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Direction of Rapid Geomagnetic Changes at Indian observatories

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ABSTRACT. The total vectors of rapid geomagnetic fluctuations at the Indian magnetic observatories, point to the South or the North direction. The dip of these vectors is maximum at Trivandrum (46°) and minimum at Alibag (13°). For cases of negative $\triangle Z$, the vectors at Trivandrum and Annamalainagar point towards the sea in agreement with Parkinson's findings for coastal observatories while the same is not the case at Alibag. Significance of this finding is examined.

1. Introduction

Parkinson (1959, 1962) has studied rapid variations of the geomagnetic field over intervals of less than an hour, at a number of observatories most of which were situated in the temperate latitudes and found that the vectors representing the rapid changes (bays and similar fluctuations) in the magnetic field tend to lie on or close to a plane called the preferred plane. The orientation of this plane differs from one observatory to another and that at coastal observatories it almost invariably tilts upwards towards the nearest deep ocean. This phenomenon, according to Parkinson, is due to electromagnetic induction in the waters of the oceans or the upper part of the earth's mantle.

2. Method

Following Parkinson, the rapid geomagnetic variations at the three Indian magnetic observatories at Alibag, Annamalainagar and Trivandrum, situated practically on the sea coast, are analysed to find out the mean direction and tilt of the difference vectors.

(*i*) The geomagnetic difference vector is defined as the vector difference between the geomagnetic field vectors at the beginning and the end of an interval of time. For each fluctuation the difference vector is scaled from the D, H and Z magnetograms for equal intervals of time, adopting the usual convention of Easterly Declination, Northerly Horizontal Component and Downward Vertical Component as positive. The direction of the difference vector is determined by the angles θ and ϕ where, θ is the angle made by the difference vector with the upward vertical and ϕ is the azimuth angle of the vertical plane containing the difference vector measured from the magnetic north direction through east. θ and ϕ are given by the following formulae—

$$\tan\theta = \left[(\triangle H)^2 + (K\triangle D)^2\right]^{\frac{1}{2}} \Big/ \triangle Z$$

$$\tan\phi = \frac{K\triangle D}{\triangle H} \quad \text{and} \quad K = \frac{H}{3440}$$

where H; $\triangle H$ and $\triangle Z$ are in γ and $\triangle D$ in minutes of arc. H is the average value of the horizontal force.

(*ii*) The directions of the difference vectors are represented on polar diagrams shown in Figs. 1, 2a, 2b and 3. ϕ is in degrees measured from the magnetic north direction. θ is represented as radial distance from the centre given by $r = C(1-\cos\theta)^{\frac{1}{2}}$, where C is a constant. For each station two polar diagrams are drawn, one for cases of $\triangle Z$ positive and the other for cases of $\triangle Z$ negative. In the polar diagrams for cases of $\triangle Z$ positive the radial distances from the centre are proportional to $[1-\cos(\pi-\theta)]^{\frac{1}{2}}$.

(*iii*) The mean direction of the difference vectors found for each of the observatories is given in Table 1.

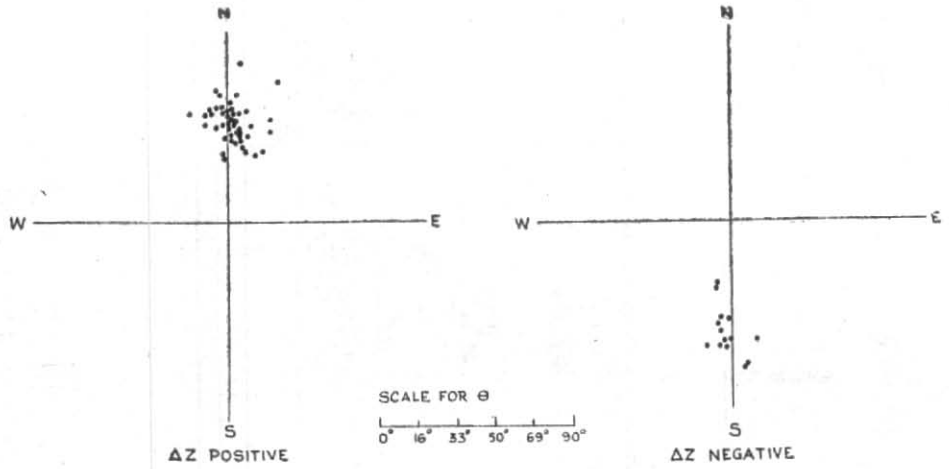

Fig. 1. Polar diagram for Trivandrum

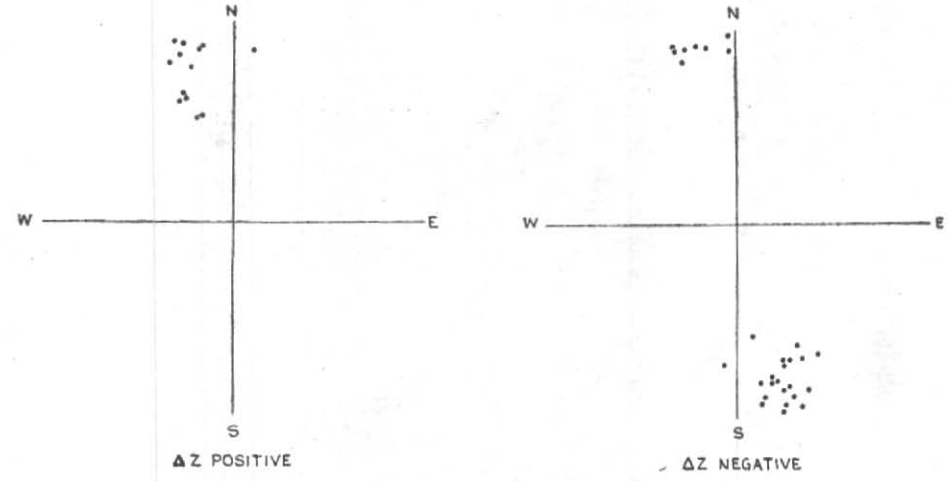

Fig. 2(a). Polar diagram for Annamalainagar during day

TABLE 1

Observatory	Geomagnetic		No. of intervals scaled	Duration of interval (min)	Direction of tilt	Tilt (degrees)		
	Lat.	Long.				Day	Night	Whole day
Trivandrum	1°.1 S	146°.3 E	73	30	S	40	47	46
Annamalainagar	1°.9 N	149°.4 E	84	30	S	16	28	22
Alibag	9°.5 N	143°.6 E	61	20	N	18	9	13

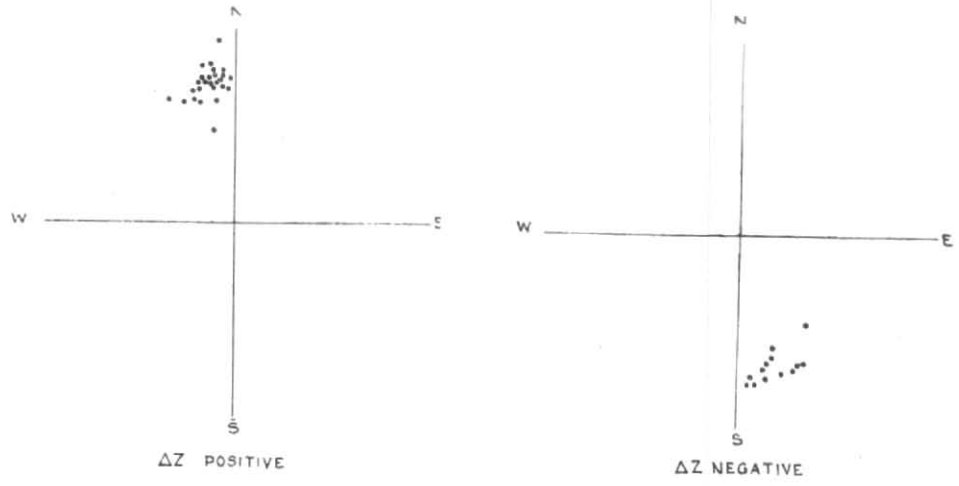

Fig. 2(b). Polar diagram for Annamalainagar during night

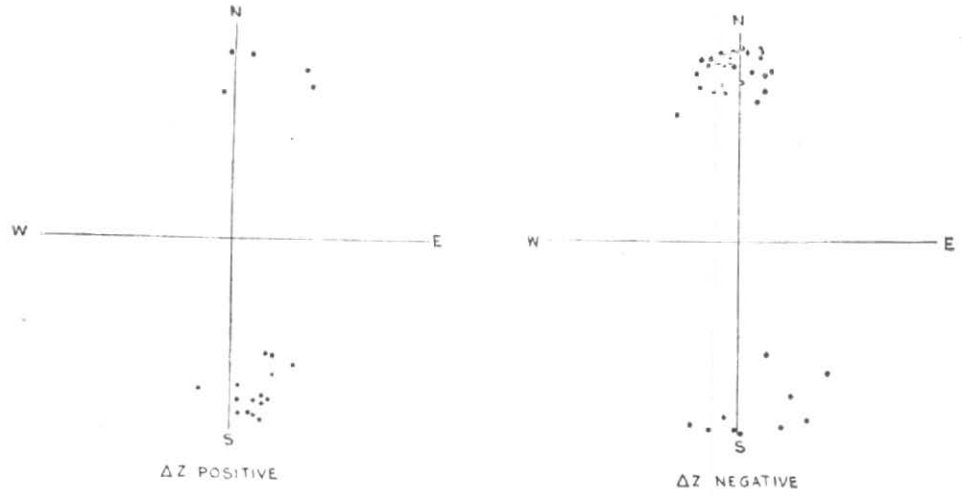

Fig. 3. Polar diagram for Alibag

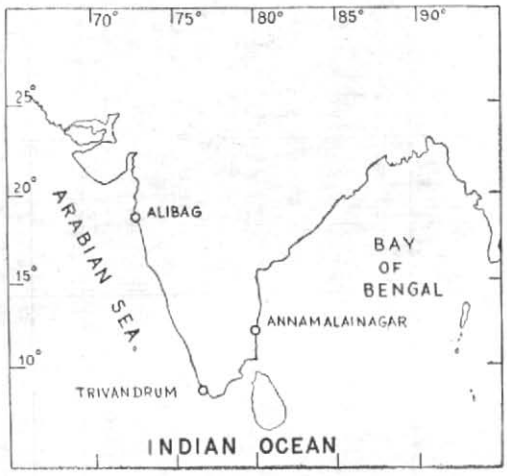

Fig. 4. Map showing the position of the Indian Magnetic observatories

(*iv*) From the polar diagrams it may be seen that the plotted points for all the stations cluster together in a narrow azimuth area near the north or south directions. This arises from the fact that fluctuations in D are very small compared with changes in H. For each observatory the direction θ is more or less the same for all the fluctuations. Thus for all the observatories the difference vectors are confined to a narrow cone whose axis represents the mean direction. This mean direction is given in Table 1 in terms of $90-\theta$ and ϕ, for the day and night and for the whole day.

3. Conclusion

It may be seen that $90-\theta$ for Trivandrum ranges between 40° and 47°, indicating that the component amplitudes of the difference vectors in H and Z are about the same. At Annamalainagar $90-\theta$ ranges between 16° and 28° while at Alibag it is between 9° and 18° indicating that magnitudes of $\triangle Z$ are much smaller than the corresponding magnitudes of $\triangle H$. Another feature that is noticed is that usually corresponding $\triangle Z$ and $\triangle H$ are of the same sense at Trivandrum and Annamalainagar whereas they are of opposite senses at Alibag, so that we find that at Trivandrum and Annamalainagar for cases of $\triangle Z$ positive, the mean difference vector dips below the horizontal plane (towards north), while for cases of $\triangle Z$ negative, it is directed upwards from the horizontal plane (towards the south). These directions are reversed in the case of Alibag. These features are the same as found by Yacob (1959).

The difference vectors do not appear to lie in any preferred plane as found by Parkinson for several middle-latitude stations. They have only a preferred direction as was found by Parkinson for Huancayo. This is only to be expected from the very small $\triangle D$ associated with any fluctuation in low latitudes. Though the mean difference vector for cases of negative $\triangle Z$ points towards the ocean area for both Trivandrum and Annamalainagar as was found by Parkinson for several observatories, it is difficult to see any significance in this, since these stations have sea on three sides. The mean difference vector (for cases of negative $\triangle Z$) at Alibag is not directed towards the sea, but to the north. However, the waters of the oceans being conductive sudden changes in the ionospheric currents will produce induced currents in the seawater, in addition to induced currents within

the conducting earth. If a particular geomagnetic fluctuation is considered to arise from ionospheric-currents, flowing either eastward or westward, the induced current in the Indian Ocean area will have the reverse direction. These induced currents will be more or less at the same level as the stations and, therefore, their contribution to $\triangle H$ will not be appreciable. On the other hand their contribution to $\triangle Z$ will be comparatively appreciable. Perhaps it is on this account that the amplitudes of $\triangle Z$ at Trivandrum and Annamalainagar are much larger than those seen at Alibag.

4. Acknowledgement

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REFERENCES

Parkinson, W. D. 1959 *Geophys. J.*, **2**, 1, pp. 1-14.

1962 *Ibid.*, **6**, 4, pp. 441-449.

Yacob, A. 1959 *Indian J. Met. Geophys.*, **10**, 4, pp. 377-392.