# II-1B. Geomagnetic Rapid Variation

Chairman:	E.	H. VESTINE
Co-chairman:	Υ.	Като

Date		Time	Paper Numbers
Sept.	6	15:30-17:30	from II-1B-1 to II-1B-8
Sept.	7	15:30-17:30	from II-1B-P1 to II-1B-P4
			and chairman's summary

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### II-1B-1. Equatorial Micropulsations

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At Legon, Ghana (5°38'N 0°11'W-geographic coords.; magnetic latitude -3.0°S), it has been found that the earth current technique has distinct advantages over the normal type of rapid-run magnetometer as far as micropulsational studies are concerned. This fact was established at the beginning of experimental work at this station, when an attempt was made to record simultaneously two earth current components and the value of dH/dt—the rate of change of the magnetic H element—as detected by means of an induction bar magnetometer of normal sensitivity, i.e. approximately 0.1 gamma per mm. These measurements showed that while the average peak to peak amplitude of the magnetic pulsations was seldom more than 1 mm., i. e. 0.1 gamma, that of the earth current pulsations was frequently 1 cm or more, corresponding to values of about 20 mv/km. The earth current system was, in fact, equivalent to a magnetometer of sensitivity at least 0.01 gamma per mm.

and if a greater sensitivity were required it could easily be increased by a factor of 10 or more. It is important to bear in mind this question of sensitivity, when considering a comparison of the Legon data with that from other observatories where the sensitivity has normally been less than that available at Legon with the earth current system.

One of the interesting features of the pulsational activity at Legon was reported at the Helsinki Meeting of the I.U.G.G. This was the fact that the regular pulsations, pc, *i.e.* continuous sinusoidal pulsations with period 20-30 seconds, occurred most frequently in early evening hours, while secondary maxima in the diurnal variation of pc occurrence existed at dawn and at mid-day. This diurnal variation is illustrated in Fig. 1, from which it is apparent that there is a considerable difference between the Legon results and the predominantly bell-shaped diurnal variation, so far reported from all other stations. A curve of similar shape

has also been obtained from an examination of magnetic records at Legon, for a period of several months when the sensitivity of the rapid-run magnetometer had been increased to a value comparable with that of the earth current system, *i. e.* 0.003 gamma/sec/ mm—Fig. 1.



Fig. 1. The daily variation of occurrence of (a) earth current (dashed curve) and (b) magnetic *pc* pulsations (full curve).

More recently, the Legon earth current records have been re-examined to determine (1) the dependence of the shape of the

- diurnal variation curve on the criteria used for *pc* detection—in particular, with regard to the minimum amplitude considered, and
- (2) the daily variation of pc amplitude.

For the first of these investigations, the number of occurrences of pc pulsations having amplitudes in the following ranges :-(1) a-2a, (2) 2a-5a, (3) greater than 5a, was determined for each hourly interval during a period of one year. There were only 15 cases during the year when the very large pulsations of category (3) were observed, and these will be discussed later. In Fig. 2, the diurnal variation of occurrence of pc is given, (a) for all pc, having amplitude greater than the threshold level a, and (b) for all pcgreater than 2a. It is clear, from the simil-





arity in shape of the two curves in Fig. 2 that further confirmation of the unusual pattern of *pc* occurrence, at this equatorial station, has been obtained. In addition, from an examination of the 15 cases of category (3), it has been found that 13 of the 15 occurrences of very large pc were in the early evening hours, and sometimes these pulsations were observed to have this very large amplitude until almost midnight, i.e. large with respect to that normally observed at Legon. A special study of these specific occurrences should be possible very shortly, as a number of observatories have kindly supplied copies of rapid-run records for these time intervals. A comparison has already been made, for one of these occasions, of records obtained at College, Alaska and at Legon. As shown in Fig. 3, there is a remarkable peak to peak coincidence between several groups of pulsations at about 1730



Fig. 3. The simultaneous occurrence of *pc* pulsations at Legon and College, Alaska.

hours U. T. at these two stations.

The daily variation of the amplitude of pc pulsations at Legon has also been determined and is given in Fig. 4. This provides the additional information, already suggested by the study of pc of different amplitude groups, that not only do pc occur most frequently in the early evening at this station, but they occur with the greatest amplitude at this time.







There seems little doubt, from consideration of these studies, that

- (a) regular pulsations of the type *pc* exist more or less continuously at the equator but that their continuous detection is dependent on the sensitivity of the equipment used, and
- (b) the amplitude of pc pulsations varies both from day to day and also during the course of a day, having a maximum amplitude at this equatorial station at 18-19 hours.

It has also been interesting to find that on more than 50% of the occasions when very large pulsations were observed at Legon, it was reported, in the data published by IAGA that pc were observed at, at least 5, other stations which covered a wide range of longitudes and latitudes. For example, pcwere frequently noted to occur at Legon and at Japanese stations during the same time intervals, a result which may probably be due more to the sensitivity of the equipment used at these stations than to any other factor.

To explain the unusual degree of pc activity at Legon at 6 hours and more especially at 19 hours, it would appear necessary to attempt to relate this activity with other geophysical phenomena which are known to have anomalous behaviour at the equator at these hours. The correlation of pc occurrence and amplitude with a number of ionospheric parameters has, however, been unsuccessful so far. It may be, however, that pc activity is more closely related to the rate of change of certain ionospheric parameters and such relationships are to be investigated shortly.

Regular pulsations, similar to normal pc, but with periods outwith the range for which the designation pc is normally used, have also been observed in the Legon records. The daily variation of short period pulsations, *i.e.* pulsations similar to normal pc but with periods 5-15 seconds, has been determined. This study has led to three main results :—

- (1) Short periods pulsations occur most frequently at Legon in night hours.
- (2) While normal pc are detected on approximately 20-50% of the total possible number of occasions, short period pulsations are a relatively rare phenomenon, having been observed on only 22 days during a 2-year period.
- (3) Short period pulsations have been observed normally on days of above-average magnetic activity, the mean K index for such occurrences being 3.5.

The occurrence of regular pulsations of period 30-120 seconds has also been determined and it has been found that such pulsations occur during daylight hours with a maximum around mid-day. As in the case of the short period pulsations, their occurrence is relatively infrequent.

In conclusion, the main features of regular pulsations at Legon may be summarized as follows :—

- The peak to peak amplitude of normal magnetic pulsations is seldom more than 0.1 gamma.
- 2) An earth current system provides a satisfactory method of extreme sensitivity for the detection of small amplitude pulsational activity, such as is observed at the equator.

 Regular pulsations *pc* are observed, more or less continuously, and often with very beautiful sinusoidal form, on the Legon records. Pulsations, with both shorter and longer periods, are also observed at Legon, but they may be regarded as relatively rare phenomena.

4) The daily variation of occurrence of *pc* has three distinct maxima at 6, 12 and

19 hours and in addition to the fact that the greatest of these maxima is at 19 hour it has been found that the amplitude of pc pulsations is greatest at this time of day.

mognetographs (with time scale 20 mm pe

### Discussion

**Campbell, W. H.:** I would like to amplify an important point in Miss Hutton's paper which will affect some models of the origin. The periods of pulsations at the equator are quite similar to those observed in the middle and auroral zone latitudes.

**Saito T.:** My question is whether the period of pc varies gradually or discontinuously near the boundary between the daytime and the night-time. It seems to be one of the most important key points to explain the mechanism of occurrence of pc. According to our analyses, the period of pc is like to vary continuously as that of the miropulsation accompanying with *ssc*. Do you think whether the period of pc varies continuously or abruptly from your observation?

**Hutton, V. R. S.:** The number of occasions, when pulsations of period less than 15 seconds, has been so small that it is not possible to give an answer to this question with any degree of certainty. The present indication is that they occur as a distinct phenomenon, as pulsations, of period 15-30 seconds, are observed normally during the day and also during the evening with unchanged period.

**Dessler, A. J.:** We have been studying pc activity at frequencies near 1 c/s (much higher than the present study) and find that they show a diurnal variation that is consistent with their being transmitted to the earth's surface by hydromagnetic waves. **Vestine, E. H.:** Would maxima in *SD* and *Sa* be related to the maxima in pc?

Hutton, V. R. S.: Yes, I think there must be some connection. For example, the SD variation as observed at Legon by the earth current technique, shows unusually large values at dawn and at early morning hours.

**Cardús, J. O.:** I like to confirm the results obtained by Miss V. R. Hutton with curves obtained from data from other equatorial stations: Ba, Pa and Hn. All these stations show the maximum in the night and early in the morning, this shows that the daily variation of pc's in the equatorial belt has particular features and it would be very interesting to study it at as many stations as possible.