523·746 : 523·75

The very long lived *M*-Regions near the Sunspot Minimum of 1933

ALI M. NAQVI and J. N. TANDON*

University of Delhi, Delhi

(*Received 16 October 1954*)

ABSTRACT. The geomagnetic activity during the years 1930-34 has been analysed, and the earlier conclusions of Naqvi and Bhargava for the geomagnetic activity during 1950-53 are confirmed. Three very long sequences of the recurrent type of geomagnetic activity designated as A, B and C have been found.

The difference in the heliographic longitudes of the M-regions responsible for the A and the B sequences is about 180°, for the B and C sequences about 45°, and for the C and the A sequences about 135°. Their respective heliographic latitudes are; above 7°·2 north, below 7°·2 south, and about 4°·8 south respectively.

In a recent paper (hereafter referred to as paper 1) Naqvi and Bhargava (1954) discussed the geomagnetic activity for the three year period 1950-53, preceding the current sunspot minimum. It was found that sequences of the recurrent type of geomagnetic activity are considerably longer than had been earlier believed. In order to check upon the conclusions obtained in paper 1, we have undertaken an extensive analysis of the geomagnetic activity for previous years of low sunspot activity. The analysis of the magnetic data for a period of about five years each near the sunspot minima of 1913, 1923, and 1933, is now complete, and that for other periods is in progress. We have also attempted to refine the method of analysis used in paper 1. In this note we shall discuss briefly the recurrence tendency for the years 1930-34. A detailed paper is in preparation.

The procedure for identifying the long sequences is the same as described in paper 1, namely, the 3-day running means of the international daily magnetic character figure, C, are plotted, and the sequences of recurrent activity with a period of 27 days are constructed.

For the period under discussion, we found three long sequences, designated by A, B and C. The information on these sequences is summarized in Table 1.

The beginning and ending of a sequence cannot be determined with complete certainty. In almost all cases one can start or end a sequence with one or two recurrences on either side of what we have considered to be the beginnings and the endings of the sequences. This, however, in no way changes any of the basic conclusions drawn.

In paper 1 the variation of activity within a sequence was studied according to the following procedure. For each recurrence, the maximum activity during the course of the disturbance was chosen to represent the activity of the recurrence. Although this criterion, if judiciously used, is found to give the correct results, further work has shown

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*Junior Research Training Scholar of the Government of India, Ministry of Education

TABLE 1

	Sequence *A*	Sequence *B*	Sequence *C*
Approx. date of beginning	1 Aug 1932	25 Jan 1931	17 Jan 1930
Approx. date of ending	16 Nov 1934	28 Apr 1934	1 May 1934
No. of recurrences	31	44	58
Months of max. activity	Sep	Mar	Feb and Apr
Months of min. activity	Mar	Sep	Sep (Primary) Mar (Secondary)
Period of sequence	12 months	12 months	12 months
Latitude of the *M*-region	Above 7°·2 N	Below 7°·2 S	About 4°·8 S

that this is not the best criterion because of the following circumstance. Superposition of disturbances occur frequently, and spurious disturbances due to causes other than the *M*-region responsible for the sequence under consideration, may be superposed on the actual activity of a recurrence. These spurious disturbances cannot generally be separated or identified. Their effect is small when the sequence is passing through its maximum, but can be substantial during the minimum phase of activity. If any spurious disturbance is superposed during the minimum phase, it will be predominant, and we will unknowingly choose its activity.

To study the annual variation of activity within a sequence, we have plotted five different curves for each of the three sequences as follows—

1. The actual *C*-figures after every 27 days starting from selected dates determined from the plots of the 3-day running means of the daily *C*-figures. These curves exhibit an unmistakable 12-monthly periodicity of the same nature as discussed in paper 1. In addition for the *C*-sequence, we find two maxima and two minima within the twelve month period, which will be discussed later.

2. The actual *C*-figures after every 27 days starting one day earlier than in the first curve.

3. The actual *C*-figures after every 27 days starting one day later than in the first curve.

The purpose of the second and the third curves is to check the appropriateness of the particular dates chosen for the first curve. Since the storms generally last two to four days, one would expect some periodicity to be present in these two curves similar to that in the first curve. This periodicity is, however, found to be much less marked than in the first curve.

4. The 3-day running means after every 27 days, centred around the dates used in the first curve. This, indeed, is a composite of the first, second and the third curves and shows a well marked periodicity as good as that of the first curve.

5. The maximum activity for the recurrences. This is the same criterion as used in

paper 1. The periodicity is still well marked but not as good as for the first curve.

In addition we have chosen some random days and plotted the actual *C*-figures after every 27 days, to see how far the same type of periodicity as found for our sequences would be present for these randomly selected "sequences". We have found that the periodicity is very slight, and whenever such periodicity is present it is always of the six-monthly type, with maxima in March as well as in September. This is undoubtedly a reflection of the well known six-monthly periodicity found in the monthly means of geomagnetic activity (Bartels 1932), and is to be expected for a randomly selected "sequence".

On the basis of this study we feel that our long sequences exhibiting a 12-monthly periodicity are real.

The most probable cause of this annual variation is the tilt of solar axis of rotation to the ecliptic (*i.e.*, the earth's heliocentric position relative to the solar equator) as discussed in paper 1. This hypothesis is called the axial hypothesis.

As mentioned earlier, the *C*-sequence shows two maxima, in February and in April and two minima, in March (secondary minimum) and in September (primary minimum). We are not absolutely sure of the reality of this affect, but it seems sufficiently pronounced to be worthy of consideration. In paper 1, the annual variation for various heliographic latitudes of the *M*-regions was discussed. From that discussion it can be seen that the latitude of the *M*-region responsible for the *C*-sequence is about 4°·8 south. Such double maxima can be explained on the basis of the axial hypothesis only, and if their occurrence is real, it should be regarded as a confirmation of the axial hypothesis. The latitudes of the three *M*-regions are given in Table 1.

The difference in the heliographic longitudes of the *M*-regions responsible for the *A* and the *B* sequences is about 180°, for the *B* and *C* sequences about 45°, and for the *C* and the *A* sequences about 135°.

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