PROPOSED INDO-SOVIET COLLABORATIVE STUDIES BASED ON THE DATA ALONG THE GEOMAGNETIC MERIDIAN 145°

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SUMMARY

A few examples are presented to demonstrate a close association in the geomagnetic fluctuations between the equatorial and auroral latitudes. They are chosen from the records obtained at a chain of stations spread over the latitudes from the dip equator to the auroral region in the longitude zone centred on 145° geomagnetic meridian. Indo-Soviet collaborative studies with the data along this meridian are suggested for investigating the possible coupling processes and mechanisms responsible for the origin of these fluctuations.

INTRODUCTION

It has been increasingly realized in recent decades that the geomagnetic phenomena in the equatorial and auroral regions are linked with each other through the ionosphere-magnetosphere coupling controlled by the interaction of solar wind with the magnetosphere. Measurements of the geomagnetic field variations on the ground level with specially organized networks, and in the space at different altitudes and on a variety of orbits, lead us to the conclusion of the global scale of the processes, as the geomagnetic storms have to be. But still there are many questions (controversies) concerning the local features and the fine as well as coarse structures in the geomagnetic variations. For a better understanding of the whole process described as the magnetospheric storm, research in the ionospheric and magnetospheric field perturbations in the high latitudes has to be complemented with parallel endeavour at the equatorial and low latitudes.

The pioneering work of Egedal[1], Chapman[2] and others established the existence of the equatorial electrojet. Initially, the geomagnetic data at low latitudes were studied for the regular solar and lunar daily variations[3-5]. Later it was shown that the auroral electrojet can greatly enhance the equatorial electrojet current[6]. In direct probing[7], it was found that the equatorial electrojet consisted of at least two layers of electric current: one near an altitude of 100 km and the other, 20 to 25 km higher, with a width of more than 300 km. The ground-based measurements of the geomagnetic and ionospheric parameters at low latitudes in India led to the inference of simultaneous existence of the two currents, one due to the solar dynamo and the other due to magnetospheric processes generating the polar substorms[8].

As is well-known now[9], in the high latitudes we have three ionospheric sources of magnetic activity: the westward electrojet, the eastward electrojet and the polar cap agitation. Each of these is related to magnetospheric processes taking place respectively in the tail, in the partial ring current and in the cusp and/or the boundary layer. The ring current and the boundary layer sources can also affect the low-latitude field directly. The links between the equatorial and polar geomagnetic variations are not easy to comprehend; besides, it has been stressed that a part of the geomagnetic storm phenomena in daytime near the dip equator is in the ionosphere and is associated with the polar substorms[10].

Considerable evidence is now available for a strong influence of solar wind and IMF (interplanetary magnetic field) conditions on the geomagnetic activity. It has been found that the

B_z-component of IMF controls the polar geomagnetic disturbances[11] and later the B_y-component control was shown to exist over the polar cap as the Svalgaard-Mansurov effect. Indian scientists inferred an IMF control for the counter-electrojet appearance[12] and also for the entire geomagnetic field changes at the low latitudes[13,14].

All the above mentioned discoveries in the geomagnetic pheonomena basically were made with extensive use of the ground-based data. The purpose of the present article is to present some background views on the problems related to ground-based co-ordinated observations along one geomagnetic meridian and to demonstrate what sort of data we can use as a tool for research and what type of research can be done in the near future.

DATA BASE FOR GEOMAGNETIC MERIDIAN 145°

In 1973, the International Association of Geomagnetism and Aeronomy (IAGA) established a Working Group on the Geomagnetic Meridian Project to evaluate the need for improved magnetometer networks at high latitudes. The main recommendation of this Working Group was along the 145° meridian which covered the latitudes from the polar cap to the equator and stretched across the Soviet Union and India. The chain of magnetometers was successfully operated from 1 November 1973 and included more than 30 sites of permanent observations. Later the operations were continued during the International Magnetospheric Study 1976–77 (IMS); and other magnetometer chains along a few other meridians were also in operation during 1977–1980[15]. As of today, the stations for the 145° geomagnetic meridian are listed in table 1 and their locations are presented in figure 1.

Future co-operation between India and the USSR is planned to include three main subjects; (i) improvements in the observatory techniques by utilisation of quartz magnetic sensors and incorporation of digital systems; (ii) co-operation in the data handling, processing, and software support for computer systems; (iii) co-operative studies of geomagnetic phenomena, scientific analysis and joint publications. All these can be broadly classified as: "Indo-Soviet Collaborative Geomagnetic Studies".

In general, the tasks for scientific study (analysis) can be categorised into five parts: (i) to evaluate the quantitative distribution of variations for separate events connected with the three different sources which operate in high latitude ionosphere; (ii) to determine the features of low-latitude events which are of ionospheric and magnetospheric origin; (iii) to develop new methods for analysis of ground-based data in the form of numerical modelling and computer simulation; (iv) to search for the characteristics of separate events in the ionospheric currents along the 145° meridian consistent with satellite magnetic data; and (v) to improve and/or define more precisely the physical models of ionospheric and magnetospheric currents which would make this study valuable.

COMPARISON OF STORM MAGNETOGRAMS

In this article we make a preliminary attempt to begin work on the first aspect in the programme. We looked through the 1978 data collected by the Indian (low-latitude) and the Soviet (high-latitude) stations and have selected 14 events covering all local hours so that the influence of all high-latitude sources can be identified precisely. An attempt has been made to search:

- the development of westward electrojet and its appearance at low latitudes for evening-local night hours;
- the geomagnetic disturbances in the late morning and day hours which are fairly well seen in low latitudes; and
- the eastward electrojet appearance and its relation with the low latitudes.

The first approach is to stack magnetograms from different stations in a common format for each component for the duration of the event as proposed in (16).

Let us consider a typical polar substorm event which took place on 12 October 1978. In figure 2 the stacked magnetograms plots for H and Z

Table 1 *List of observatories along Indo-USSR longitude zone*

	Station Name	CODE	Geographic Lat.	Geographic E. Long	Geomagnetic Lat.	Geomagnetic E. Long
1.	Trivandrum	TRD	8 5	77.0	−1.1	147.8
2.	Ettayapuram	ETT	9.2	78.0	−0 7	148.8
3.	Kodaikanal	KOD	10.2	77.5	0.6	148.4
4.	Annamalainagar	ANN	11.2	79.4	1.4	150.4
5.	Hyderabad	HYB	17.4	78 6	10.5	148 8
6.	Alibag	ABG	18 4	72 5	11.8	142.7
7.	Ujjain	UJJ	23.0	75.8	17.0	146 0
8.	Shillong	SHL	25.6	91.9	19.5	163.8
9.	Jaipur	JAI	26.9	75 8	21.4	146.0
10.	Sabhawala	SAB	30.3	77.8	25.2	148.0
11.	Gulmarg	GUL	34.0	74 4	28.0	146.2
12.	Ashkhabad	ASH	38.0	58.1	33.4	128.1
13.	Tashkent	TKT	41.3	69.6	37.2	139.6
14.	Alma-Ata	AAA	43.2	76.9	39 2	146.9
15.	Karaganda	KGD	49.8	73.1	46.0	143.3
16.	Novosibirsk	NVS	55.0	82.9	51.2	153.4
17.	Tevris	TEV	57.5	72.4	53.6	143.3
18.	Ugut	UGT	61.0	74.0	57.0	145.4
19.	Numto	NMT	63.5	71 4	59 2	143.5
20.	Nyda	NDA	66.6	73.0	62.1	145.8
21.	Yar-Sale		67.0	71.0	62.5	144.1
22.	Cape Kamenniy	CKA	68 5	73 6	63.8	146.9
23.	Amderma	AMD	69.5	61.4	64.8	136.9
24.	Skeykha	SEY	70.1	72 6	65.3	146.5
25.	Kharassovei	KHS	71 1	66.8	66.3	142.2
26.	Tambey	TMB	71.5	71.8	64.6	146.5
27.	Maliye Karmakuly	MKL	72.3	52 5	67 8	131.6
28.	Beliy Island	BEY	73.3	70.0	68.2	145.9
29.	Dixon Island	DIK	73.6	80.6	68.3	154.7
30.	Cape Zhelania	CZA	77 0	68 6	71.5	147.4
31.	Heiss Island	HIS	80 6	58.0	74.8	144.5
32.	Cape Chelyuskin	CCS	77.7	104.3	71 6	174 2

Note: Geomagnetic coordinates corresponding the Gusstaffsson's model from (17).

components are presented. On the right side, the scales in nT are given. Figure 2 demonstrates the development of a polar substorm along the same meridian in the auroral and equatorial latitudes.

Preliminary phase of the substorm began after 1300 UT with small positive impulses in H-component, which is very well observed in the auroral zone and at the Indian stations. Furthermore, the decrease in the H-component at low latitudes continued, which corresponds to the preliminary stage of the substorm growth during which the storage of energy in the ring current due to the injection of particles continued. Around 1432 UT the break-up was observed at which stage very sharp gradients in the geomagnetic field are seen at high latitudes from 1432 to 1530 UT and the Ps6 fluctuations are also observed during this period. The recovery phase then began and the quiet level appeared at about 1630 UT. All the signatures of the substorm development are also reflected on the low-latitude magnetograms. The entire period of the substorm from 1330 to 1630 UT is seen fairly well. In accordance with the eastward electrojet development a smooth depression in the H-component is observed at low latitudes. During the explosive phase when strong discrete westward electroject appears, a well-defined positive bay from 1432 to 1530 UT is seen at low latitudes.

For each of the auroral electrojets there appears to be a current flowing through low

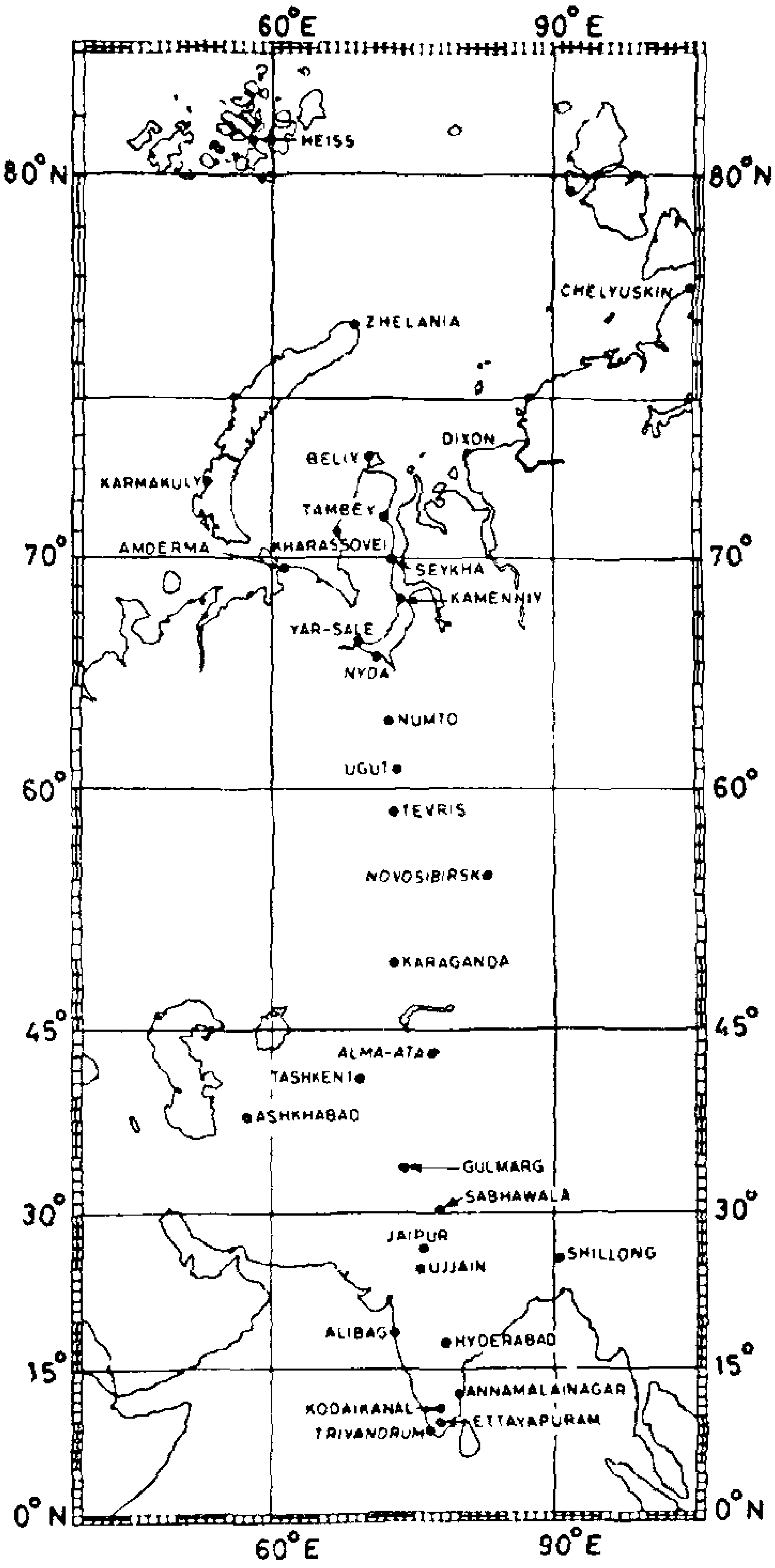

Figure 1. Map showing the locations of Indian and Soviet magnetometer stations in the 145° geomagnetic meridian zone.

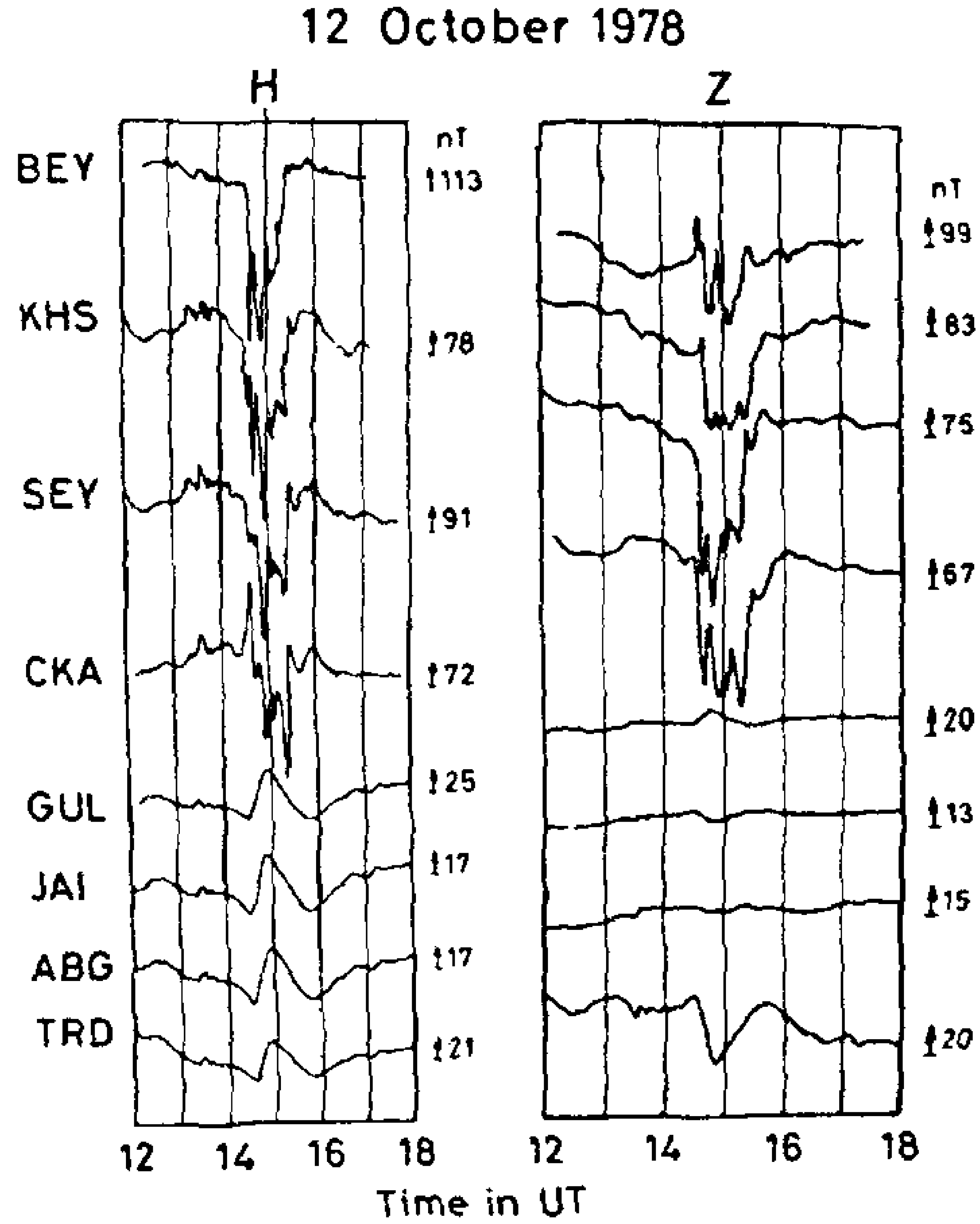

Figure 2. Magnetospheric substorm event of 12 October 1978. The length of the arrow for each station gives the scale factor.

latitudes in one cell pattern, so that the sign of H-component variation is in accordance with such simple current model. The Z-component variation gives the position of the electrojet at high latitudes and sets the limit of the vortex current pattern at low latitudes. This type of events, presented in figure 2, are quite often observable along the geomagnetic meridian. Few selected events listed in table 2 when analysed can confirm precisely the pattern for this type of substorms.

It may be stated that, at both high and low latitudes, such events which are observed between 1900 and 0800 local time do not show any season dependence and they are very likely the manifestation of burst-type substorm under UT-control.

The events developed during local evening hours are different. An example is presented in figure 3. The definitions are the same as before. The continuous activity has a prominent increase which took place from 1150 to 1500 UT. At the auroral stations, the Ps6 pulsations are very well observed. The strong depression in the H-component has the same phase at the equatorial stations. Thus, besides the ionospheric currents, one can see very well-developed ring current effects. Along the geomagnetic meridian such events demonstrate the influence of two current effects of the magnetospheric substorms. If we

Table 2 *List of events during 1978 selected for the task study*

	Day of events	UT	MLT	Type of deviation of the events
1	12 October	14 00	19 00	The burst type substorm,
2	10 February	18.15	23.00	the one-cell pattern
3	12 February	21.35	03.00	current system in low
4	18 February	17.40	23.00	latitudes without
5	19 February	20.15	01.00	intensification on
6	26 March	02.40	08.00	dip equator
7	18 April	02.30	08 00	
8	4 August	19.15	24.00	
9	1 May	12.00	17 00	The continuous disturbances with ionospheric and
10	1 September	14.30	20.00	magnetospheric origin
11	12 August	09.30	15.00	The eastward electrojet
12	9 March	11.00	16.00	appearance the one-cell
13	19 June	10.00	15.00	pattern
14	22 June	10.30	16.00	

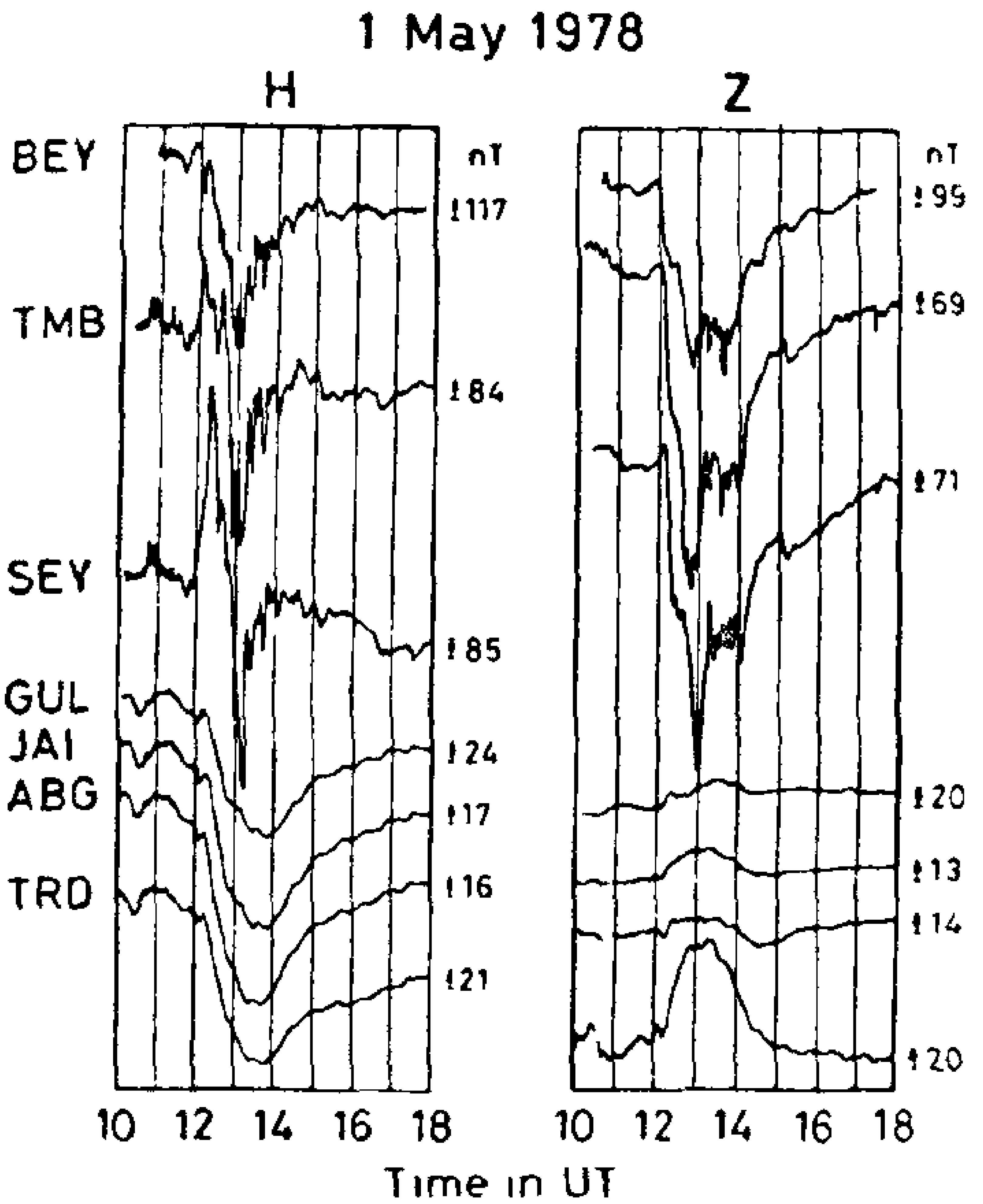

Figure 3. Magnetospheric substorm event of 1 May 1978, developing during local evening hours. Format same as for figure 2.

can carefully observe some minor changes in low latitudes, fluctuations in accordance with Ps6 can be inferred. The main features of substorm development such as the commencement at 1150 UT, the maximum at 1340 UT and the recovery phase after 1500 UT are noticed on the auroral and low latitudes stations very well. From such particular events, we can conclude that the influence of polar electrojet, shielded by the ring current, may strongly affect the field at both latitudes.

An example of the afternoon events is shown in figure 4, a typical manifestation of eastward electrojet at high latitudes. In the equatorial latitudes, a wide depression superposed with small scale features is observed. The positive burst near 0730 UT is probably due to magnetospheric currents. But the main pattern for such cases looks very simple—the increased intensity of the eastward electrojet in the auroral zone leads to the decreasing field at low latitudes. So, again, only one cell current system spreads along the same geomagnetic meridian.

The summary for this task study will confirm that the low-latitude events show the influence from different sources:

— auroral electrojets westward (DPW) and eastward (DPE))
— ring current (DR)
— currents on the surface of the magnetosphere (DCF).

Thus disturbances (D) in low latitudes may be

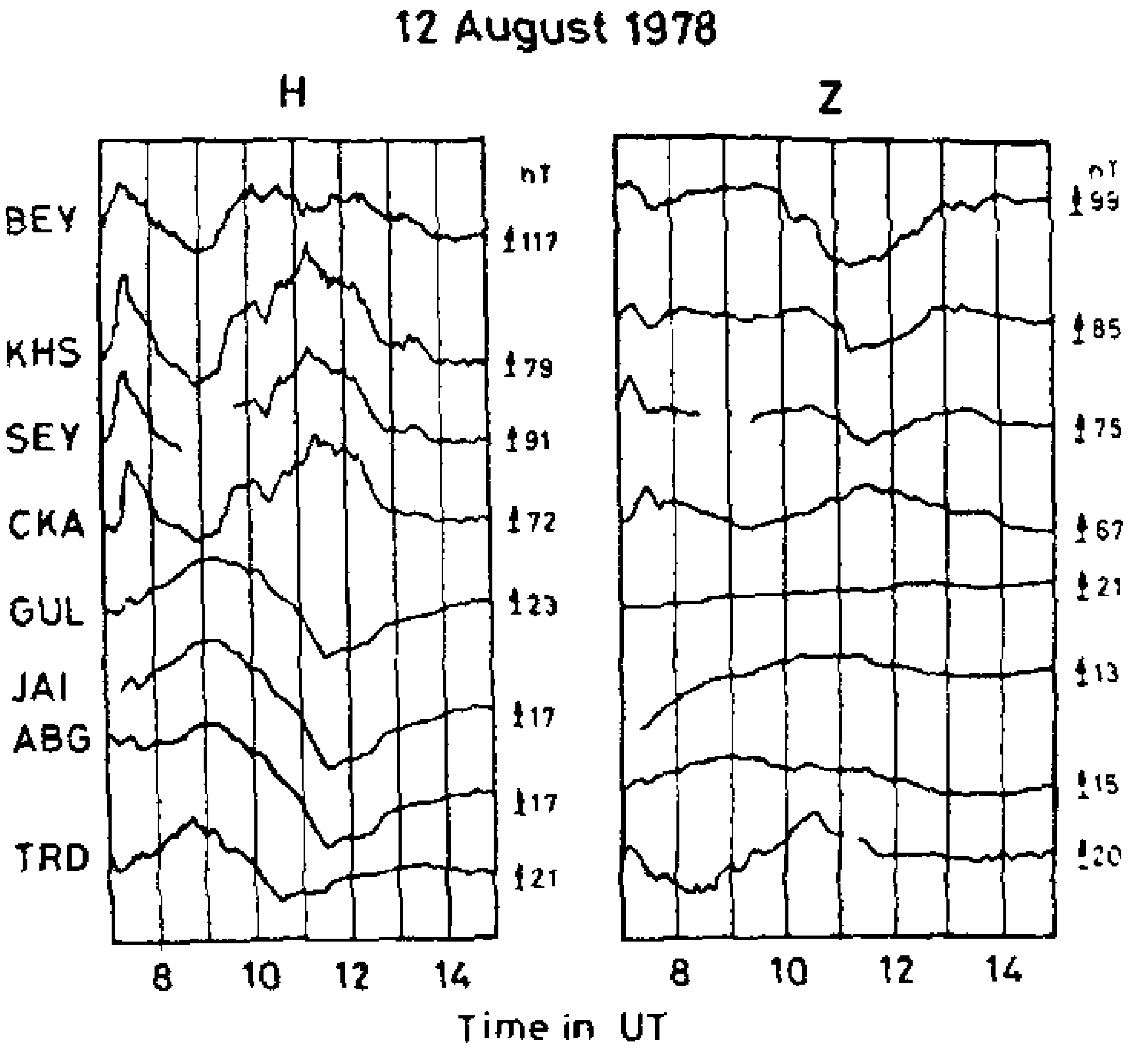

Figure 4. Magnetospheric substorm event of 12 August 1978, developing during afternoon hours. Format same as for figure 2.

considered as a sum:

$$D = DPW + DPE + DR + DCF.$$

According to the Indo-Soviet geomagnetic meridian 145° data base, we can choose events with any perferable source, so that each source can be studied in great detail. Another clue lies in their simultaneous appearance which can be studied after a systematic search of separate events and their association with magnetospheric changes.

15 April 1985

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