

Magnetic and Ionospheric Observations During the October 24, 1995 Total Solar Eclipse in Vietnam

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ABSTRACT

The track of the Moon's shadow during the Total Solar Eclipse of October 24, 1995 passed parallel to the magnetic Equator in the Vietnam sector. This fact together with its lengthy 2-minute duration at around noon time of totality provided an ideal opportunity to study the solar eclipse effect both on the global Sq and electrojet currents.

In Vietnam, the recording of the magnetic variations in order to study the Equatorial Electrojet's effect has been carried out at 4 magnetic stations since 1987. These stations are situated in the region with the magnetic inclination (I) between 0°N and 34°5N. During the period of the Total Solar Eclipse of October 24, 1995, two new temporary magnetic stations were installed and operated for one week at Phanthiet and Baoloc, two places directly lying under the belt of the Total Solar Eclipse.

The eclipse effect on the H component was observed only in the region of the magnetic Equator (inside the range of 400 km from the magnetic Equator): the H component started to decrease immediately with the beginning of the solar eclipse at 09.33 ÷ 09.38 LT; at the moment of the maximum Sq(H) for October 1995 the ΔH with reference to the night time base value decreased to 76-82% of the value of the normal Sq .

Ionospheric observations were carried out in Hanoi (with obscuration 0,78) by the Ionosondes IPS-71 made by KEL Aerospace Pty. Ltd. (Australia). The analyses of ionograms showed that at the beginning of the local solar eclipse, foF1, with a slightly larger value than that of the monthly median , started to gradually decrease following the decrease in local solar radiation to its minimum value around the time of local maximum occultation. After the end of the local eclipse, foF1 returned to its monthly median value.

These results suggest that the normal electric field in the Sq band was left unaffected , and the eclipse effect on the geomagnetism in the region of the magnetic Equator was due to the decrease in the ionization in the Equator.

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torial Electrojet Current.

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1. INTRODUCTION

The study of the effect of a solar eclipse on the geomagnetic field was first carried out as early as 1900 by Bauer. According to the theoretical discussion of Chapman (1933), the ideal conditions to clearly demonstrate the reduction in the geomagnetic Sq variation at the time of a solar eclipse are: a magnetically quiet day, the eclipse occurring around local noon when Sq attains its peak value, the observation site being located within the path of totality or close by and a duration of several minutes for the totality. Chapman and Bartels (1940) pointed out that partial eclipses (with 70 per cent or more of the Sun obscured at its maximum phase) were as worthwhile as total eclipses for the observation of magnetic effects on the ground. Since the Sq variations are abnormally large in the Equatorial Electrojet region as compared to those in low latitude stations situated outside the jet region, the eclipse reduction can also be expected to be quite large at the electrojet stations, even if the eclipse is not total.

The most intensive observations of the effects of an eclipse on the electrojet were done in Peru during the solar eclipse of November 12, 1966 (Giesecke *et al.*, 1968). It was found that the maximum effect of the solar eclipse at different stations in Peru was proportional to the corresponding normal Sq variation. Rastogi (1982) reviewed the observations of solar eclipse effects at low latitudes and concluded that they are distinct on the electrojet when the tracks of totality are parallel to the magnetic Equator.

A Total Solar Eclipse occurred on October 24, 1995 over the Asian sector. It started during the sunrise hours in Iraq and terminated near Indonesia during pre-sunset hours. In the territory of Vietnam, the track of the Moon's shadow passed parallel to the magnetic Equator at the distance of 300km to the South (Figure 1). The important factor is that the path of the eclipse ran obliquely to the dip Equator, therefore providing opportunity to study the effect in both the global Sq and the electrojet regions. The facts that the time of totality was around noon (about 11.20 LT) and the duration of totality was the longest in the Vietnam sector provided the ideal setting to qualify eclipse-induced changes in the magnetic field (Table 1).

2. RESULTS OF MAGNETIC OBSERVATIONS

In Vietnam, the recordings of magnetic variations so as to study Equatorial Electrojet's effect have been carried out at 4 magnetic stations since 1987. These stations are situated in the region with the magnetic inclination (I) between 0°N and 34°5N.

During one week both before and after the Total Solar Eclipse of October 24, 1995 the geomagnetic field was recorded at six stations in the territory of Vietnam : 2 new temporary stations were inside, while the other 4 regular stations were outside of the track of the Moon's shadow (Figure 2). The positions of the geomagnetic stations in Vietnam during the Total Solar Eclipse on October 24, 1995 and the time of the eclipse on the ground are shown in Table 1. At all of the magnetic stations, the variometer type Bobrov (made at the Institute of

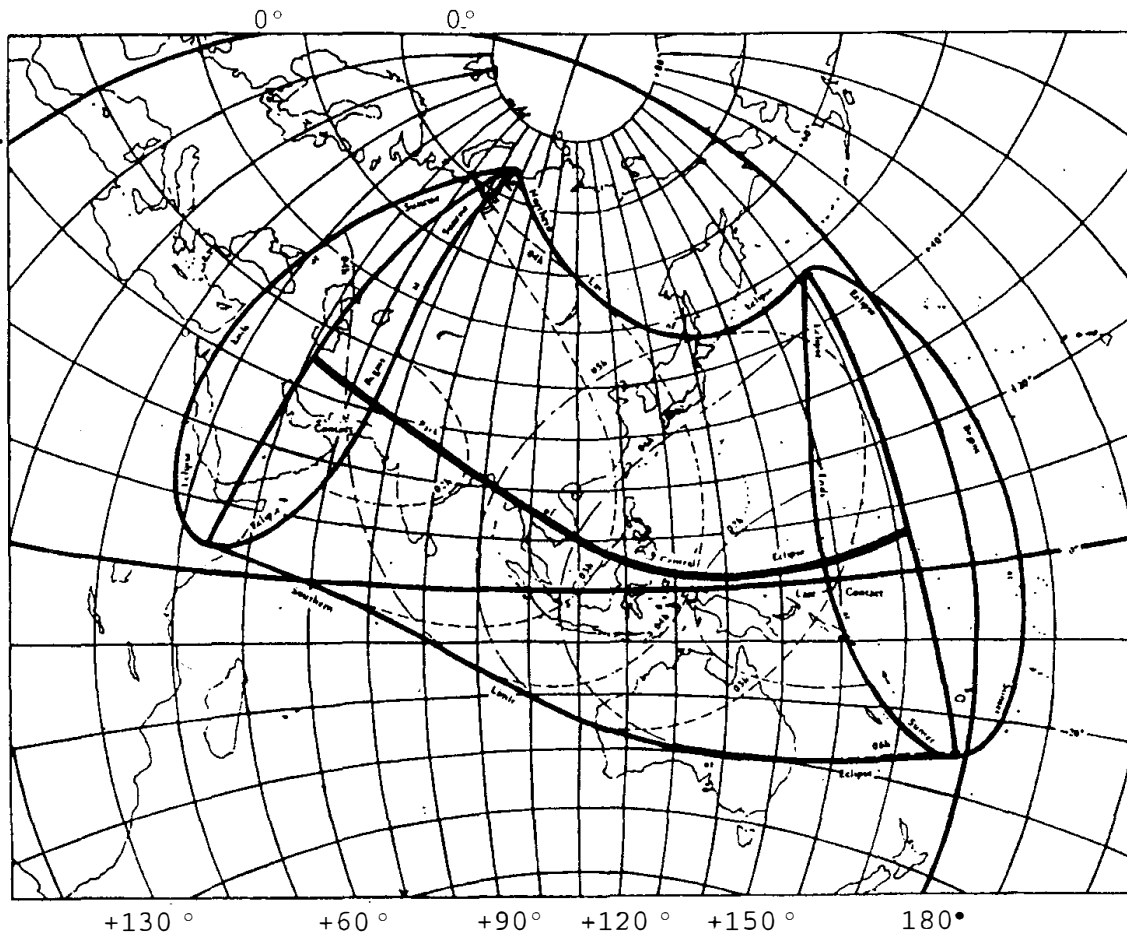


Fig. 1. Total Solar Eclipse of October 24, 1995.

Terrestrial Magnetism, Ionosphere and Radio Propagation, Moscow, Russia) with a paper speed of 20 mm/hour and sensitivity of H of about 2.5nT/mm were used to record magnetograms.

Table 1. Geomagnetic stations in Vietnam during the Total Solar Eclipse on October 24, 1995.

Observing Point	Geographic Coordinate		Dip Angle $I(^{\circ})N$	Time of Eclipse on the Ground (LT)			Percent of Obscuration
	φ	λ		Beginning h m s	Maximum h m s	Ending h m s	
Baclieu	09 ^o 17'48"	105 ^o 44'48"	2.2	09 33 30	11 08 00	12 49 39	97%
Phanthiet	10 ^o 56'13"	108 ^o 05'15"	7.4	09 38 02	11 14 04	12 55 08	100%
Baoloc	11 ^o 24'40"	107 ^o 37'30"	8.0	09 38 03	11 14 06	12 55 09	100%
Dalat	11 ^o 56'30"	108 ^o 28'42"	9.6	09 37 09	11 13 09	12 54 07	98%
Phuthuy	21 ^o 01'40"	105 ^o 57'04"	31.6	09 27 09	10 56 08	12 32 04	78%
Chapa	22 ^o 02'00"	103 ^o 50'00"	34.6	09 25 56	10 52 47	12 28 21	77%

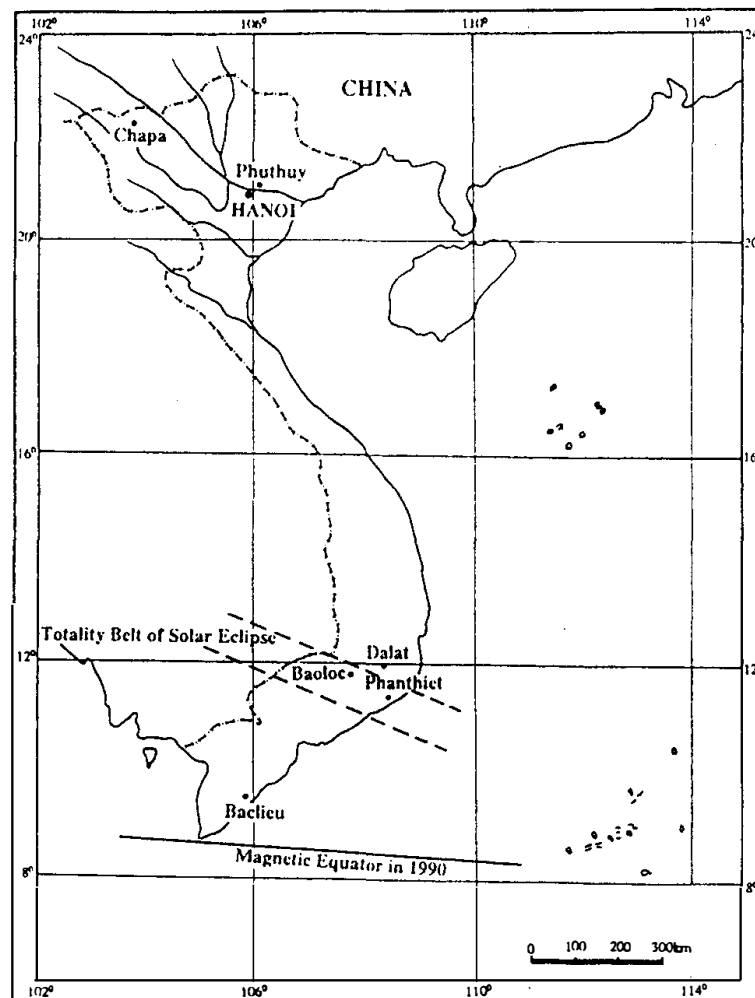


Fig. 2. Map of Vietnam showing the location of the 6 magnetic stations, the track of the Moon's shadow and the magnetic Equator.

The day of October 24, 1995 was almost a magnetically quiet day ($\sum K_p=16$ and $\sum A_p=10$).

The mean quiet day variations in the H-component during October 1995 in the geomagnetic stations in Vietnam are shown in Figure 3. When compared with the magnetograms of every magnetic station of 24 October, 1995 with the mean of the quiet day variations in the H-component for October 1995 from the same stations, it is interesting to note the following variations in the behavior in the region within the distance of 400 km from the magnetic Equator and those in the region farther to the north of Vietnam at more than 1400 km from the magnetic Equator (see Figure 2).

In the first region (between the totality belt of the solar eclipse and the magnetic Equator) the maximum of the Sq(H) reaches 11.20 LT (see Figure 3) for the magnetic stations Baclieu and Dalat. On the magnetograms of October 24, 1995 the H component starts to decrease immediately when the solar eclipse begins (at 09.33 or 09.38LT). The maximum eclipse occultation occurs near the time of the maximum of the Sq(H) (Table 1). It is found that at the

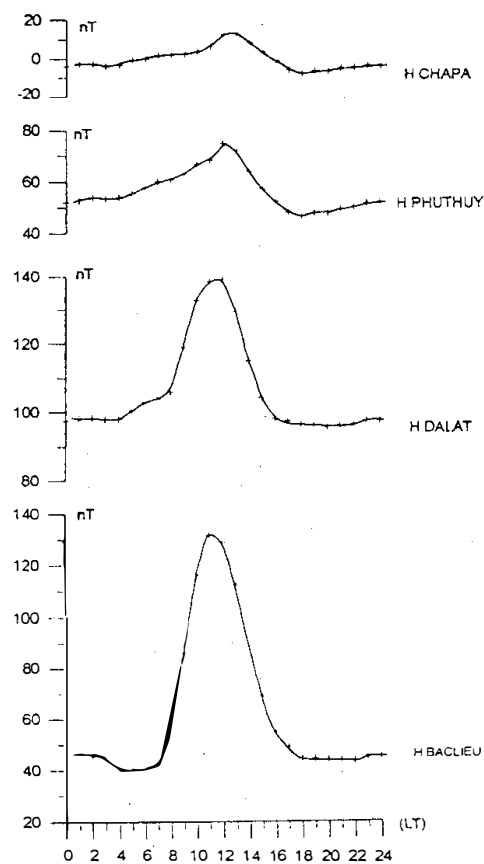


Fig. 3. Average solar quiet day variations in the H component for October 1995 for 4 magnetic stations in Vietnam.

moment of the maximum Sq(H) for October, 1995, the ΔH with reference to the night time base value decreases to 76% of the normal Sq for the Phanthiet magnetic station in the track of the Moon's shadow (Figure 4a). The same decrease is observed for the second station at Baoloc in the belt of the Total Solar Eclipse. But for the station of Baclieu (Figure 2) which is situated under the influence of the equatorial electrojet belt (Dip=2°2N) ΔH with reference to the night time base value decreases to only 82% of the normal Sq value for October, 1995 (Figure 4b).

For the second region (far to the north of Vietnam, outside the influence of the Equatorial Electrojet), the maximum Sq(H) for October 1995 reaches at 12.00 LT as usual (Nguyen Thi Kim Thoa *et al.*, 1990). On the other hand, on the magnetograms of October 24, 1995, a similar eclipse effect is not found either at the stations of Phuthuy or Chapa.

Figure 5 shows the variations in the normal Sq (H) as well as the maximum eclipse effect on the H component at 4 stations in the region of the magnetic Equator during the Solar Eclipse on October 24, 1995. It is worth noting that the variations in both these parameters at the distance from the centre of the magnetic Equator are very similar to each other. Furthermore, the ΔH due to the eclipse has a linear relation with the ΔH due to the Sq current (Fig.5).

The above results confirm the suggestion of Rastogi (1982) that the normal electric field in the Sq band remained unaffected, and the eclipse effect on the geomagnetic field in the

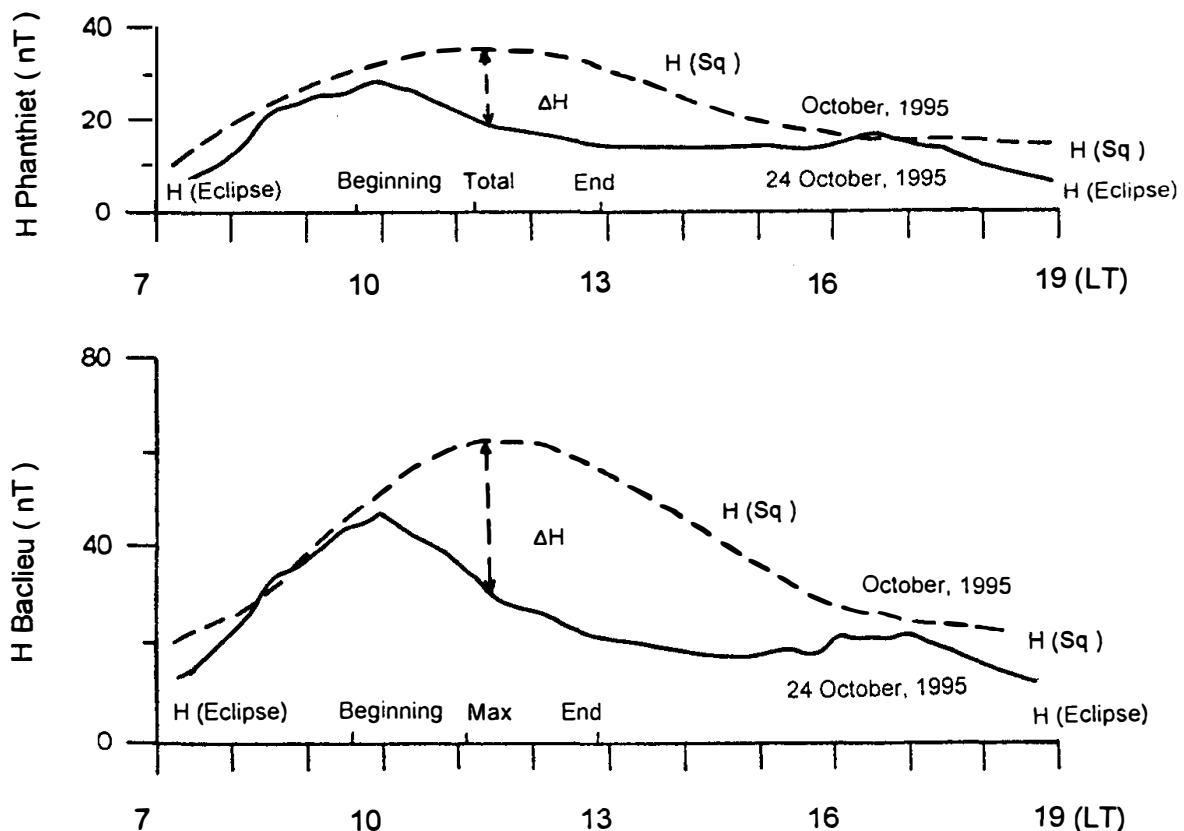


Fig. 4. Variations in the horizontal geomagnetic field due to the eclipse of October 24, 1995 in comparison with the average solar quiet day for October 1995 at Phanthiet (in the center of the totality belt) and Bac Lieu (near the magnetic Equator).

region of the magnetic Equator was due to the decrease in the ionization in the Equatorial Electrojet Current.

3. RESULTS OF IONOSPHERIC OBSERVATIONS

It is known from radio observations that during a solar eclipse the ionization of the E, F1 and F2 layers is reduced (Chapman, 1962). In this study, the ionospheric observation was carried out at Hanoi ($\phi = 21^{\circ}02'N$, $\lambda = 105^{\circ}58'E$ dip= $31^{\circ}6'N$). The maximum percentage of obscuration (78%) of the solar disc occurs at 10.57LT as seen from Hanoi on the eclipse day, October 24, 1995. The digital ionosonde system IPS-71 was operated continuously every 2 minutes during October 1995. The important ionospheric parameters foF2, foF1 and h'F1, h'F2 were scaled from the ionograms of the eclipse day (24th October 1995) and of the control days (23th and 25th October 1995).

The Eclipse of October 24, 1995 at Hanoi begins at 09.28 LT, reaching a peak of 78% at 10.57 LT and ending at 12.32LT. It is found that because of strong absorption and sporadic E, the value of foE is not worth noting due to its lack of reliability.

The two-minute value of foF1 and foF2 as a function of local time from 08.00 LT to 14.00LT on the eclipse day (October 24, 1995) and control days (October 23 and 25, 1995) are

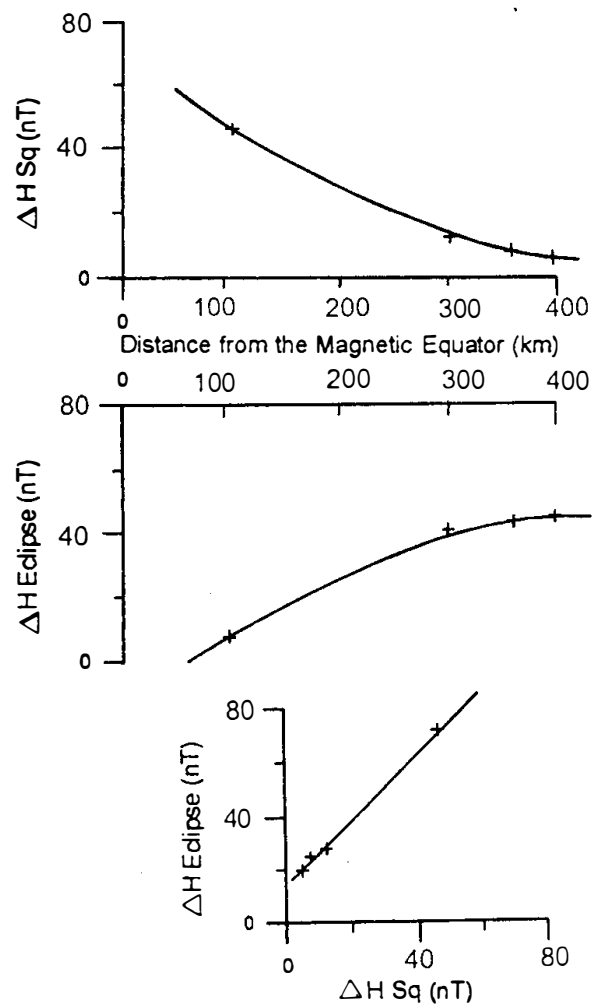


Fig. 5. Latitudinal variation in the normal Sq(H) and the maximum solar eclipse effect on the horizontal geomagnetic component at the magnetic stations in Vietnam during the Total Solar Eclipse of October 24, 1995. The linear relation between the ΔH due to the eclipse and the ΔH due to normal Sq is also shown.

presented in Figure 6a, 6b. One can see that at the local solar eclipse, foF1 starts to gradually decrease following the decrease in the local solar radiation to its minimum value around the time of maximum occultation and recovers gradually following the recovery of local solar radiation (Figure 6a).

From Figure 6b, foF2 continues to increase after the start of the local eclipse as the case of two control days until 30 minutes before the maximum occultation at Hanoi, when foF2 reaches the stable value. Afterward, foF2 maintains a stable value until one hour before the end of the eclipse.

The variation of h'F2 and h'F1 as a function of local time from 08.00 to 14.00LT on the solar eclipse day October 24, 1995 and control day of October 23 and 25, 1995 are presented in Figure 7. No reliable effect on h'F1 is observed, but in h'F2 the decrease of about 25 to 45 km in comparison with control days (23th October and 25th October) at the moment near the

maximum occultation is noted.

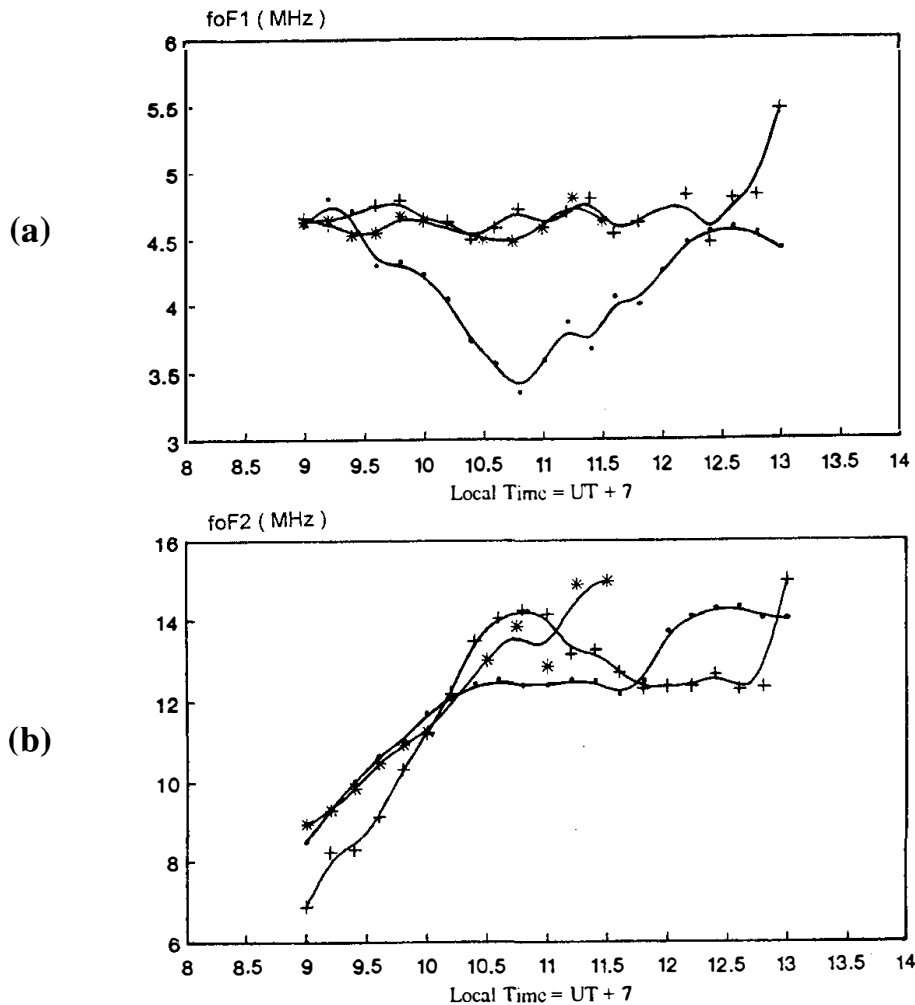


Fig. 6. Variation of foF2 and foF1 at Hanoi on eclipse and control days.

4. CONCLUSIONS

1. In the Vietnam sector, the Total Solar Eclipse of October 24, 1995 provided an ideal opportunity for the observation of the eclipse effect on the geomagnetic field: a magnetically quiet day, with the eclipse occurring around local noon for a duration of about 2 minutes and the track of Moon's shadow passing parallel to the magnetic Equator.
2. The eclipse effect on the geomagnetic field was observed only in the region of magnetic Equator (within the distance of 400km from the magnetic Equator): the ΔH due to the eclipse had a linear relation with ΔH due to the Sq current.
3. At the local solar eclipse at Hanoi (obscuration 78%), foF1 changed in the same way as that of the local solar radiation.
4. These new results confirm the suggestion of Rastogi (1982) that the normal electric field in the Sq band remained unaffected, and the eclipse effect on geomagnetism in the region of

the magnetic Equator was due to the decrease in the ionization in the Equatorial Electrojet Current.

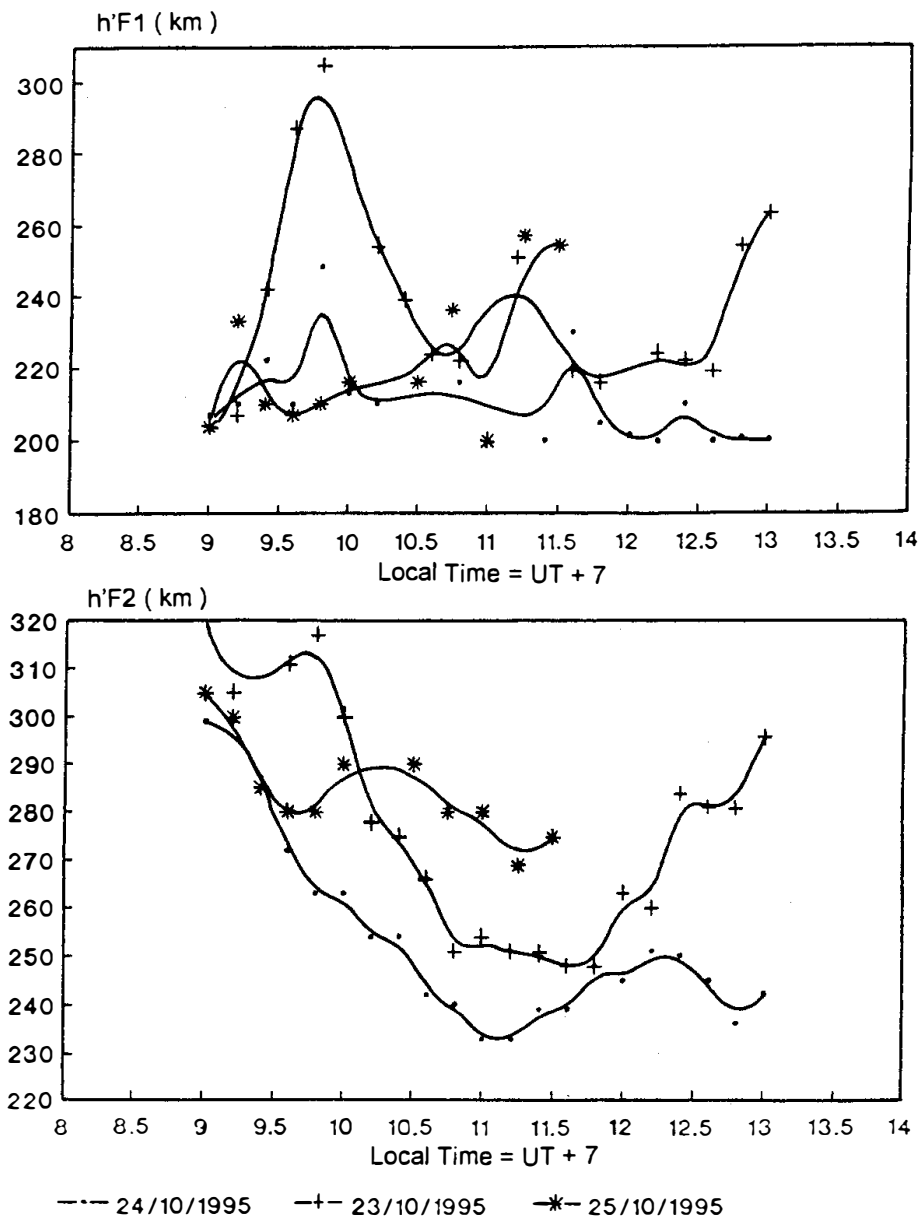


Fig. 7. Variation in h'F2 and h'F1 at Hanoi on eclipse and control days.

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