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The Geomagnetic solar flare effect of 6 July 1968 and its implications

by

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RESUME. – *Une étude de l'effet géomagnétique de l'éruption solaire (SFE) du 6 juillet 1968 observé dans cinq observatoires magnétiques indiens, se trouvant à des longitudes de 72-80°E, a révélé que cet effet géomagnétique de l'éruption solaire est caractérisé par une diminution dans la composante H aux stations situées sous l'électrojet et une augmentation de la composante H dans des stations situées en dehors de l'électrojet. L'examen des ionogrammes et des magnétogrammes de Kodaikanal, une station située sous l'électrojet, a indiqué ce jour là l'existence d'un électrojet inverse, juste avant et juste après le SFE. Les implications de ces observations sont discutées.*

ABSTRACT. – *A study of the geomagnetic solar flare effect (SFE) of 6 July 1968 observed at five Indian magnetic observatories, lying in the longtitude range 72-80°E, revealed that this SFE is characterised by a decrease in the H-component at electrojet stations and an increase in the H-component at stations outside the electrojet. Examination of relevant ionogram and magnetogram data of Kodaikanal, a station under the electrojet, for this day indicated the existence of a counter-electrojet just prior to and after the occurence of SFE. The implications of these observations are discussed.*

Introduction

The sudden short lived perturbation in the geomagnetic variation in the sunlit hemisphere concurrent with the occurrence of a solar flare is known as *SFE* (Crochet). The characteristics of *SFE* have been studied over the past three decades and are now well known (refer to the review paper of Nagata, 1966 and Richmond and Venkateswaran, 1971). Recently, Srivastava (1974) observed for the *SFE* of 3 May 1973, the amplitude in the *H*-component of the *SFE* to be relatively low at equatorial electrojet stations compared to that at stations outside the electrojet ; which feature he attributed to the presence of a 'counter-electrojet' current system flowing from east to west. This understanding stems from the fact that the amplitude of *SFE* (in the *H*-component) is usually larger at equatorial electrojet stations compared to that at stations outside the electrojet (Pisharoty and Joseph, 1963).

In this brief communication, the characteristics of the geomagnetic solar flare effect (*SFE*) of 6 July 1968 as observed at five Indian magnetic observatories are presented and the implications of its unique features are discussed. The names and coordinates of the stations are listed in Table 1. The locations of the stations and that of the electrojet are depicted in Figure 1. It may be noticed that while Alibag and Hyderabad lie outside the influence of the equatorial electrojet, Annamalainagar, Kodaikanal and Trivandrum are situated well within the electrojet. The geomagnetic solar flare effect of 6 July 1968 which occurd with a solar flare of importance 2B is a confirmed event as Sudden Ionospheric Disturbances

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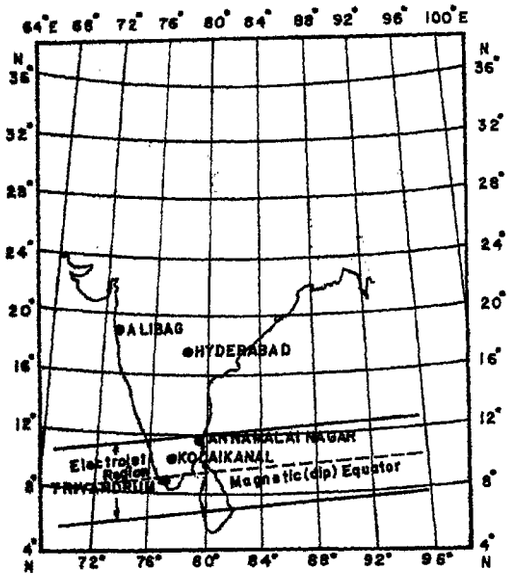

Fig. 1

A map showing the locations of the five magnetic observatories and the equatorial electrojet.

(SWF, SCNA, SEA, SPA and SES) and fade-out on ionograms (at Kodaikanal) occurred simultaneously with this SFE (see Table 1 for details).

Observation

Figure 2 shows the geomagnetic solar flare effect of 6 July 1968 as evidenced in the *H*-traces of the normal run magnetograms of the five stations mentioned. The characteristics of this SFE as observed at the various stations are presented in Table 1. The amplitude of SFE at each station is obtained from the difference in the value of the *H*-component at the maximum (or minimum) of the SFE and the average value at the begining and end of the SFE, following accepted practice. The unique feature of this SFE, as can be clearly seen from figure 2 and Table 1, is that although the amplitude in the *H*-component of the SFE increases with decrease in latitude, the sign of the perturbation is consistently negative at all the three electrojet stations, while it is positive at the two stations outside the influence of the electrojet.

Discussion

A plausible cause of the above described characteristic of the SFE of 6 July 1968 could be the existence of a 'counter-electrojet' current system

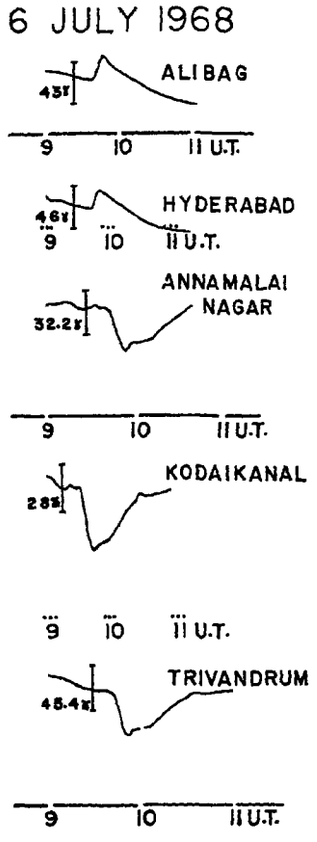

Fig. 2

The geomagnetic solar flare effect (SFE) of 6 July 1968 at the five Indian stations showing the decrease in the *H*-component at electrojet stations and the increase in the *H*-component at stations outside the electrojet.

in the equatorial region at the time of occurrence of the solar flare effect. The presence of 'counter-electrojet' in the equatorial region which manifests itself as a negative effect in the diurnal variation of the horizontal component around 0700 hr, noon and 1 500 hr local time has been brought to light by Gouin and Mayaud (1967). Later studies showed the phenomenon of 'counter-electrojet' to occur most frequently around sunspot minimum period and when the magnetic activity is very low; and is closely associated with the disappearance of equatorial Es (Esq) and reversal of drift direction of electrons from westward to eastward (Hutton and Oyinloye, 1970; Sastri and Jayakar, 1972; Rastogi et al, 1971; Krishnamurthy and Sen Gupta, 1972). The cause mechanism responsible for 'counter electrojet' current system is however yet to be established. Van Sabben (1968) interpreted the counter-electrojet as an equatorial anomaly associated with the SFE current system following the

Table I

Solar flare effect of 6 July 1968 as observed at Indian magnetic observatories

Observatory	Geographic coordinates Lat.	Long.	Dip(I)	Characteristics of SFE Start	Max U.T.	End	SFE Amplitude in Gammas (*H*-component)
Alibag	18 38'N	72 52'E	24.4	0940	0948	1036	+ 26
Hyderabad	17 25'N	78 33'E	20.5	0942	0950	1038	+ 26
Annamalinagar	11 22'N	79 41'E	5.4	0942	0953	1035	+ 30
Kodaikanal	10 14'N	77 28'E	3.0	0939	0947	1032	+ 38
Trivandrum	8 29'N	76 57'E	− 1.0	0941	0948	1037	+ 46

Associated SID's : SWF : 0948 – 1010E – 1020U U.T.
SCNA : 0945 – 0949 – 1015 U.T.
SEA : 0940 – 0945 – 1042 U.T.
SPA : 0940 – 0943 – 1200 U.T.
SES : 0940 – 0949 – 1110 U.T.
(after Solar-Geophysical Data ESSA/NOAA).

observation of small reversed vortices in the morning and evening sectors in the equatorial region for the five SFE's analysed by him. However, Hutton and Oyinloye (1970) found no evidence in support of this from a study of solar flares in relation to the manifestation of the 'counter-electrojet', A study of the lunar modulation in the occurrence of the phenomenon suggested that the 'counter-electrojet' currents may be situated in the same ionospheric layers as the lunar currents (Sastri and Jayakar, 1972).

In view of the above investigations the relevant quarter-hourly ionogram and normal run magnetogram data of Kodaikanal has been examined for the manifestations of 'counter-electrojet' around the time of the occurrence of SFE on 6 July 1968. 6 July 1968 is one of the quiet days of the month, the value of A_p for this day is 6.0 and the magnetic character figure C_p is 0.3. In figure 3 is shown the magnetogram of Kodaikanal on 6 July 1968. It can be seen that there is an indication of a 'counter-electrojet' on this day just prior to and after the occurrence of SFE, as during this period the value of the horizontal component of the magnetic field is below the average night time level (shown by the dotted line in figure 3). In Plate I are shown the ionograms of Kodaikanal around the time of occurrence of the SFE on 6 July 1968. It can be seen that at 1330 hrs I.S.T. (0800 U.T.), well before the occurrence of SFE, equatorial sporadic-E (Esq) is present. The E_s configuration underwent drastic changes in the next 30 minutes and by 1 400 hrs I.S.T. (0830 U.T.) it is of total blanketing type (Esb). This is expected as it is known that the occurrence of blanketing E_s at Kodaikanal is usually accompanied by a decrease in the *H*-component and disappearance of equatorial sporadic – *E* (Bhargava and Subrahmanyam, 1964). Equatorial sporadic – *E* (Esq) is again seen at 1500 hrs I.S.T. (0930 U.T.) when the *H*-component value just crossed the average night time level. The solar flare effect on vertical sounding is then seen with total fade-out at 1530 hrs I.S.T. (1000 U.T.) and with the progress of time the recovery of the ionogram trace took place It is interesting to note that at 1630 hrs I.S.T. (1100 U.T.) when the ionogram trace completely

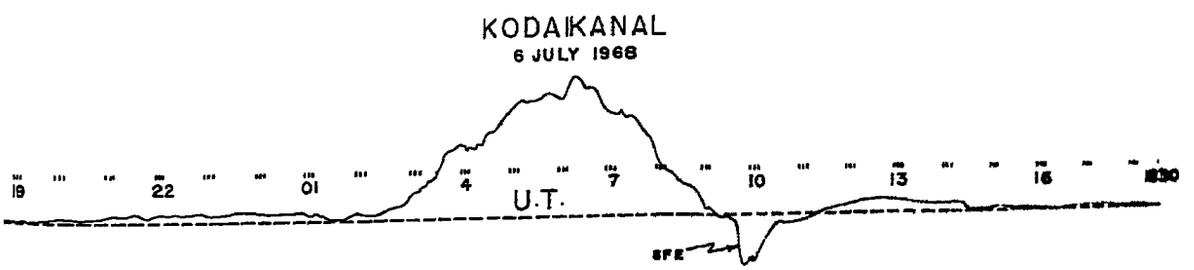

Fig. 3

Normal run magnetogram of Kodaikanal on 6 July 1968 showing the depression in *H*-component below the average night time level (counter-electrojet) just prior to and after the occurrence of SFE.

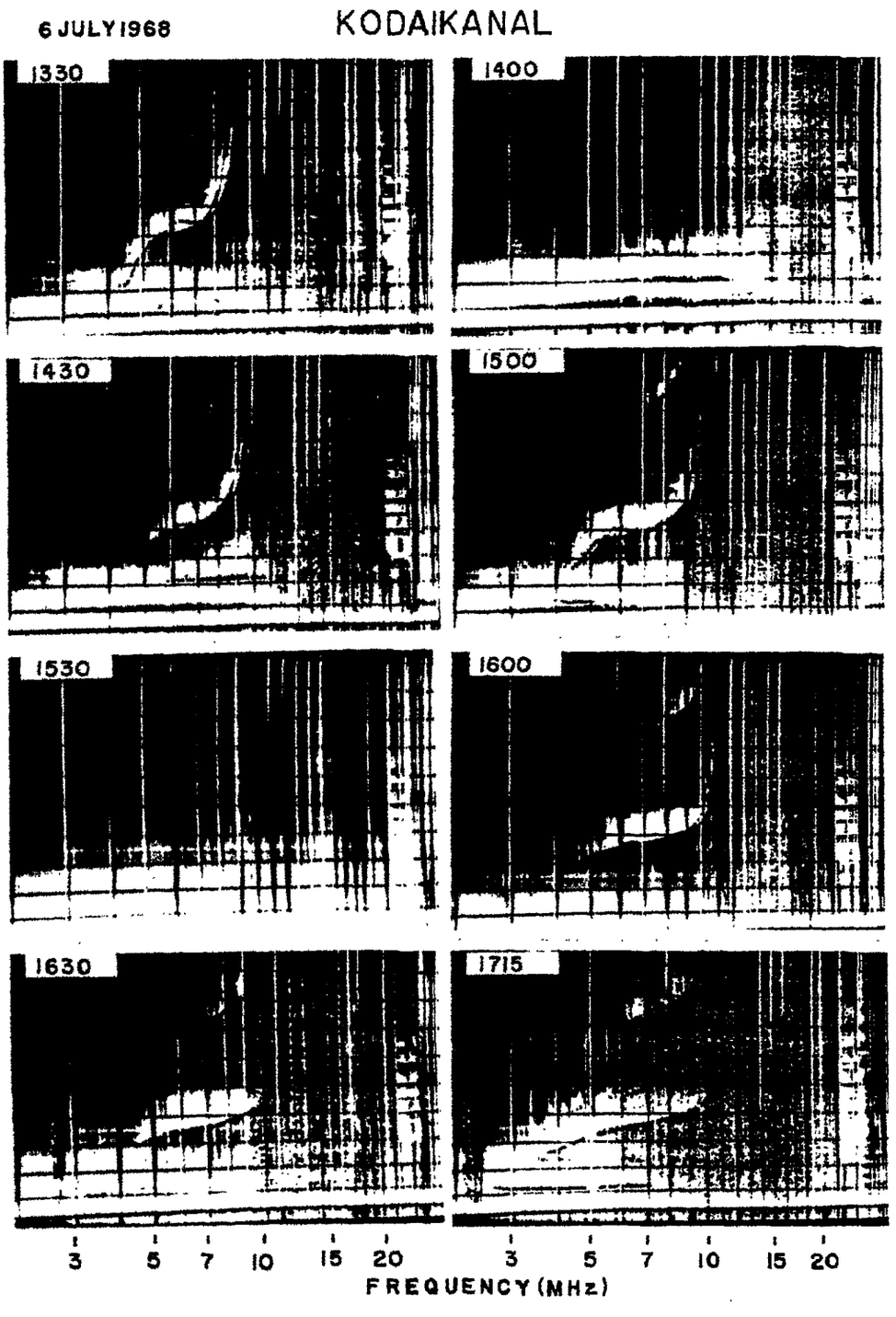

Plate I

ionograms of Kodaikanal on 6 July 1968 around the time of occurrence of SFE. Note the conspicious absence of Esq at 1630 hrs I.S.T. when the *H*-component is below the average night time level (counter-electrojet). Height marks are at intervals of 100 km. The time indicated is in I.S.T. (U.T. + 0530 hrs).

recovered, equatorial sporadic – E (Esq) is conspiciously absent and only normal E-region trace is noticed (the value of the H-component is below the night time level indicating the presence of 'counter-electrojet'). Equatorial sporadic – E (Esq) reappeared only at 1715 hrs I.S.T. (1145 U.T.) when the value of the H-component rose well above the night time level. The above observations indicate the existence of a reversed electric current system in the electrojet region just prior to and after the occurrence of the SFE, enabling to interpret the unique features of the SFE, mentioned earlier, as due to 'counter-electrojet'.

It is fortuitous that the SFE of 6 July 1968 occurred just at the time of the afternoon depression in the H-component (manifestation of counter-electrojet) posing some ambiguity as to which is the cause and which is of the effect of the two : counter-electrojet and the characteristics of the SFE current system. However, already mentioned, the work of Hutton and Oyinloye (1970) shows that 'counter-electrojet' could not be due to the SFE current system as interpreted by Van Sabben (1968). Hence we reach the view that the characterictic features of the SFE of 6 July 1968 are due to the presence of a 'counter-electrojet' current system in the equatorial region at the time of occurrence of this SFE.

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References

Bhargava B.N. and Subrahmanyam R.V., "A study of blanketing sporadic – E in the Indian Equatorial region.," *Proc. Ind. Acad. Sci.* Vol. LX, 271-285, 1964.

Gouin P. et Mayaud P.N., "A propos de l'existence possible d'un contre-électrojet aux latitudes magnétiques equatoriales", *Ann. Geophys.*, 23, 41-47, 1967.

Hutton R. and Oyinloye J.O., "The counter-electrojet in Nigeria.," *Ann. Geophys.*, 26, 921-926, 1970.

Krishnamurthy B.V. and Sen Gupta K., "Disappearance of Equatorial E_s associated with magnetic field depressions.," *Planet. Space Sci.*, 20, 371-378, 1972.

Nagata T., "Solar flare effect and the geomagnetic field." *J. Geomag. Geolect*, 18, 197-219, 1966.

Pisharoty P.R. and Joseph P.V., "SFE and S_q vectors at Indian geomagnetic stations.," *Proc. IGY. Symp. New Delhi*, 2, 70-73, 1963.

Rastogi R.G., Chandra H. and Chakravarty S.C., "The disappearance of equatorial E_s and the reversal of electrojet current.," *Proc. Ind. Acad Sci.*, 74, 62-67, 1971.

Richmond A.D. and Venkateswaran S.V., "Geomagnetic crochets and associated ionospheric current systems." *Radio. Sci.* 6, 139-164, 1971.

Sastri N.S. and Jayakar R.W., "Afternoon depression in the Horizontal component of the geomagnetic field at Trivandrum," *Ann. Geophys*, 28, 589-591, 1972.

Srivastava B.J., "The geomagnetic solar flare effect of 3 May 1973 at Indian stations and its dependence on the counter-electrojet", *J. Atmosph. Terr. Phys.*, 36, 1571-1575, 1974.

Van Sabben D., "Solar flare effects and simultaneous magnetic daily variation, 1959-1961.," *J. Atmos Terr. Phys.*, 30, 1641-1648, 1968.