer by an amount which varies throughout the year. The difference in height appears to be greatest around the times of the equinoxes amounting to approximately 5 km, and least near the solstices, when the difference diminishes to zero.

The seasonal variation of this observed evening–morning height effect is illustrated in Fig. 1, in which the mean monthly height differences have been plotted throughout the year. The error bars represent the magnitude of twice the average mean deviation for each month, and the arrows indicate the times of the vernal and autumnal equinoxes which, for a 90 km sodium layer, occur on February 22 and October 21 respectively, due account being taken of the effect of atmospheric screening. It is clear from Fig. 1 that, within the limit of experimental error, the maximum height differences occur at the times of the equinoxes while the minimum differences occur at the solstices.

Although measurements of evening and morning heights have been recorded by Blamont and Donahue[1], no systematic seasonal variation in their mean monthly height differences could be reported, because the effect seemed to reverse several times throughout the year.

The observations made at Victoria have been very carefully corrected for the contaminating effects resulting from Rayleigh scattering so that the resulting intensity curves represent a very pure signal. Only observations made under clear or slightly hazy skies, and adequately corrected for the effects of white light, have been included in the analysis; furthermore, only pairs of observations, in which a morning run was immediately preceded or followed by an evening run, were considered. Where three or more consecutive observations were possible they were considered in triplets, the heights of the first and third members having been interpolated linearly to the time of

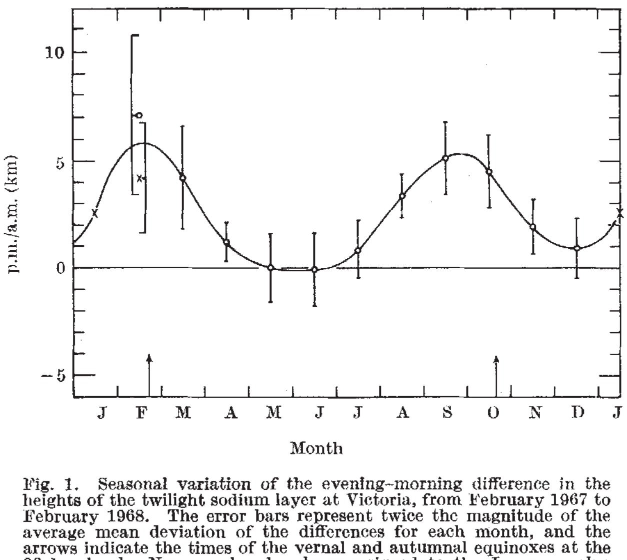

Fig. 1. Seasonal variation of the evening–morning difference in the heights of the twilight sodium layer at Victoria, from February 1967 to February 1968. The error bars represent twice the magnitude of the average mean deviation of the differences for each month, and the arrows indicate the times of the vernal and autumnal equinoxes at the 90 km level. No error bar has been assigned to the January value because very few observations were available for this month. ○, 1967; ×, 1968.