On the Characteristics of the SC of 13 July 1961 in the Indian Equatorial Region

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Sudden commencement geomagnetic storms, as the name implies, start with an abrupt change in the earth's magnetic field, which is referred to as storm sudden commencement (SSC or SC). It has been demonstrated that SC is due to the interaction of hydromagnetic shock waves with the magnetosphere (BURLAGA and OGILVIE, 1969). The signature of SC's is known to be variable and three main types, designated as SC or SC(+), SC* or SC (− +) and inverted SC or SC (−) have been identified (NEWTON, 1948). Occasionally, inverted SC* or SC (+ −) is also observed. It is an established fact of observation that during day time, there is an equatorial enhancement of the amplitude in the *H*-component of SC's (SUGIURA, 1953; VESTINE, 1953; FERRARO, 1954; MAEDA and YAMAMOTO, 1960; MATSUSHITA, 1960; SRINIVASAMURTHY, 1960). FORBUSH and CASAVERDE (1961) noted the amplitude of SC at the equatorial stations in Peru to vary with latitude in a manner very similar to solar diurnal range of *H* at these stations. Further, a close association between the SC size and the equatorial electrojet is reported by RASTOGI (1963) and RASTOGI *et al.* (1964). JACOBS and WATANABE (1963) explained the equatorial enhancement of SC as due to an increase in the intensity of electrojet at the time of SC caused by a downward movement of charged particles in the ionosphere under the influence of westward electric field associated with the SC-variations of the geomagnetic field. This movement causes an increase in the ionospheric electrical conductivity and hence the intensity of electrojet. BHARGAVA and SUBRAHMANYAM (1966) attributed the day time equatorial enhancement of the amplitude in the *H*-component of SC's to probable reduced attenuation of hydromagnetic waves due to lower number density of positive ions at great heights in the *F*-region resulting from vertical divergence under the influence of electrojet and meridional transport of ionization along field lines in the equatorial region during day time.

The purpose of this brief communication is to present the characteristics

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Table 1. Amplitude in *H*-component of the SC of 1112 UT (1642 IST), 13 July 1961 as observed at stations in the Indian equatorial region.

Station	Geographic co-ordinates		Magnetic dip (I)	Amplitude in *H*-component of SC (in gammas)
	Lat.	Long.		
Alibag	18 38′N	72 52′E	24.4	+70
Annamalainagar	11 22′N	79 41′E	5.4	+60
Kodaikanal	10 14′N	77 28′E	3.5	+58
Trivandrum	8 29′N	76 57′E	−1.0	+52

of the SC of 1112 UT, 13 July 1961 as observed at geomagnetic stations in the Indian equatorial zone, and to attempt an understanding of the interesting latitudinal variation noticed in the amplitude of the *H*-component of this SC. The names and co-ordinates of the four stations whose published data is used in this study are given in Table 1. It may be seen that the stations: Trivandrum, Kodaikanal and Annamalainagar lie under the influence of equatorial electrojet, while Alibag is outside the influence of electrojet.

The period from 11 July through 28 July, 1961 is one of considerable solar-terrestrial activity, consisting of 12 solar flares of importance 2 or 3 (Solar-Geophysical Data–CRPL) and four principal storm periods (LINCOLN, 1961, 1962). The SC of 1112 UT, 13 July 1961 is considered to be due to the solar flare of 1615 UT, 11 July 1961 (PIEPER *et al.*, 1962). In Table 1 are presented the amplitudes of the *H*-component of this SC as observed at the four stations in the Indian equatorial zone. The interesting feature of this SC, as can be seen from Table 1, is the increase in the SC amplitude with increasing magnetic dip, a behaviour exactly opposite to the one commonly observed. Further, the ratio of the amplitude of this SC at Alibag to that at Trivandrum is 1.35, indicating a significant reduction of its amplitude at an electrojet station compared to that at the non-jet station.

As mentioned earlier, since the earlier work showed a close association between the size of SC's and the electrojet strength in the equatorial regions, the observed latitudinal variation for the SC of 1112 UT, 13 July 1961 (with a significantly reduced amplitude in the *H*-component at the jet stations compared to the non-jet station), could be due to the existence of a counter-electrojet (westward) current system around the time of the occurrence of this SC. GOUIN and MAYAUD (1967) reported the existence of counter-electrojet at Addis Ababa, which manifest as a negative effect in the diurnal variation of the *H*-field around 0700 hrs, noon and 1500 hrs local time. Subsequent studies showed the phenomenon of counter-electrojet to occur at other equatorial stations and most frequently during periods of low solar and magnetic activity; and in close association with the disappearance of equatorial sporadic $-E$ (E_{sq}) (HUTTON and

In view of the above investigations, the quarter-hourly ionogram data of Kodaikanal for 13 July 1961 has been examined for any manifestation of counter-electrojet (disappearance of E_{sq}) prior to and around the time of the occurrence of the SC at 1112 UT (1642 IST). It is found that E_{sq} on this day suddenly disappeared at 1500 hrs IST (0930 UT) and reappeared only at 1715 hrs IST (1145 UT), indicating the probable existence of counter-electrojet prior to and around the time of SC at 1642 IST (1111 UT). This can be clearly seen from the sequence of ionograms of Kodaikanal in the afternoon hours of 13 July 1961, presented in Fig. 1. Equatorial sporadic $-E$ (E_{sq}) with slant E_s embedded in it is seen at 1330 hrs IST (0800 UT). However, by 1500 hrs E_{sq} disappeared and blanketing E_s is noticed on the ionograms at 1615 and 1630 hrs (with f_bE_s about 4.2 MHz). This is to be expected as the appearance of blanketing E_s at Kodaikanal is known to be associated with either a weakening or complete disappearance of E_{sq} and a reduction in the H-field (BHARGAVA and SUBRAHMANYAM, 1964). E_{sq} reappeared only at 1715 hrs IST and continued till 1800 hrs IST.

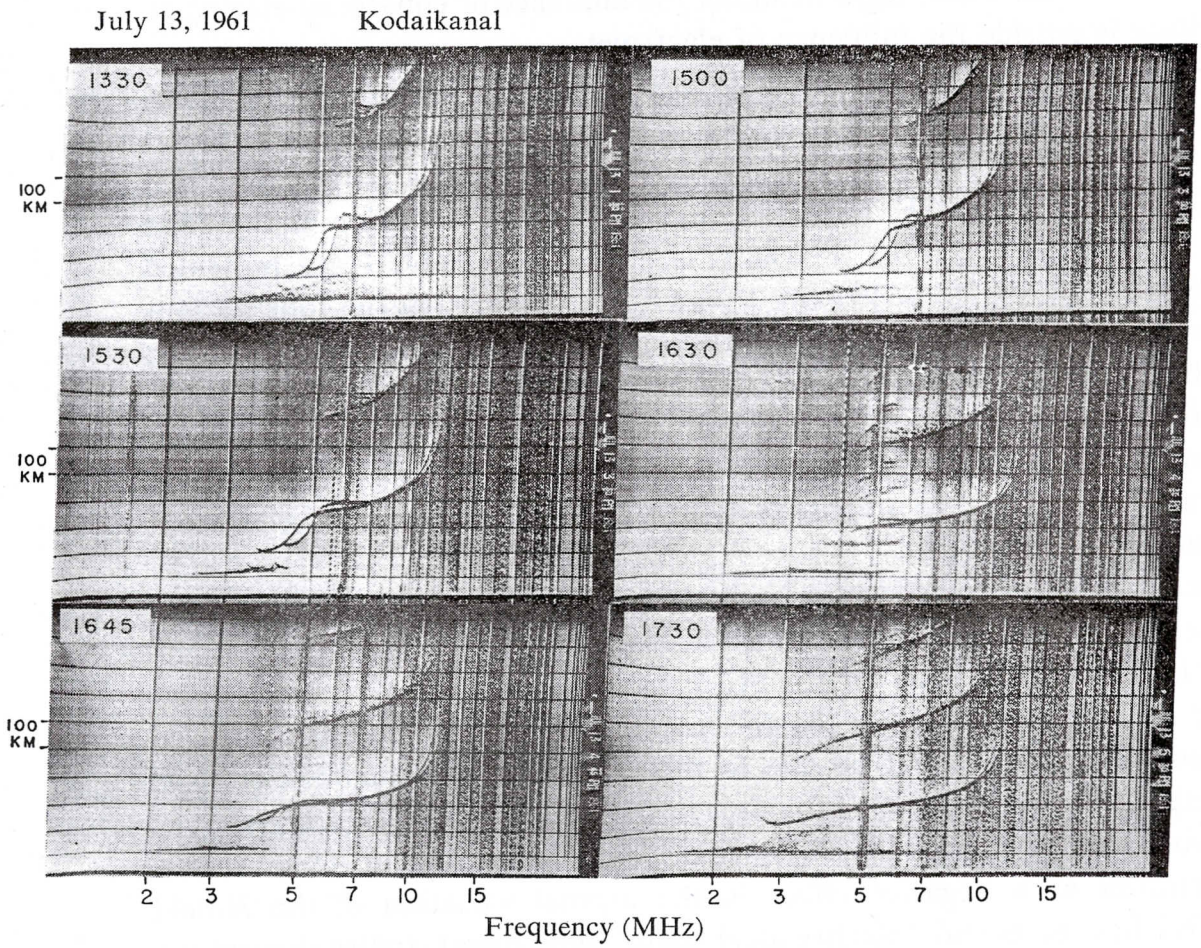

Fig. 1. Sequence of ionograms in the afternoon hours of 13 July 1961 at Kodaikanal, illustrating the temporary disappearance of E_{sq}. The time indicated is in IST (UT+5½ hrs).

OYENLOYE, 1970; RASTOGI *et al.*, 1971; RASTOGI, 1973; SASTRI and JAYAKAR, 1972).

In order to obtain further support for our reasoning, we have listed up all SC's (from published data) that occurred during the afternoon hours (0830–1215 UT) in tne Indian zone over the period from January 1957 through October 1970, in view of the fact that the occurrence of 'Counter-Electrojet' is a maximum in the afternoon hours in the Indian equatorial region (RASTOGI, 1973) (data for the years 1966, 1967 and 1968 were not available). A total of 23 SC events (excluding the one on 13 July 1961) occurred during this period, for which the variation in the amplitude of H of SC with the dip angle has been studied. It is noticed that:

(1) None of them exhibited the characteristics of the SC of 13 July 1961, i.e. an increase in the amplitude in H of SC with increasing dip angle.

(2) The corresponding ionogram data at Kodaikanal showed that none of them was associated with the manifestation of 'Counter-Electrojet' (disappearance of E_{sq}).

To sum up, it is inferred from the above observations that the unique latitudidal variation of the amplitude in the H-component of the SC of 1112 UT, 13 July 1961 observed in the Indian equatorial region is due to the existence of a counter-electrojet (westward) current system around the time of the occurrence of the SC.

REFERENCES

BHARGAVA, B.N. and R.V. SUBRAHMANYAM, A study of blanketing sporadic-*E* in the Indian equatorial region, *Proc. Ind. Acad. Sci.*, **60**, 271–285, 1964.

BHARGAVA, B.N. and R.V. SUBRAHMANYAM, Some features of geomagnetic sudden commencements following cosmic ray flares, *Planet. Space Sci.*, **14**, 871–889, 1966.

BURLAGA, L.F. and K.W. OGILVIE, Causes of sudden commencements and sudden impulses, *J. Geophys. Res.*, **74**, 2815–2825, 1969.

FERRARO, V.C.A., Some remarks on recent notes by Drs. Sugiura and Vestine, *J. Geophys. Res.*, **59**, 309–311, 1954.

FORBUSH, S.E. and M. CASAVERDE, *Equatorial Electrojet in Peru*, C.I.W. Publications No. 620, 1961.

GOUIN, P. and P.N. MAYAUD, A propos de l'existence possible d'un contre-electrojet anx latitudes magnetiques equatoriales, *Ann. Geophys.*, **23**, 41–47, 1967.

HUTTON, R. and J.O. OYINLOYE, The counter-electrojet in Nigeria, *Ann. Geophys.*, **26**, 921–926, 1970.

JACOBS, J.A. and T. WATANABE, The equatorial enhancement of sudden commencements of geomagnetic storms, *J. Atmosph. Terr. Phys.*, **25**, 267–279, 1963.

LINCOLN, J.V., Geomagnetic and solar data, *J. Geophys. Res.*, **66**, 3947–3949, 1961.

LINCOLN, J.V., Geomagnetic and solar data, *J. Geophys. Res.*, **67**, 381–387, 1962.

MAEDA, H. and M. YAMAMOTO, A note on day time enhancement of the amplitude of geomagnetic storm sudden commencements in the equatorial region, *J. Geophys. Res.*, **65**, 2538–2539, 1960.

MATSUSHITA, M., Sudden commencements of geomagnetic storms, *J. Geophys. Res.*, **65**, 1423–1435, 1960.

NEWTON, H.W., Sudden commencements in the Greenwich magnetic records (1879–1944) and related sunspot data, *Mon. Not. R. Astr. Soc. Geophys. Suppl.*, **5**(6), 159–185, 1948.

PIEPER, G.F., A.J. ZMUDA, and C.O. BOSTROM, Solar protons and magnetic storms in July 1961, *J. Geophys. Res.*, **67**, 4959–4981, 1962.

RASTOGI, R.G., Longitudinal inequalities in the lunar tide and in sudden commencement in H near the magnetic equator, *J. Atmosph. Terr. Phys.*, **25**, 393–399, 1963.

RASTOGI, R.G., Counter equatorial electrojet currents in the Indian zone, *Planet. Space Sci.*, **21**, 1355–1365, 1973.

RASTOGI, R.G., H. CHANDRA, and S.C. CHAKRAVARTY, The disappearance of equatorial E_s and the reversal of electrojet current, *Proc. Ind. Acad. Sci.*, **74**, 62–67, 1971.

RASTOGI, R.G., N.B. TRIVEDI, and N.D. KAUSHIKA, Some relations between the sudden commencement in H and the equatorial electrojet, *J. Atmosph. Terr. Phys.*, **26**, 771–776, 1964.

SASTRI, N.S. and R.W. JAYAKAR, Afternoon depression in the horizontal component of the geomagnetic field at Trivandrum, *Ann. Geophys.*, **28**, 589–591, 1972.

SRINIVASAMURTHY, B., Sudden commencements and impulses in Kodaikanal magnetograms—Their hourly frequency, *Ind. J. Meteor. Geophys.*, **10**, 209–212, 1960.

SUGIURA, M., The solar diurnal variation in the amplitude of sudden commencements of magnetic storms at the geomagnetic equator, *J. Geophys. Res.*, **58**, 558–559, 1953.

VESTINE, E.H., The immediate source of the field of magnetic storms, *J. Geophys. Res.*, **58**, 560–562, 1953.