Polarization of Long Period Geomagnetic Pulsation, pc 5

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Polarization of the Long Period Geomagnetic Pulsation, pc 5

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Abstract

The sense of the rotation of the vector diagram of the long period geomagnetic pulsation, pc 5 (the period is 150 sec–600 sec), which is observed in high latitude geomagnetic observatories, is studied.

It is found that the sense of the rotation of the vector diagram of these pulsations is counterclockwise when these pulsations occur before the local noon of the station, on the other hand, the sense of the rotation is clockwise when these pulsations occur after the local noon.

These characters are very distinct at College and Sitka, while these characters are clear at Point Barrow only when it is magnetically quiet days ($K_p=0,1$ and 2).

These long period puslations are considered as the isotropic hydromagnetic oscillation excited at the external boundary of the exosphere by the fluctuation of the solar wind and converted to the transverse mode of the hydromagnetic wave along the line of force of the geomagnetic field. Therefore these characters show the mechanism of the excitation of the hydromagnetic disturbance at the boundary of the exosphere and these characters are explained if we consider the isotropic hydromagnetic oscillations caused by the periodic external stress due to the fluctuation of the solar wind.

Introduction

Dungey, Kato (one of the present authors) and other scientists investigated already the characters of the geomagnetic micropulsations as the hydromagnetic oscillations in the magnetosphere.

There are long period pulsations which are observed mainly at the high latitude region as already reported by Kato [1] and others. [Fig. 1] In this paper, the authors studied the characters of the sense of the rotation of the vector diagram of these long period pulsations, pc 5's (pc 5 is new notation of the long period geomagnetic pulsation which is resolved in the general assembly of IAGA at Berkeley, 1963).

IAGA Resolutions (Berkeley General Assembly, 1963)

On account of experimental knowledge obtained since the IGY, IAGA recognizes the need of improving the present classification of puslations. Pulsations fall into main classes: those of a regular, and mainly continuous character, and those with an irregular pattern.

The first class, for which the name pc is retained, covers the whole range of pulsations (0.2–600 sec). This class is provisionally divided into five sub-groups.

pc 1 : 0.5 to 5 sec.
pc 2 : 5 to 10 sec.
pc 3 : 10 to 45 sec.
pc 4 : 45 to 150 sec.
pc 5 : 150 to 600 sec.

The second class of puslation is characterized by their irregular form, their close connection with disturbances of the magnetic field and their correlation with upper atmospheric phenomena. This class is provisionaly divided into two sub-groups covering different frequency ranges.

pi 1 : 1 to 40 sec.
pi 2 : (primarily pt) 40 to 150 sec.

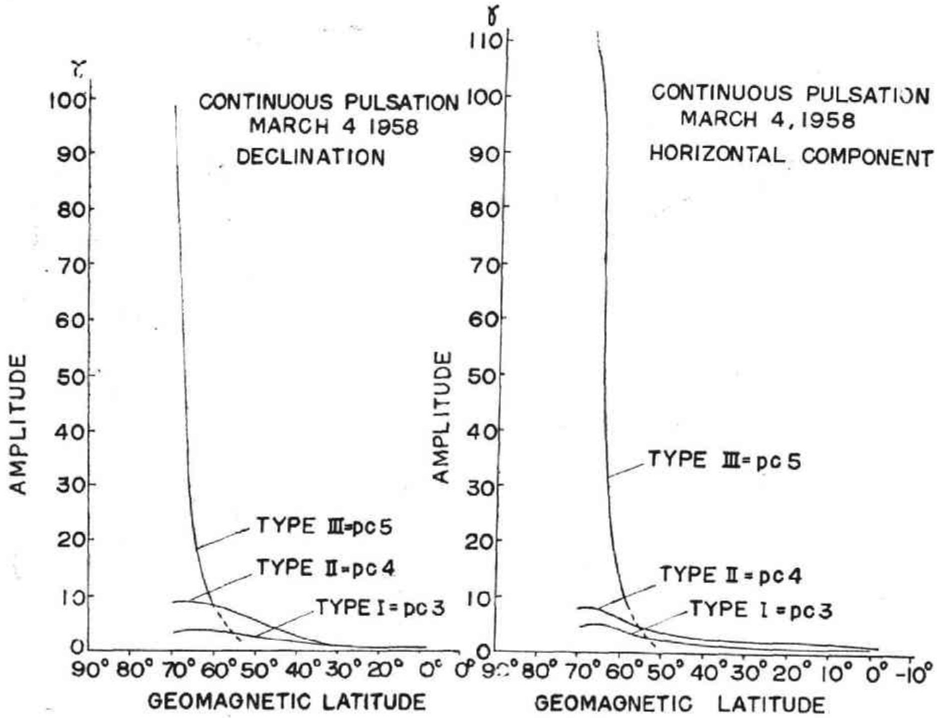

Fig 1. The latitudinal dependence of the amplitude of continuous pulsations.

On the characters of the sense of the rotation of the vector diagram of the geomagnetic micropulsation, Wilson and Sugiura [2] studied the sense of the rotation of the geomagnetic pulsation accompanying the ssc (sudden commencement of magnetic storm) and they found that the sense of the rotation is counterclockwise when it occurs before the local noon and clockwise when it occurs after the local noon and they concluded that these characters were explained as the hydromagnetic wave excited by the azimuthal stress at the boundary of the exosphere when the hydromagnetic shock passed the external boundary of the exosphere.

In this present paper, the authors studied the sense of the rotation of the vector diagram of pc 5 which observed at Point Barrow, College and Sitka using the rapid-run magnetograms obtained during IGY.

It is found that the sense of the rotation is countercloskiwse when these puslations occur before the local noon and clockwise when these pulsations occur after the local noon.

These characters are very clear at College and Sitka, while at Point Barrow, these characters are clear only when it is magnetically quiet days.

Table I

Station	Geographic		Geomagnetic	
	Latitude, Longitude		Latitude, Longitude	
Point Barrow	71°18′N	156°46′W	68°. 6	241°.0
College	64°51′N	147°50′W	64°. 7	256°.5
Sitka	57°03′N	135°20′W	60°. 0	275°.4

Observational facts

We used the records of pc 5 which observed at Point Barrow, College and Sitka during IGY and picked up 190 numbers of pc 5 in the period from July 1957 to June 1958 (Table II).

Fig. 2(a, b, c, d, e and f) show the examples of these long period pulsations, pc 5's. The period is about 250 sec–500 sec and the amplitude of these pulsation is depends strictly on the latitude of the station. Uning these magnetograms we discribed the vector diagram of these puslations.

Fig. 3 (a, b, c, d, e and f) show the examples of these diagrams. As the figures show, it is very clear that the sense of the rotation of the vector diagram at College is countecrlockwise for the pulsations which occur before the local noon at the station and clockwise for the pulsations which occur after the local noon.

At Sitka, these characters are also clear, and at Point Barrow these characters are clear only for the pulsations which occur on the magnetically rather quiet days (K_p=0, 1 and 2).

Fig. 4 shows the distributions of the pulsations for the local time classifying these characters of the sense of the rotation of the pc 5 observed during one year.

Table III shows the percentage of the occurrence frequency of each sense of rotation.

Table III

Station	Counterclockwise sense		Clockwise sense	
	before noon	afternoon	before noon	afternoon
Point Barrow	61.4%	38.6%	26.3%	73.7%
College	80.6%	19.4%	1.8%	98.2%
Sitka	80.0%	20.0%	2.6%	97.4%

While we picked up the pulsations which are observed on magnetically quiet days (K_p=0, 1 and 2) and examined the direction of the sense of the rotation for the local time and found that even at Point Barrow the sense of the rotation is counterclockwise on before noon and clockwise on afternoon, that is the character becomes clear.

Table II. List of the pc 5

No.	GMT	Date	No.	GMT	Date	No.	GMT	Date
1	0330	July 2 1957	66	1855	Oct. 18 1957	131	2050	Mar. 13 1958
2	2335	2	67	1505	19	132	0725	14
3	1640	4	68	1945	19	133	1825	14
4	1835	5	69	0430	21	134	2055	14
5	0340	6	70	1825	21	135	0100	15
6	0445	10	71	0440	22	136	0120	19
7	0755	12	72	0515	23	137	0130	20
8	0030	15	73	1825	23	138	0500	22
9	0225	15	74	2355	23	139	0735	26
10	0640	21	75	0530	24	140	0550	27
11	0250	24	76	1830	25	141	1720	29
12	0640	24	77	1455	26	142	1820	Apr. 2 1958
13	0620	27	78	1900	26	143	0150	4
14	0225	28	79	1655	29	144	1940	6
15	1635	28	80	1940	30	145	0305	8
16	0700	Aug. 3 1957	81	1750	31	146	0025	9
17	2025	3	82	2040	Nov. 3 1957	147	1715	9
18	0720	4	83	1340	5	148	0910	10
19	0245	6	84	1900	7	149	2220	10
20	0335	9	85	2320	9	150	0450	11
21	1930	9	86	1745	10	151	1735	13
22	0520	10	87	1927	12	152	2300	13
23	0520	11	88	1900	13	153	1855	24
24	2020	14	89	1142	14	154	0510	27
25	0615	15	90	0315	16	155	1920	29
26	2140	15	91	0131	24	156	1720	May 2 1958
27	1750	16	92	1900	24	157	2150	3
28	0510	17	93	0515	29	158	0305	5
29	1710	17	94	1905	29	159	0155	6
30	1810	23	95	1845	Dec. 1 1957	160	1815	7
31	0115	24	96	2140	2	161	0425	8
32	0420	25	97	2134	6	162	1325	8
33	1430	25	98	1600	7	163	1735	8
34	2005	25	99	0250	8	164	2320	8
35	2210	25	100	2000	8	165	2235	9
36	1850	30	101	0155	13	166	0430	10
37	1925	30	102	1930	13	167	0555	12
38	1915	Sept. 1 1957	103	0600	15	168	0650	13
39	2230	3	104	1855	15	169	0315	19
40	1317	4	105	0200	16	170	0305	22
41	1530	5	106	1505	17	171	0230	23
42	0050	6	107	0455	18	172	2235	26
38	1905	7	108	1850	24	173	1635	27
44	1725	8	109	0345	Jan. 1 1958	174	2335	29
45	0245	9	110	1615	11	175	1200	June 3 1958
46	0318	14	111	1635	12	176	0210	4
47	1833	16	112	1815	15	177	0405	4
48	1953	17	113	2005	20	178	1630	4
49	0420	19	114	1510	21	179	1610	7
50	0712	24	115	1625	21	180	0135	8
51	0135	26	116	1735	27	181	0505	18
52	0325	26	117	1930	27	182	2125	18
53	0755	30	118	1700	28	183	0450	19
54	0655	Oct. 1 1957	119	0710	30	184	0210	20
55	1650	1	120	0445	Feb. 4 1958	185	1630	20
56	0550	2	121	0245	13	186	0030	21
57	1740	2	122	0155	19	187	2040	24
58	0345	3	123	1730	20	188	2340	26
59	0525	3	124	1725	22	189	0200	30
60	0450	4	125	1950	23	190	0905	30
61	1256	4	126	1750	26			
62	0335	5	127	1945	26			
63	2053	11	128	2130	27			
64	1435	16	129	1700	Mar. 9 1958			
65	1830	16	130	0435	11			

Fig. 5 shows the distributions of the puslations for the local time, showing the character of the sense of the rotation.

Table IV shows the percentage of above mentioned distribution of the character.

Table IV

Station	Counterclockwise sense ($K_p=0,1$ and 2) before noon	Clockwise sense ($K_p=0,1$ and 2) afternoon
Point Barrow	80.0%	72.4%
College	97.9%	82.4%
Sitka	96.8%	82.6%

It is very interesting that the sense of the rotation of the polarization of pc **5** is counterclockwise before noon and clockwise afternoon, and especially in magnetically quiet days even at Point Barrow this character is clear.

Discussion

As already Kato and Tamao [3] argued, the isotropic mode of hydromagnetic wave excited by the hydromagnetic disturbance at the external boundary of the exopshere due to the pressure of the solar wind propagates to inside of the magnetosphere, and this isotorpic mode of hydromagnetic wave of long period is converted to the transverse mode of hydromagnetic wave and propergates to the high latitude region along the line of force of the geomagnetic field, because the isotropic mode of hydromagnetic wave is partially reflected there and converted to transverse mode, and propagates along the line of force.

Wilson and Sugiura [2] studied the sense of the rotation of the pulsation accompanying the ssc and concluded that this character was expected if they considered the hydromagnetic wave excited by the azimuthal stress due to the passage of hydromagnetic schok wave at the external boundary of the exosphere.

In the present case, however, the azimuthal stress may be considered only in the thin boundary layer at the external boundary of the exosphere, and the line of force passing through the region of the latitude 70° (higher than that of Point Barrow) crosses the equatorial plane at the inside of the external boundary of the exopshere

Table V

Observatory	Geomag. Latitude	Distance where the line of force crosses.
(boundary surface)	79°	7.5 earth radii
	75°	7.0
	70°	6.1
Point Barrow	68.6°	—
	66°	5.2
College	64.7°	—
Sitka	60°	3.9

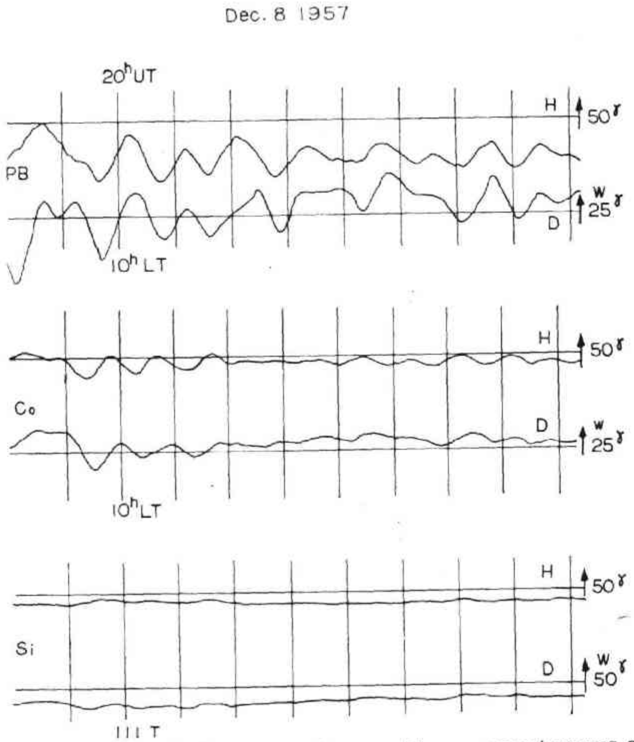

Fig. 2a. Example of pc 5. Traces are from rapid-run magnetograms at Point Barrow, College and Sitka.

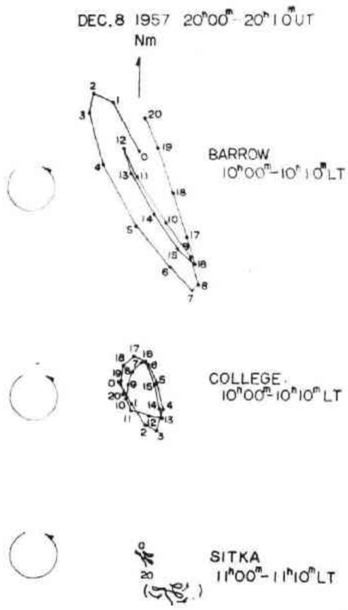

Fig. 3a. The polarization of the pc 5 shown in Fig. 2a.

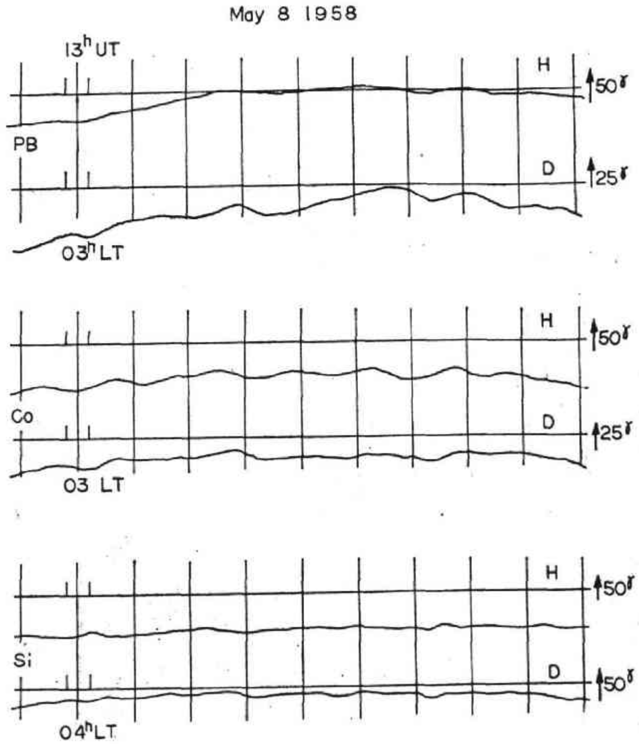

Fig. 2b. Example of pc 5.

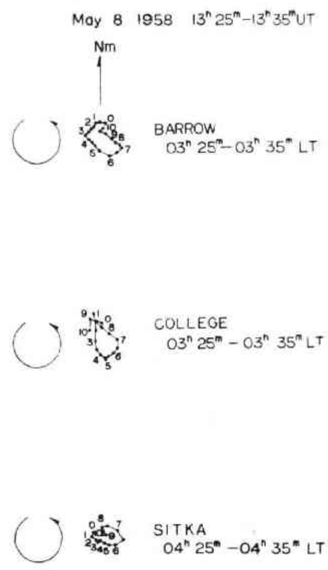

Fig. 3b. The polarization of the pc 5 shown in Fig. 2b.

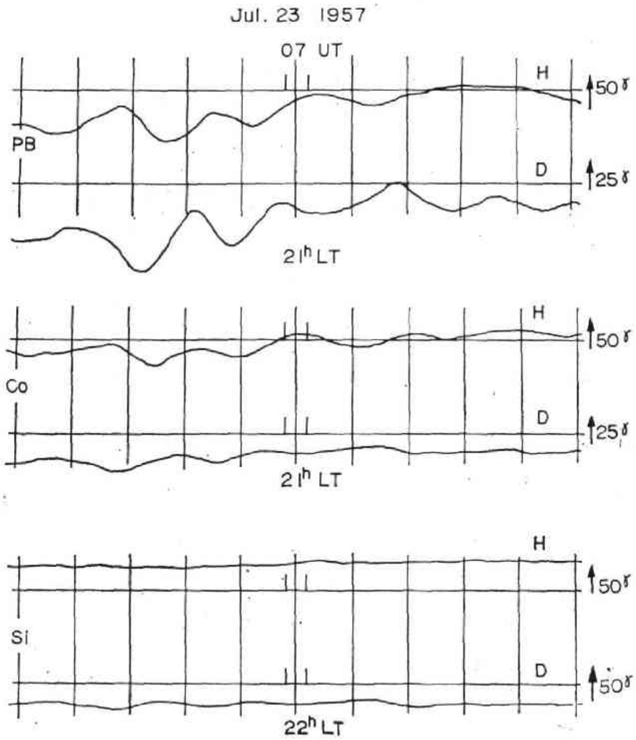

Fig. 2c. Example of pc 5.

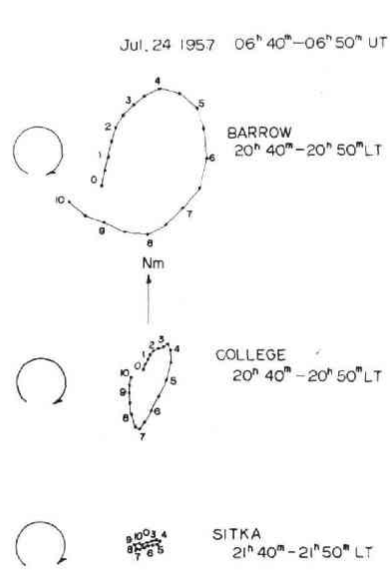

Fig. 3c. The polarization of the pc 5 shown in Fig. 2c.

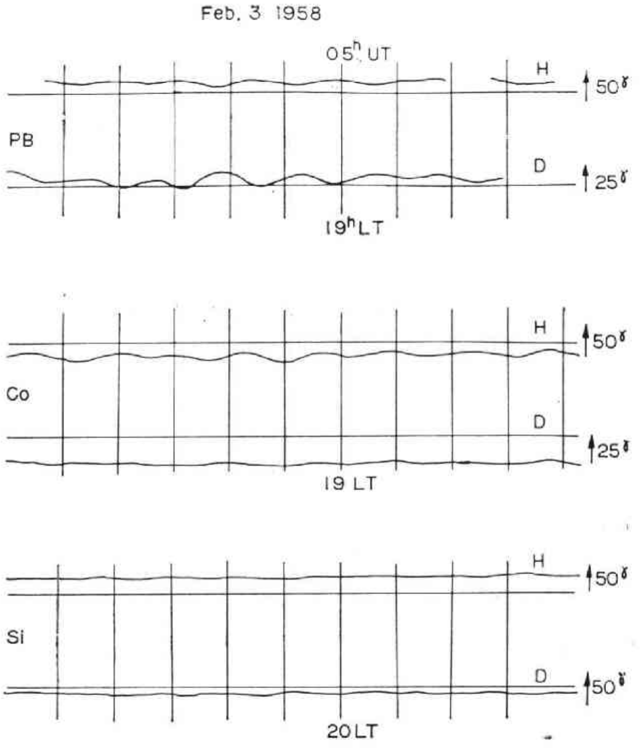

Fig. 2d Example of pc 5.

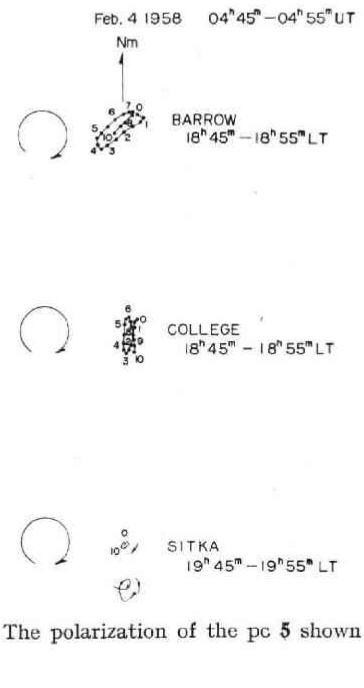

Fig. 3d. The polarization of the pc 5 shown in Fig. 2d.

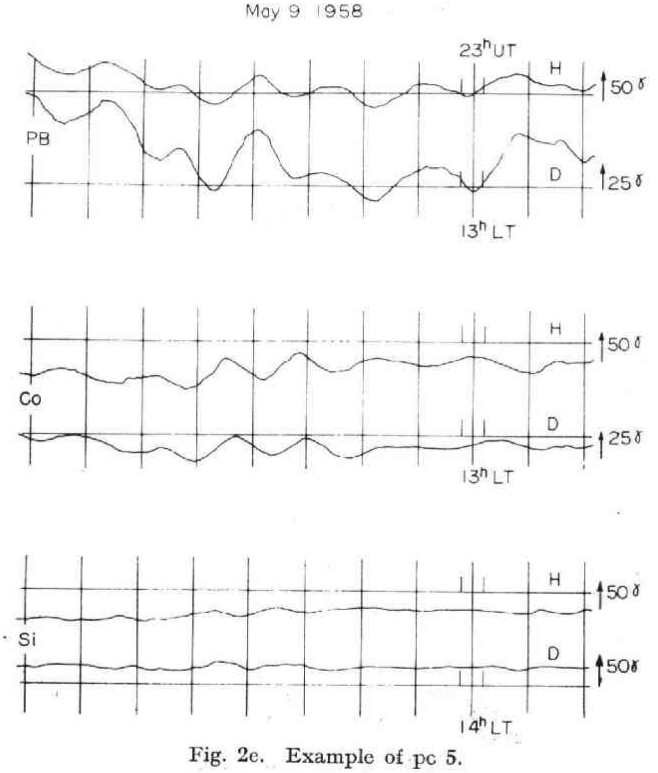

Fig. 2e. Example of pc 5.

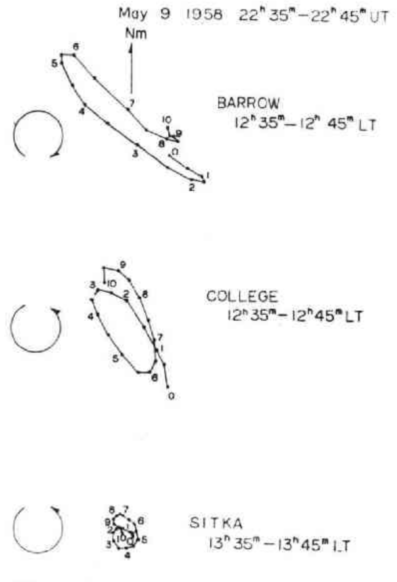

Fig. 3e. The polarization of the pc 5 shown in Fig. 2e.

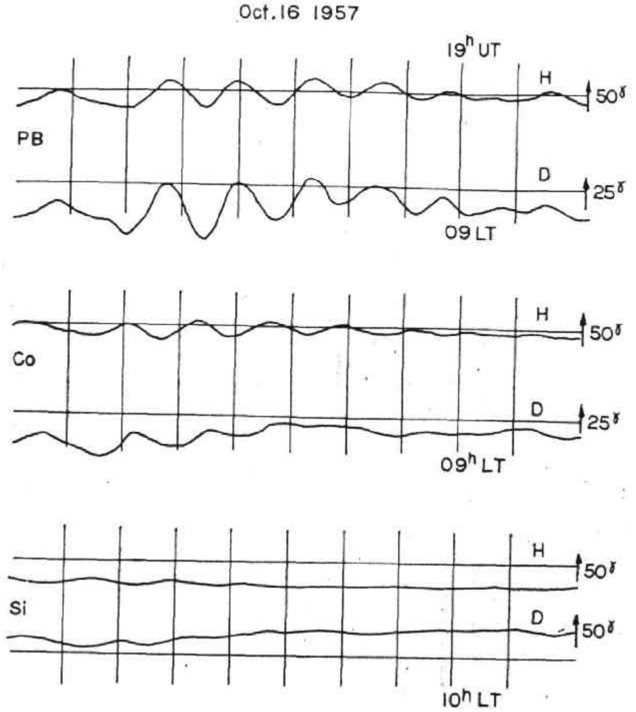

Fig. 2f. Exmaple of pc 5.

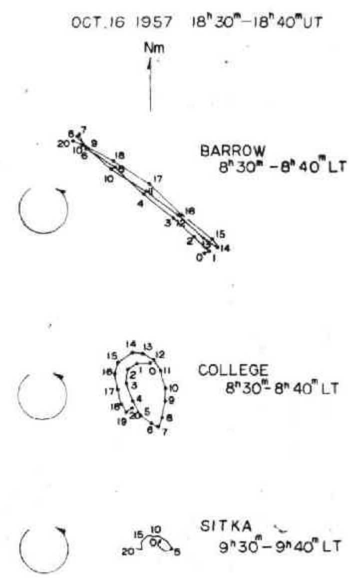

Fig. 3f. The polarization of the pc 5 shown in Fig. 2f.

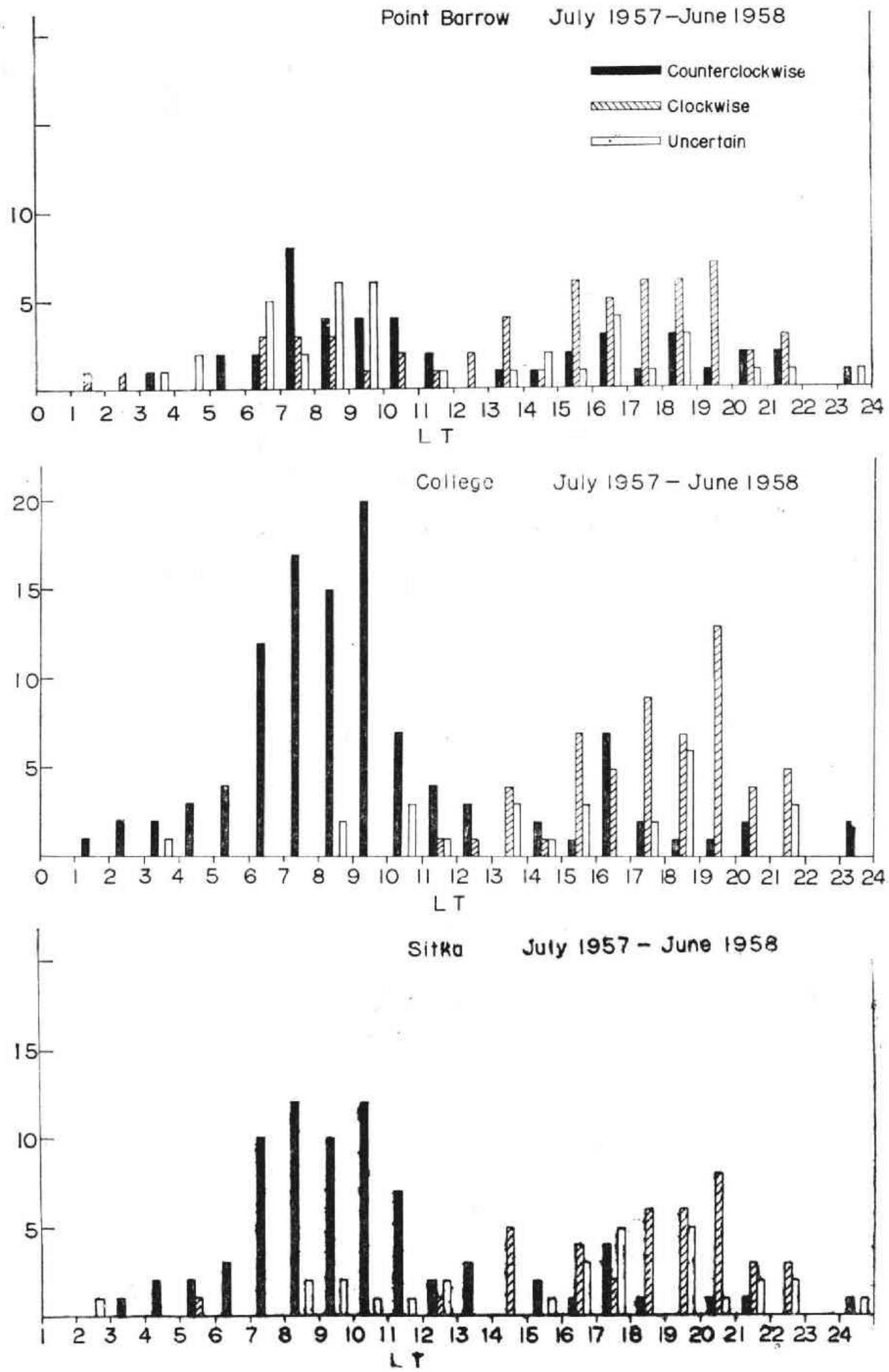

Fig. 4. Local time distribution of pc 5, with connterclockwise rotation and clockwise rotation of the magnetic vector, for stations in the northern high latitude during the IGY.

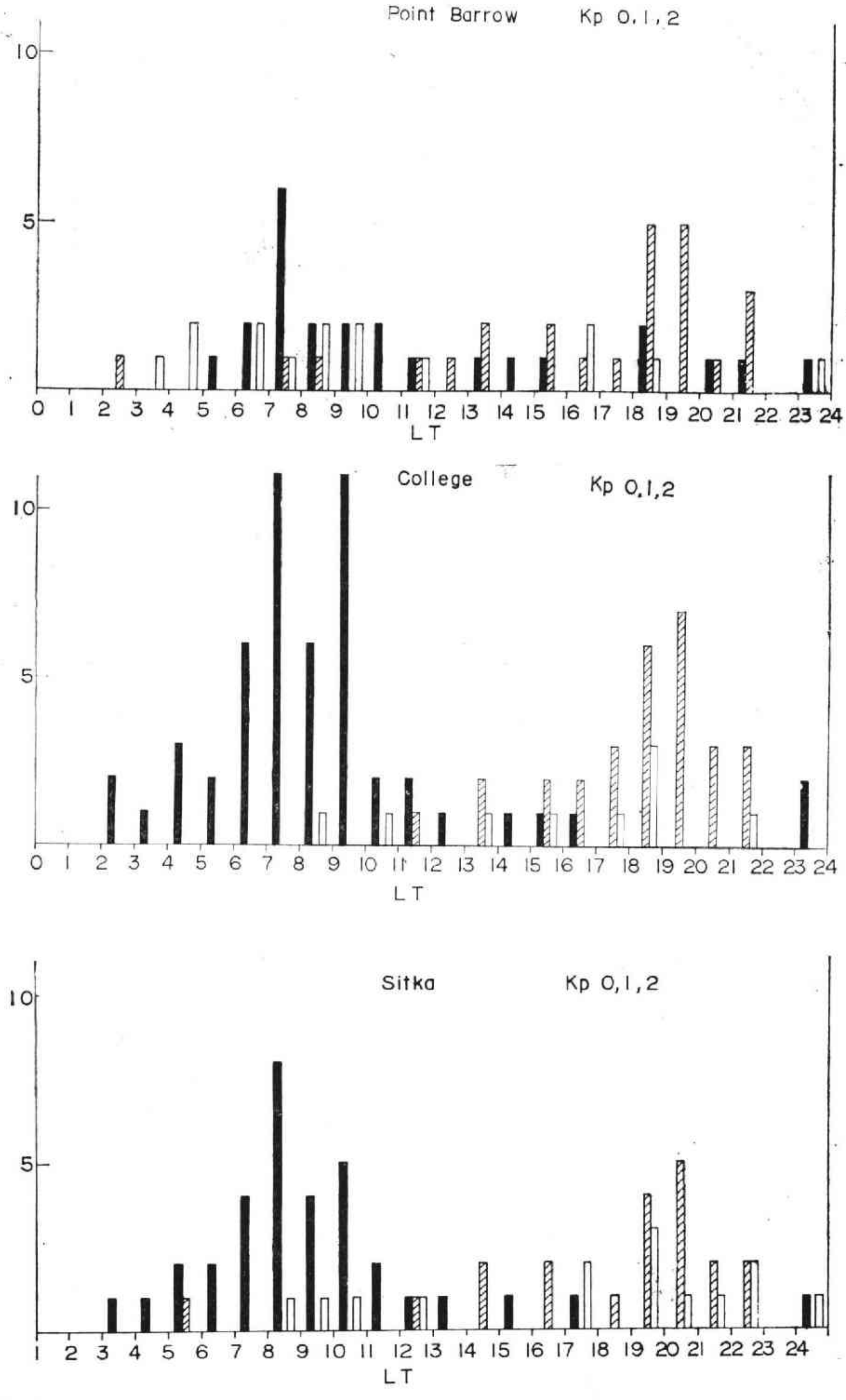

Fig. 5. Local time distribution of pc 5, with counterclockwise rotation and with clockwise rotation of the magnetic vector, on magnetically quiet days (Kp=0,1 and 2).

according to the Hones's model [4] of distorted field as shown in Table V.

Kato and Tamao [5] discussed on this character of the sense of the rotation of pc 5 and concluded that if we considered the periodic external stress (gass kinetic pressure and radial periodic external stress) at the external boundary due to the fluctuation of the pressure of the solar wind, we could calculate the polarization of the disturbed magnetic field vectors and the sense of the rotation of this vector was counterclockwise before noon and was clockwise afternoon. (The paper will be published in near future).

This isotropic mode of hydromagnetic wave is converted at certain level to the transverse mode of hydromagnetic wave and propagates along the line of force to the high latitude region and we may observe it as the magnetic pusltaion, pc 5.

At Point Barrow, if it is rather disturbed day ($K_p \geqq 3$), above mentioned character of the sense of vector rotation becomes not so clear, therefore we consider that at disturbed days the external boundary is compressed and the line of force passing through Point Barrow will cross the equatorial plane at just near or in the distorted boundary layer of external exosphere.

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