Induction in Short-period Events in the Indian Peninsula

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Abstract—The amplitudes of sudden commencements, sudden impulses and bays were measured from magnetograms of all peninsular stations in an attempt to isolate the induced effect in each component. Anomalous amplitudes in Z are very marked for Annamalainagar and Trivandrum, the coastal stations under the electrojet. A comparison of the H and D amplitudes at the five observatories shows that even these elements have an anomalous part at Annamalainagar and Trivandrum. The Parkinson vectors at these two stations and Alibag point towards the nearest sea. The length of the vector for the inland station Hyderabad is comparatively small, but for Kodaikanal the vector is significantly large. Untiedt's linear regression method was employed to calculate the vectors. The results are compared with those of other workers.

INTRODUCTION

Transient variations over the Earth's magnetic field can be separated into the external part caused by ionospheric and extra-ionospheric currents and the internal part due to currents induced in turn in the earth's crust and mantle. The effect of the induced field is to add to the horizontal components (H and D) of the inducing field and oppose the vertical component. Thus, in a layered earth with radially varying conductivity, the vertical component is extinguished. But under normal circumstances, the crust and mantle have considerable lateral heterogeniety and this serves to augment the Z component so that conspicuous Z variation is the signature of lateral conductivity contrasts. The commonest of these contrasts is the land-sea or ocean-continent boundary. Of the five magnetic observatories in peninsular India, three lie on the coast. Night-time events were selected in order to obtain uniform H and D amplitudes. In Peru and Bolivia it has been shown by Schmucker et al. (1971) that for night-time bays there is very little change in amplitude over 37° of equatorial latitude. The over all variation in H is so small that the primary field can be assumed to have too small a spatial non-uniformity to make a significant contribution to Z.

ANALYSIS

In order to investigate induced variations in short period events, 40 to 50 events each of SSCs, SIs and bays occurring at night were selected. Only events recorded at all five stations were taken. The phase difference between the occurrence of maxima in Z and H traces was small and therefore neglected; the inference being that the maxima occurred simultaneously in all 3 traces. The amplitudes of ΔH, ΔD and ΔZ are related through the following equation:

$$\Delta Z = A.\Delta H + B.\Delta D + \epsilon \qquad (1)$$

This is equivalent to Parkinson's inference that vector changes lie on a preferred plane (Parkinson, 1959). Here we follow a slightly different representation after Untiedt (1970), who relates the induction vector $\vec{S} = -\vec{i}A - \vec{j}B$ to Parkinson's vector $\vec{P}$ as, $\vec{P} = \vec{S}/\sqrt{1+|S|^2}$ where $\vec{i}$ and $\vec{j}$ are the unit vectors in the magnetic north and east directions respectively. θ, the azimuth of vector $= \tan^{-1}(B/A)$ and is measured clockwise from the south. The vectors calculated in this manner are shown in Fig. 3 for all the stations for SIs, SSCs and bays.

In equation (1) it has been assumed that the whole of ΔZ is anomalous and ΔH and ΔD are entirely normal. If this is to be valid, the horizontal inducing field should be identical at all the stations. H and D for bays and SSCs are plotted for each station separately, to give the mean horizontal field for the event. As seen from Fig. 1 the direction of this field is the same at ALB, HYD and KOD. However, at ANR it is more westward and at TRV east of north. This cannot be attributed to latitudinal variation since there is no systematic change in the slope of the line as we go from ALB to TRV. This is an indication that the inducing field is itself anomalous at ANR and TRV. The anomalous parts of ΔH and ΔD are separated using HYD and KOD which are reference stations by virtue of being inland and apparently remote from any lateral discontinuity. The plots of the residual anomalous field given by $(H_{STN} - H_{NOR})$ and $(D_{STN} - D_{NOR})$ are shown in Fig. 2. NOR stands for normal, reference station and STN for the station whose anomalous field is being studied.

This anomaly further affects the estimation of induction vectors since it was assumed that ΔH and ΔD are entirely normal. To comply with this condition, equation (1) was modified thus:

$$\Delta Z_{STN} = A.\Delta H_{NOR} + B.\Delta D_{NOR} + \epsilon \qquad (2)$$

HYD and KOD were used in turn as NOR. The coefficients are given in Table 1.

RESULTS

The anomalies observed in H and D at ANR and TRV are given in Fig. 2 and the induction vectors computed for all stations in Table 1. The scatter in data about the line of regression is seen from the standard deviation of the coefficients A and B in Table 1. For TRV in particular σB is twice as large as B for SSCs and bays and therefore B can be either positive or negative when the values from normal stations are used. Hence the induction arrows lie east and west of south. At ANR also σB is large. The cause for the large scatter in B is the large scale values for D at both stations (= 5'/cm. For the same reason, KOD data is not reliable, the scale value for D being 14'/cm. Taking the large scatter into account one can only conclude that with improved sensitivities of D at ANR, TRV and KOD, the induction vectors can be more accurately determined, which is essential before any quantitative assessment of the anomalies arising from the proximity of the Indian Ocean or ocean continent boundary can be made.

DISCUSSION

The vectors at ALB exhibit a strong coastal effect and point westward towards the Arabian sea. This differs from earlier results given by Srivastava et al. (1968). The difference arises from the change in method of computation. Parkinson's plots for determining his vector was applicable to mid-latitudes but in low latitudes where the points tend to lie on a cone rather than a plane, it is difficult to determine the plane from the clusters of points obtained. This was the main reason for our application of Untiedt's linear regression equation.

The induction vectors at KOD are as large as at ANR and at both stations they point southward. Thus, KOD cannot be a proper reference station and though it is 130 km from the nearest sea, induced effects are strongly present. This has been pointed out earlier by Sastri and Rao (1971) with regard to the separation lunar variations into ionospheric and oceanic components. At ANR, instead of pointing eastward to the nearest deep sea, the vectors are aligned in the same direction as TRV vectors, although of lesser magnitude. It is possible that the induction effect observed at ANR, KOD and TRV is due to the same structure, which, because of limitations in magnetic recording cannot be defined here. With a few temporary stations and estimates of a matrix of coefficients for anomalies in H and D as well as Z, the structure causing these anomalous variations in peninsular India can be delineated.

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STN	Z_{STN} , $(H,D)_{STN}$		Z_{STN} , $(H,D)_{HYD}$		Z_{STN} , $(H,D)_{KOD}$	
SSC	A± σA	B± σB	A± σA	B± σB	A± σA	B± σB
ALB	-.06±.02	.59±.08	.12±.02	.45±.14	.07±.04	.64±.21
HYD	-.06±.01	-.10±.06				
ANR	.48±.03	-.11±.10	.58±.02	-.25±.13	.63±.03	-.09±.17
KOD	.50±.02	-.05±.14				
TRV	1.33±.05	-.29±.48	1.34±.05	.56±.32	1.38±.08	.29±.44
BAYS						
ALB	-.11±.02	.15±.07	-.12±.01	.10±.05	-.13±.02	.07±.07
HYD	.006±.01	-.21±.03				
ANR	.55±.05	.25±.19	.54±.03	.06±.10	.58±.03	.26±.13
KOD	.43±.07	-.57±.24				
TRV	1.10±.02	.16±.26	1.09±.05	.01±.16	1.14±.07	.39±.25

TABLE 1

The coefficients A and B as calculated for all 5 stations and each coastal station, using H and D values of HYD and KOD in turn.

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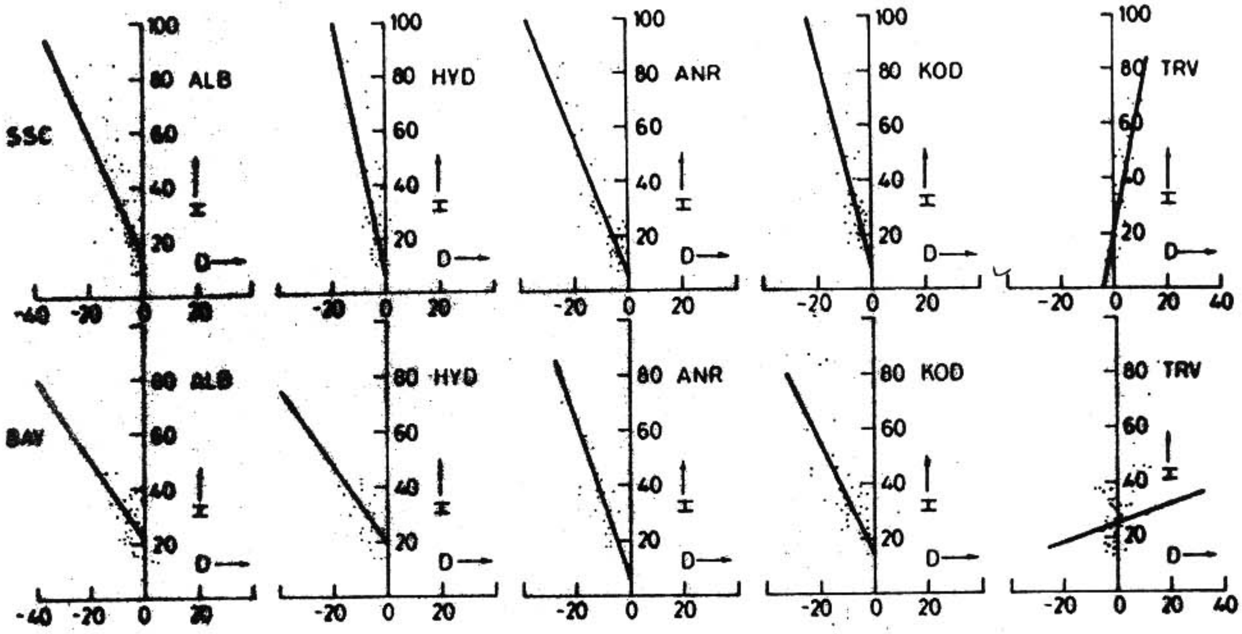

FIG. 1 The plots of the near horizontal field for bay and SSC events are shown for all 5 stations.

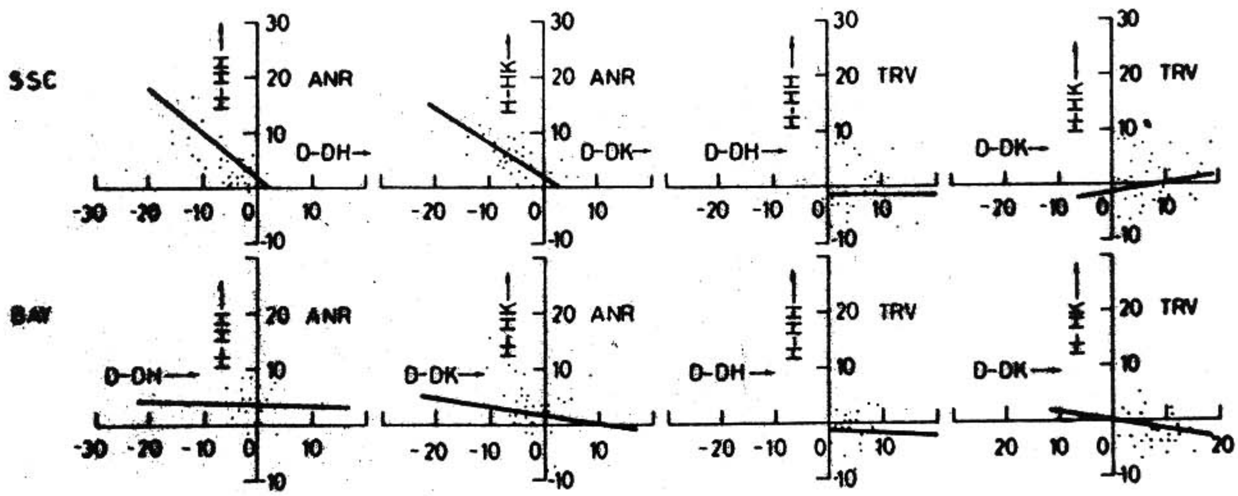

FIG. 2 The anomalous horizontal field at ANR and TRV for bays and SSC events found by using HYD(H) and KOD(K) as a normal station in turn.