Development of Magnetic Bay Disturbances and Associated f_{min} Increases

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Abstracts

The equivalent current systems of many individual magnetic bay disturbances and associated f_{min} increase ($\Delta f_{min} \geq 3$ Mc/s) patterns at successive hourly stages are investigated concerning the relation of two phenomena in morphological features. Our main purpose is to examine the characteristics of time variation and spatial distribution of these two disturbances. It is confirmed that the f_{min} increase pattern is sensitive to the magnetic disturbance pattern, and the primary activated areas of both the disturbances are in the dawn hemisphere. It is discussed briefly whether or not the present results can be explained by some existing theoretical evidences or models.

Finally the brief statistical results on the behavior of the equatrial Dst-field during the bay disturbances and the occurrence correlation of bay disturbances between the auroral zone (College) and the low latitude zone (Honolulu) are shown. It is concluded that the morphological feature of the magnetic bay disturbance is quite similar to that of the magnetic storm.

1. Introduction

For a long time the world-wide morphology of magnetic bay disturbances has been studied vigorously by many investigators, for example, Chapman and Bartles (1940)[1], Silsbee et al (1942)[2], Nagata et al (1952)[3], Fukushima (1953)[4], Hakura et al[5] and others (1965). The much extensive study on the bay disturbance and its associated phenomena, that are auroral displays and various ionospheric disturbances, has been carried out by Oguchi (1962, 1963)[6]. Some of his most important results are summarized in Table 1 and 2. As given in the tables, the magnetic bay disturbance is classified into three kinds, positive bay, sharp negative bay and broad negative bay in the auroral zone.

On the other hand, various theories have been proposed to explain these phenomena by many workers. They are, for examples, the dynamo theory in the ionosphere by Fukushima (1953)[4], Obayashi and Jacobs (1957)[7] et al, the polarized electric field theory in the lower magnetosphere by Kern (1961)[8], Fejer (1964)[9] et al, and the hydromagnetic theory in the upper magnetosphere by Axford, Fejer

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and Hines (1962)[10] and Piddington (1962)[11][12].

Table 1. Occurrence local time of the upper atmosphere disturbance phenomena (quoted from Oguchi 1963).
The parts appended by a star * are the author's additions from the present study.

Local time	12 15 18 21 0 3 6 9 12h
Magnetic disturbance	Positive bay *(Negative DS in low lat.)
	Sharp negative bay *(Isolated positive bay in low lat.)
	Broad negative bay *(Positive DS in low lat.)
	Pc 5
Ionospheric disturbance	Es increase (height falls)
	Blackout (f_{min} increase)
Auroral phenomena	H_α
	5577 (Height falls)
	IPG

Table 2. Summary of some upper atmospheric disturbances and their agents (After Oguti) (AZA: Auroral zone absorption, PCA: Polar cap absorption.)

Aurora	Ionospheric disturbances	Magnetic disturbances	Agents	Energy
Visible discrete	Es, f_{min}	Sharp neg. bay	Electron	5 kev~1 Mev
Visible diffuse	AZA, Es	Broad neg. bay Positive bay	Proton Electron	5 kev~1 Mev
Polar glow	PCA	S_q^p Augmentation	Proton Electron	10~100 Mev

At present one of the most interesting problems in this field is the one concerning the energetic particles in the space surrounding the earth. Some of these energetic particles might contribute to the origin of magnetic disturbances and related phenomena, or might be produced when these phenomena occur. For many years our study concerned had been limited to be made from the ground-level observations of various phenomena. A large amount of observational data at distant regions by means of the many American and Russian spacecrafts becomes available. And many new informations of the magnetospheric configulation and the behavior of energetic particles surrounding the earth have been given (O'Brien, 1964, Ness 1965, Anderson, 1965, McDiramid et al, 1965 and others)[13]~[16]. Thus, various studies become possible to be made also from the above distant observations. The many have been already carried out vigorously (Pidddington, 1965, Taylor and Hones, 1965, and et al)[12][17]. It is much interesting to compare the results of the new distant observations with those ot the ground-level observations.

In this paper, the energetic particles (electrons $\geq$ 10 Kev) which precipitate into the lower ionosphere and cause f_{min} increases are shown in details and examined in order to make sure of the relation of these two phenomena in morphological features. Some possible interpreations to explain the present results are discussed briefly referring some existing models of the magnetospheric disturbance and some results of the distant observations of energetic particles.

2. Morphology of Magnetic Bay Disturbance and f_{min} Increase

It should be kept in mind that the magnetic bay disturbance used in the present paper never means only a disturbance which appears in middle and low latitudes in the form of an isolated typical bay with the duration of one or a few hours. Of course, this disturbance is included within the magnetic disturbances. As will be discussed in the last section, the isolated typical positive bay in middle and low latitudes corresponds almost always only to the sharp negative bay out of three kinds of magnetic bay disturbance in the auroral zone. Therefore, the magnetic bay disturbances investigated here are the gradually commenced stormy disturbances with a small activity owing to which they have not been reported as a magnetic storm from almost all of the stations in the world.

In Figs. 1-4 are presented the world-wide current patterns of magnetic bay disturbances and associated f_{min} increase regions at successive hourly stages for four events. To measure the disturbance from the magnetograms in high latitudes, the straight line at the level of the undisturbed period before the beginning of bay disturbance is determined as the base value from which the disturbance is scaled. For the same purpose the Sq-variation curve is used in middle and low latitudes. The examples of magnetograms for each event recorded at Big Delta are shown in Fig. 5. F_{min} increase patterns are indicated by three degrees of Δf_{min}; $5\,\mathrm{Mc/s} > \Delta f_{min} \geq 3\,\mathrm{Mc/s}$, $\Delta f_{min} \geq 5\,\mathrm{Mc/s}$ and blackout, where Δf_{min} is the deviation of f_{min} value from the monthly median.

(1) Event on Dec. 23 in 1958

In Fig. 1 are shown the equivalent current systems and their associated f_{min} increase patterns of the event on Dec. 23 in 1958. The example of the magnetogram for this event at Big Delta is reproduced in Fig. 5 a. As seen in the figures the bay disturbance occurred at about 10h and ended at about 20h UT with two distinct maximum stages in activity at 14h and 18h UT, respectively.

The current systems at each stage of the first bay disturbance were nearly confined in the dark hemisphere, rotating slightly counterclockwise around the

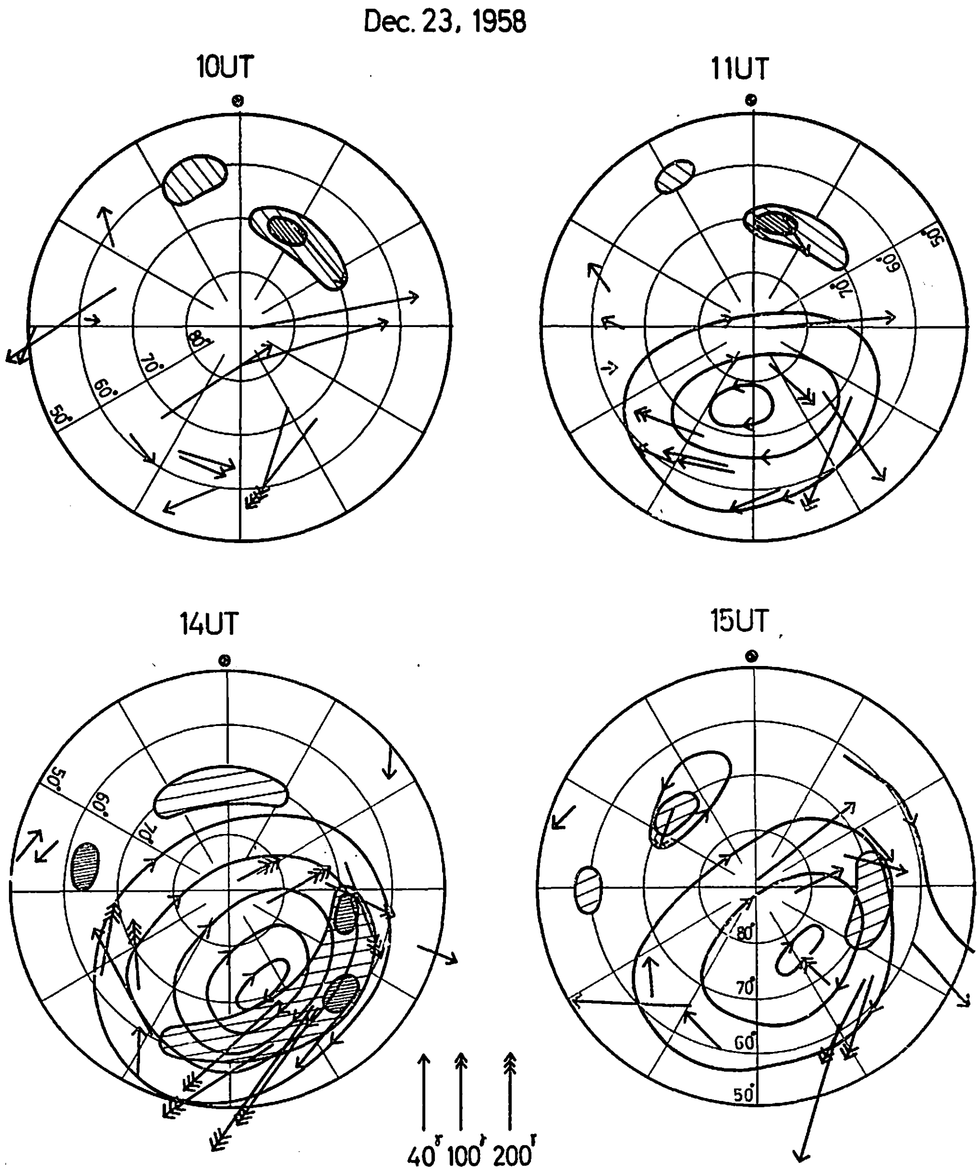
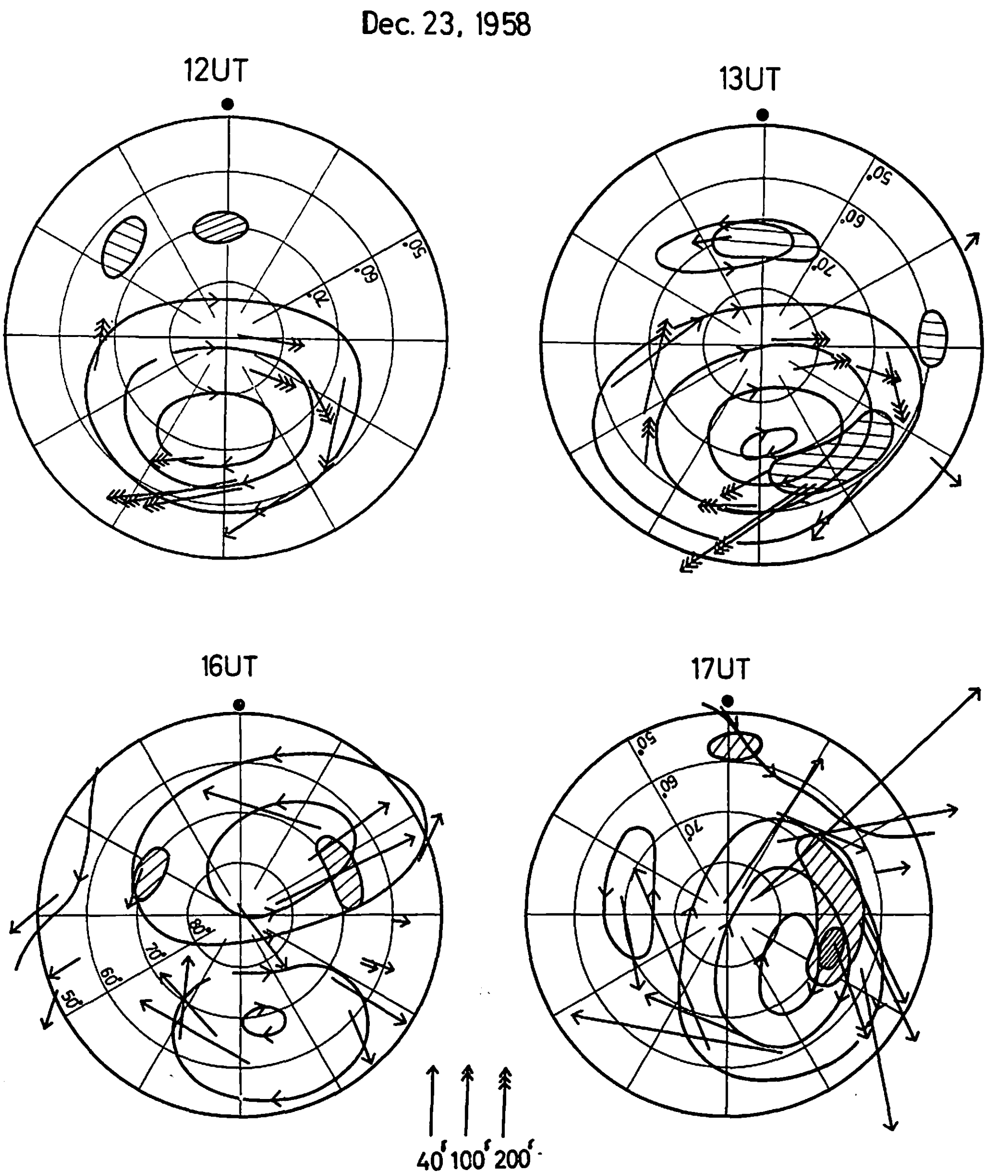


Fig. 1 a. Magnetic bay disturbance and ionospheric f_{min} increase patterns at the a hatched region. (thin hatch: 5 Mc/s$>\Delta f_{min}\geq$3 Mc/s, moderate hatch: Δf_{min}

pole from a stage to another. The disturbance in the sun-lit hemisphere was so much weak that it was almost absent. These current systems are quite similar to the one of the sharp negative bay reported by Oguti (1963)[6]. It is, however, doubtful to identify the first disturbance merely with a sharp negative bay judging



stages from 10h to 17h UT on Dec. 23 in 1958. F_{min} increase is indicated by ≥ 5 Mc/s and thick hatch: blackout) The mark ● indicates the sun's position.

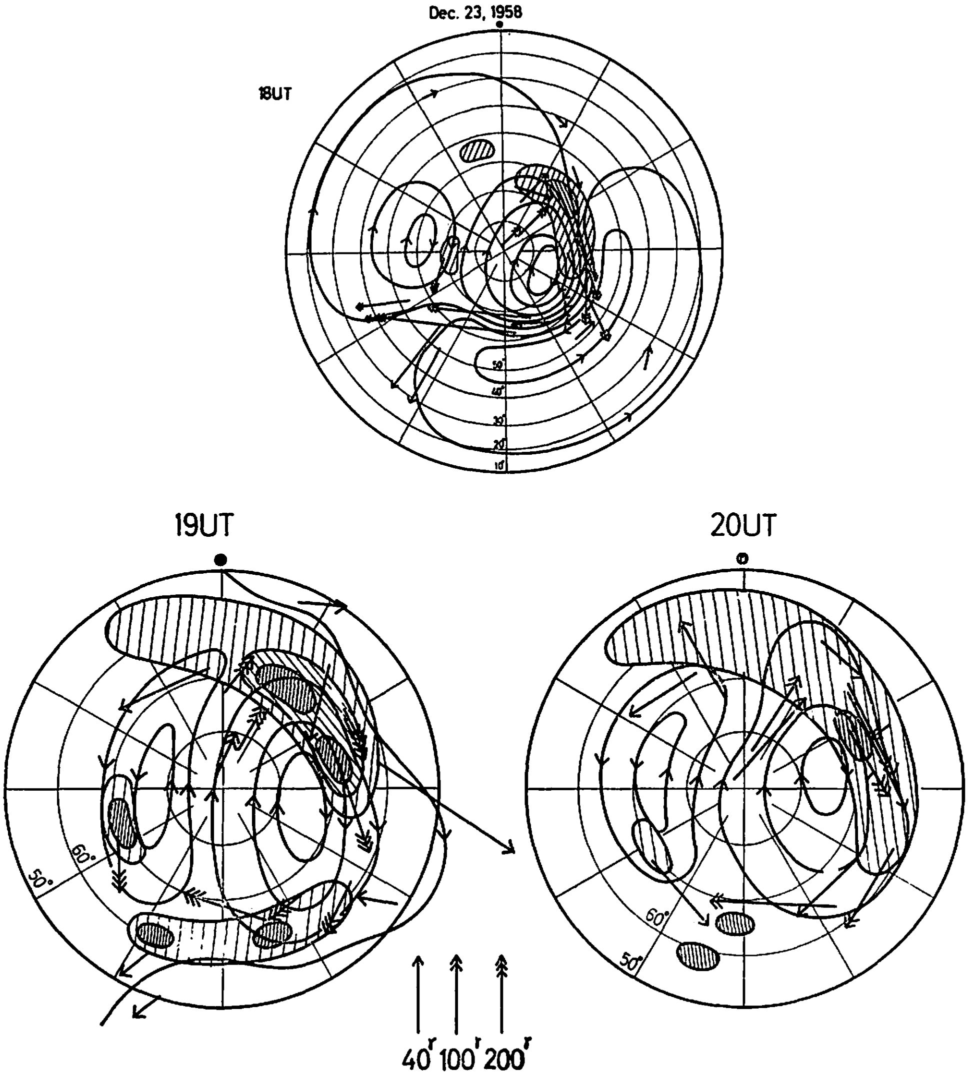


Fig. 1 b. Similar patterns to Fig. 1 a at the stages from 18h to 20h UT on Dec. 23 in 1958.

from the shape on the magnetogram at Big Delta of Fig. 5 a. This is maybe a combination of a sharp negative bay and a broad negative bay.

The dominant f_{min} increase region associated with this disturbance appeared at 13h UT after one or two hours around the early morning side. This f_{min} region extended mainly eastward and weakened corresponding to the change of magnetic activity. The spatial distribution of these regions was almost restricted between 60° and 70° in the geomagnetic latitude, that was in the auroral zone, and in the east side of the center of current vortex through the whole period except the maximum stage. At the maximum stage it extended nearly all over the activated area of the magnetic disturbance in the auroral zone.

The second bay disturbance occurred at 17h UT and ended at 20h UT with the maximum stage at 18h UT after the first one decayed to the considerably low activity. This disturbance exhibited a little different feature from the first one. However, each pattern of the current systems is similar to that of the usual DS-field or of the isolated typical bay reported by many investigators (Fukushima 1953(4), Nagata et al 1962(18), Oguti 1963(6), et al). It is easy to find that these current systems are different from those of the first bay disturbance in spatial distribution of the disturbance and in direction of the current flow in the polar cap zone. All of them except the one at the maximum stage can be undoubtfully identified with a positive bay part in the dusk hemisphere and with a broad negative bay part in the dawn hemisphere. The current system at the maximum stage is like the one which consists of the above two parts and a superposed great sharp negative bay in the mid-night region.

The second f_{min} increase patterns showed also some different features from the first one. Namely the second f_{min} increase region in the morning side appeared 'simultaneously' with the second magnetic disturbance. It persisted in considerable activity, being rather intensified and extending strongly towards the noon side still after the magnetic disturbance became very weak. Furthermore, a different kind of f_{min} increase region suddenly appeared in the mid-night region at 19h UT just after the maximum stage. This region had disappeared already at the next hour stage. This f_{min} increase may be closely related to the occurrence of a great magnetic disturbance, possibly, a sharp negative bay.

While, it should be noted that many island regions of f_{min} increase appeared and disappeared from a stage to another on the day time side or on the evening side. Some of them might be those accompanied with the positive bays as seen in Figs. 1 a—b, but the others seemed to be independent of the magnetic disturbance.

(2) Event on Nov. 25 in 1958

In Fig. 2 is shown the second example for the event which occurred at about 12h and ended at about 12h UT. This had two maximum stages, too, at 16h and 18h UT. At each maximum stage a typical sharp negative bay disturbance occurred in the mid-night sector. The general features on the relationship between the magnetic disturbance pattern and the f_{min} increase pattern are similar to those of the above-shown event, though this example is more complicated. Following a few points, however, have to be noted here again.

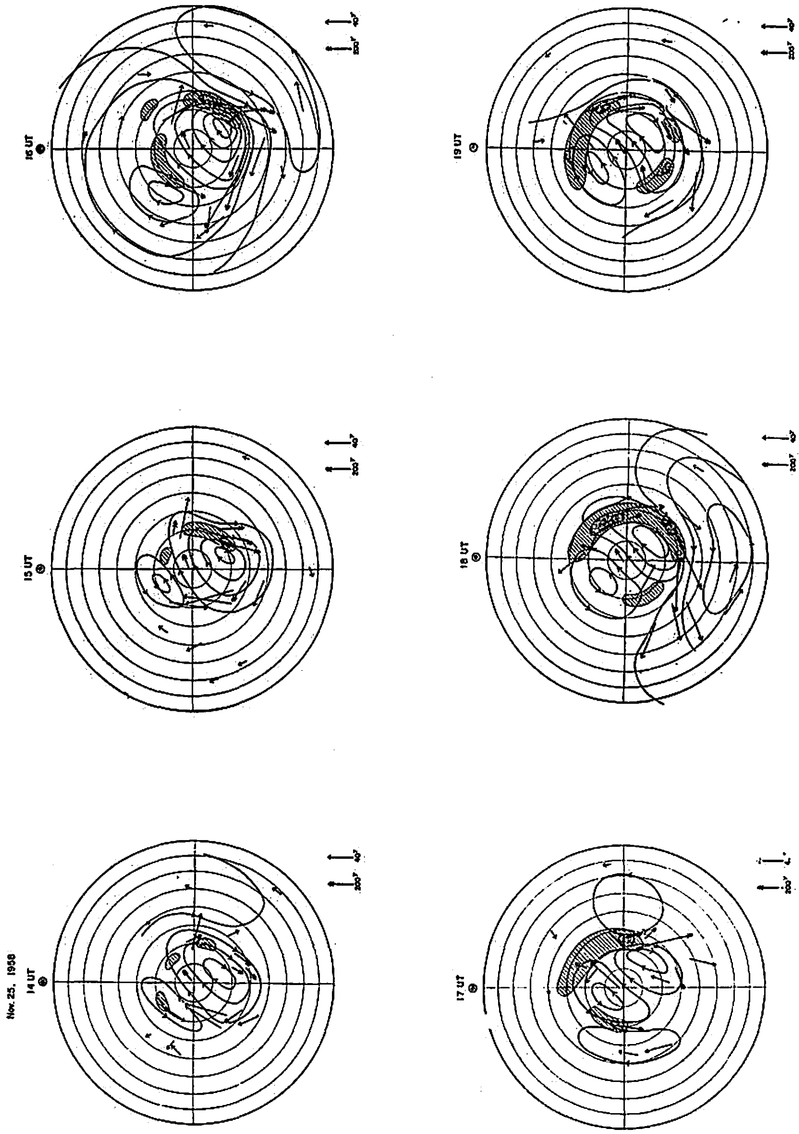


Fig. 2. Magnetic bay disturbance and ionospheric $f_{\min}$ increase patterns at successive stages on Nov. 25 in 1958. Indication of $f_{\min}$ increase pattern is the same as in Fig. 1.

The first point is that the f_{min} increase regions in the morning side, which were closely related to the broad negative bay disturbance, remained dense even after the magnetic disturbance recovered. This can be seen at the stages of 17h and 19th UT in Fig. 2. The second point is that the f_{min} increase regions seem to move steadily eastwards, in other words, to rotate counterclockwise around the pole. While the direction of current systems in the polar cap zone changed a little. The last point is that the f_{min} increase region at the second maximum stage (18h UT) was suddenly extended to the mid-night meridian corresponding to the great magnetic disturbance in the mid-night side which was identified undoubtfully with a sharp negative bay. At the next hour (19h UT) this region on the early morning side almost disappeared simultaneously with the decay of the sharp negative bay. Therefore, the pattern of f_{min} increase at the maximum stage was a combination of the f_{min} increase regions associated with the broad negative bay and the sharp negative bay.

(3) Event on Nov. 2 in 1958

The former two examples are too complex to see simple or distinct relations of two phenomena in morphological features. So, an example of relatively simple disturbances, is presented in Fig. 3. This is the magnetic bay disturbance which commenced gradually at 10h and ended 20h UT on Nov. 2 in 1958 as shown in Fig. 5 c. The current systems and associated f_{min} increase patterns are shown in Fig. 3. It is easily recognized from these figures at a glance that this disturbance changed quite regularly from a stage to another, attaining the maximum stage at 18h UT after a rather monotomic growth. As any remarkable sharp negative bay did not occur, this magnetic disturbance is a most typical bay of the auroral zone which consists of the positive bay and the broad negative bay.

(4) Event on Jan. 29 in 1958

Another similar example is shown in Fig. 4. The disturbance commenced at about 3h UT and continued till 20h UT on Jan. 29 in 1958 as seen on the magnetogram of Big Delta in Fig. 5 d.

The features of this example are nearly the same as for the previous examples. However, it should be noted that no evident f_{min} increase region appeared on the evening side even though the very clear positive bay occurred in the auroral zone.

3. Summary of the Preceding Section

As introduced in the section 1, the magnetic bay consists of three kinds of

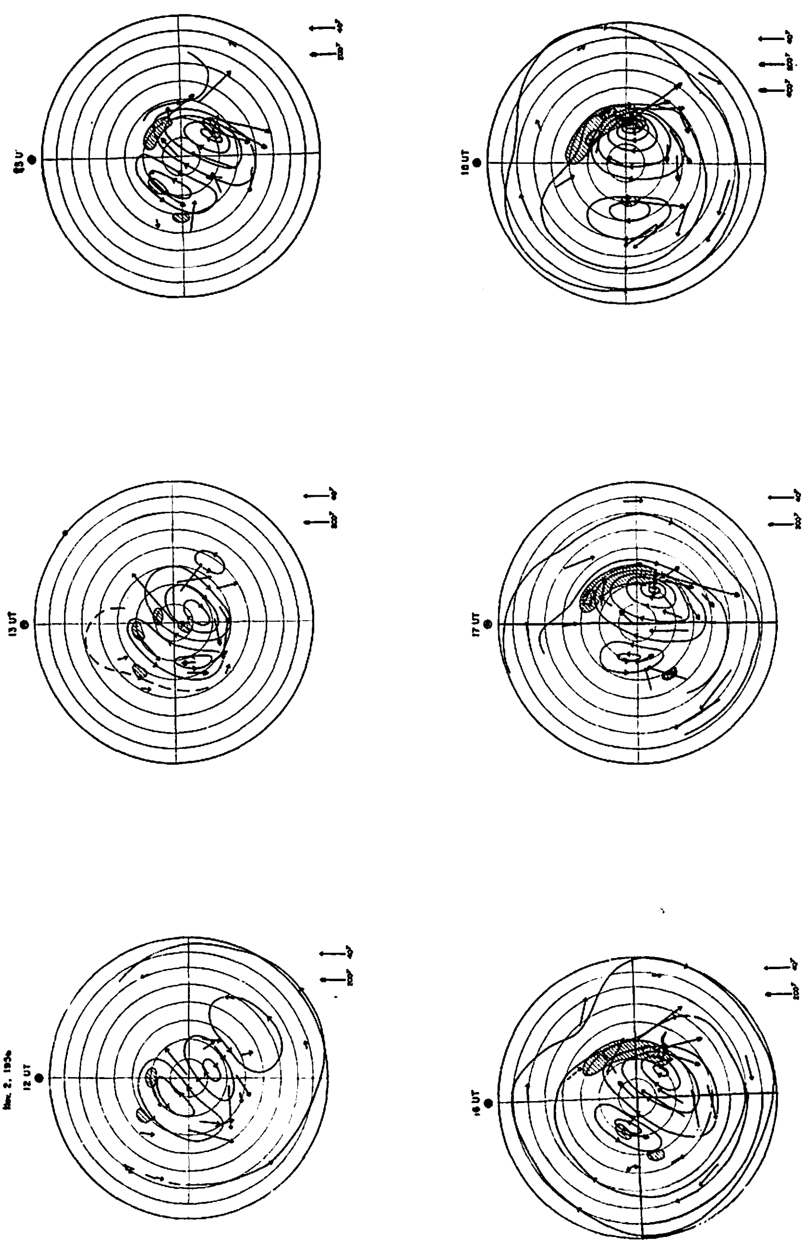


Fig. 3 Magnetic bay disturbance and ionospheric f_{min} increase patterns at successive stages on Nov. 2 in 1958. Indication of f_{min} increase is the same as in Fig. 1.

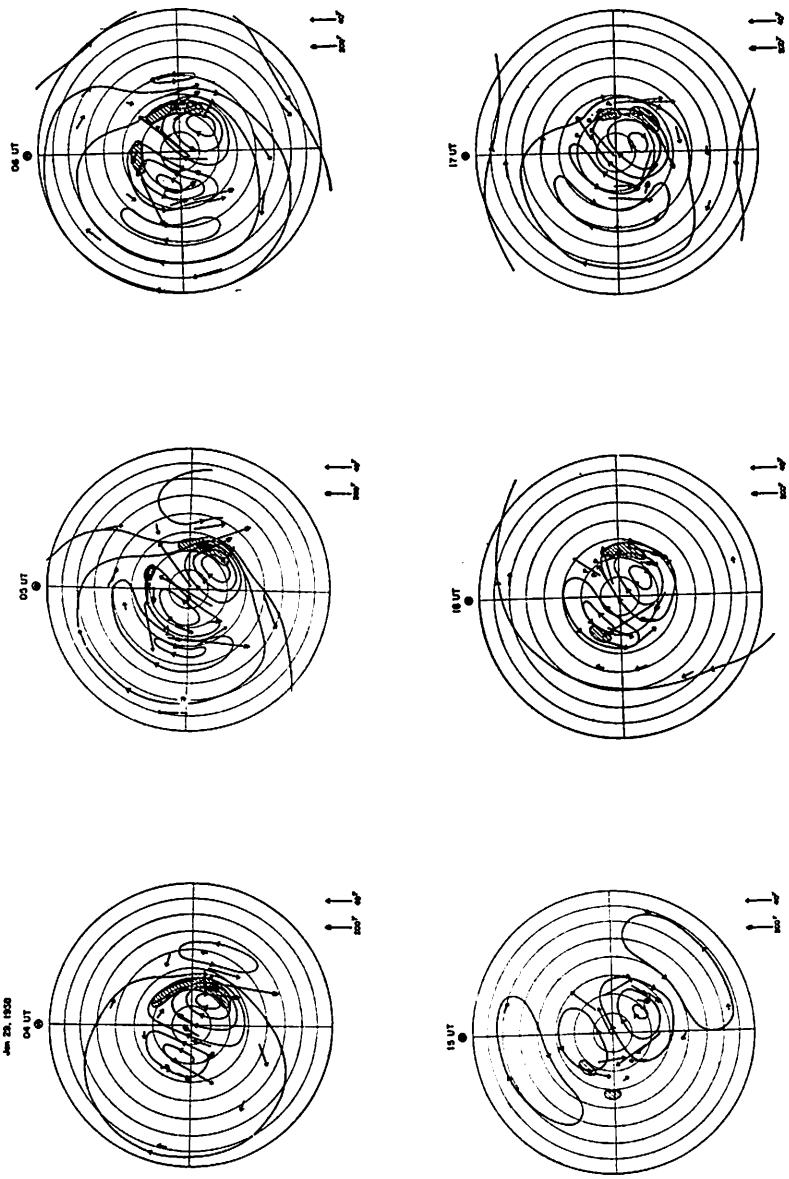
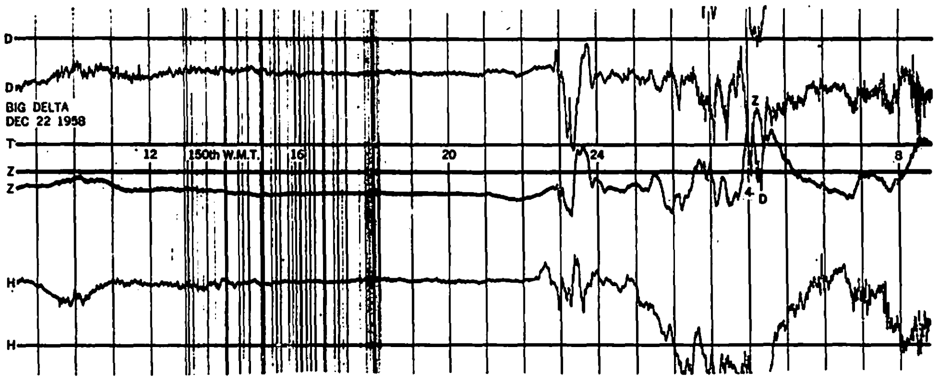
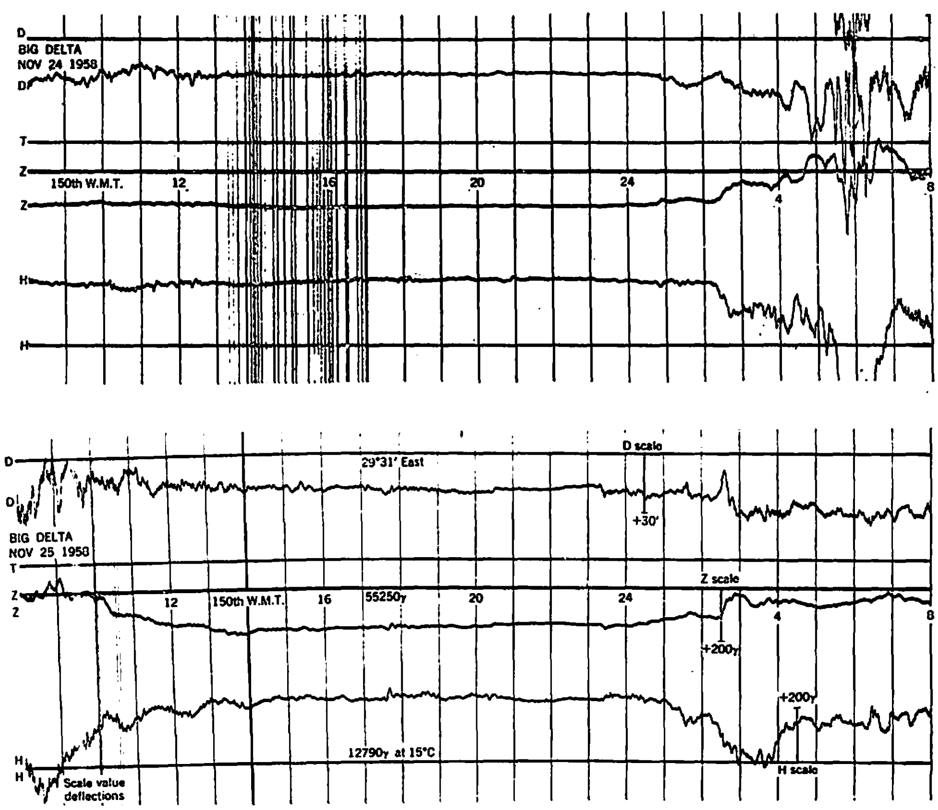


Fig. 4. Magnetic bay disturbance and ionospheric $f_{\min}$ increase patterns at successive stages on Jan. 29 in 1958. Indication of $f_{\min}$ increase is the same as in Fig. 1.

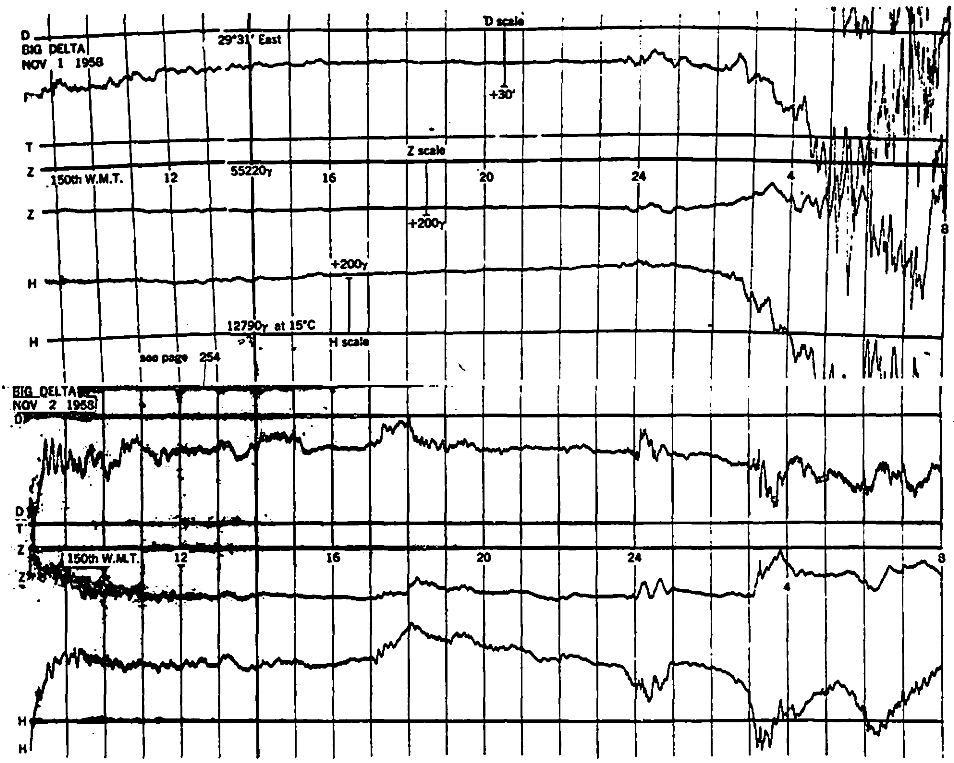


[a]

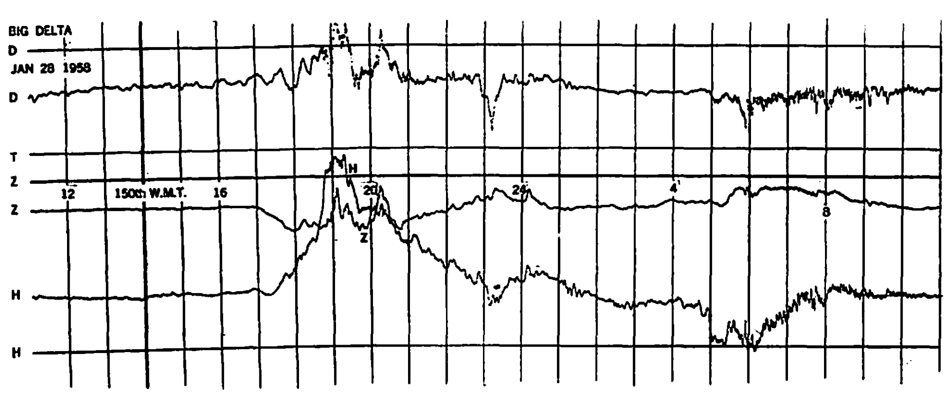


[b]

Fig. 5. Reproductions of the bay disturbance magnetograms recorded at Big Delta for



[c]



[d]

each event. (quoted from Magnetcgrams and Hourly Values, Big Delta, Alaska, 1957–1958.)

disturbance which are distinguished as positive bay, broad negative bay and sharp negative bay in the auroral zone. Next some general features in the relation of f_{min} increase patterns and three kinds of disturbance are summarized briefly as follows:

(1) Relation between broad negative bay and its associated f_{min} increase.

(a) Relation of occurrence time in developing and decaying process of two phenomena.

In general, the relation of the occurrence time between the magnetic disturbance (broad negative bay) and its associated f_{min} increase in the developing course is summarized as that the former starts one or more hours earlier than the latter under the very calm periods. This can be clearly seen in the cases of Dec. 23 and Nov. 2 events. However, when a new magnetic disturbance has become very weak or disappeared, the above time relation is broken in almost all cases. In these cases, two phenomena seem to grow simultaneously. The above feature is typically represented at the stage of 17h UT in Fig. 1 b.

As for the decaying process of two kinds of disturbance, it is said safely that the f_{min} disturbance decays more slowly than the magnetic one. Thus, in most cases, the f_{min} increase region remains widely after the magnetic disturbance recovers considerably. This feature can be found typically in the case of the Dec. 23 event of Fig. 1.

(b) Spatial relation of two phenomena.

As seen clearly in Fig. 3, the spatial distribution of f_{min} increase region usually spreads widely along the auroral zone (between about 60°N and 70°N in geomagnetic latitudes) on the east side near the center of the magnetically activated area. And the f_{min} increase region often shifts a little to the lower latitudes as spreading eastwards. Consequently, the spatial distribution of f_{min} increase region changes sensitively corresponding to the magnetic disturbance pattern from a case to another. This relation, of course, is broken sometimes at the declining stage of magnetic disturbance as represented in Fig. 1.

The above characteristic relation of the spatial distribution also confirmed by the parallelism that both patterns of the currents and f_{min} increase regions similarly move eastwards or rotate counterclockwise from a stage to another as clearly shown in Fig. 3.

(2) Relation between the sharp negative bay and its associated f_{min} increase.

In general, the sharp negative bay cannot be so clearly distinguished from the broad negative bay because of the superposition of a part of the broad negative bay in addition to its very small activated area and short life time. Hence, the relation between the disturbances of the current system and the f_{min} increase for the sharp negative bay cannot be derived so distinctly as the broad negative bays.

However, the narrow f_{min} increase region which appears sporadically around the mid-night meridian in the auroral zone is closely related to the sharp negative bay. And the relation of occurrence time seems to be similar to that in the case of the broad negative bay. The occurrence region of f_{min} increase is distributed rather simply in or near the activated area of the sharp negative bay. These features are typically represented in the cases of the Dec. 23 and Nov. 25 events.

(3) Relation between the positive bay and its associated f_{min} increase.

The positive bay disturbance is much smaller in amplitude than the other two disturbances and its dominantly activated area is much narrow similarly to the sharp negative bay. The occurrence time and spatial relations between the positive bay disturbance and its associated f_{min} increase region are not so clear. It is not doubtful that the small f_{min} increase regions appearing on the evening side are the ones corresponding to the positive bay. In conclusion, the f_{min} increase region corresponding to the positive bay is hard to appear widely on the evening side.

(4) Other kinds of f_{min} increase region

In addition to the above three kinds of f_{min} increase region, there occur many sporadic small f_{min} increase regions in the day-time side as seen in all the figures shown above. These may be different from the above-discussed f_{min} increases. These dense regions may be the same as the f_{min} increase regions occurring on the sun-lit side at initial stages of the magnetic bay disturbance.

4. Possible Interpretations of Magnetic Bay Disturbances and Their Associated f_{min} Increases.

The typical magnetic bay disturbance in the auroral zone usually consists of the broad negative bay and the positive bay. This disturbance may be well interpreted by the recent hydromagnetic theory of the DS-field generation. The viscous-like interaction between the magnetosphere and the solar wind induces the electric potential associated with the circulation of magnetospheric plasma and this electric potential is projected onto the polar ionosphere along the magnetic lines of force (Axford, Fejer and Hines 1962[10], and Piddington 1962[11], 1965[12]). But the current system predicted by this theory cannot simply explain the sharp negative bay which is essentially different from the broad negative bay and the positive bay in the current system. The patterns of the current system of sharp negative bay and its associated f_{min} increase region have very proper features, that they are almost confined in the antisolar direction and occur sporadically.

The sharp negative bay may be interpreted by a circulating plasma motion in the dark magnetosphere caused by the earth's rotation. Such a plasma motion, which may exist even at the calm state, may be enhanced suddenly, greatly and sporadically by some anormalous instability generated in the magnetic tail at the disturbed state. Though the mechanism of the above anormalous instability is quite unknown, it is, for example, an enhanced sheering effect between the magnetosphere corotating with the earth and the nonrotating part of the magnetic tail (Piddington 1965)[12].

The features of the sharp negative bay and the f_{min} increase in buildup time, duration time and occurrence local time are quite similar to those of the island flux of energetic particles (Anderson 1965)[15] or high latitude electron spike (McDiarmid et al 1965)[16]. Hence, the sharp negative bays and their f_{min} increases may closely relate to the islandfluxes of energetic electrons in the magnetic tail.

Taylor and Hones (1965)[19] have computed the precipitation zones of electrons ($E \leq 35$ Kev) and protons, which are solar particles ($E \simeq 1$ Kev) once trapped on the

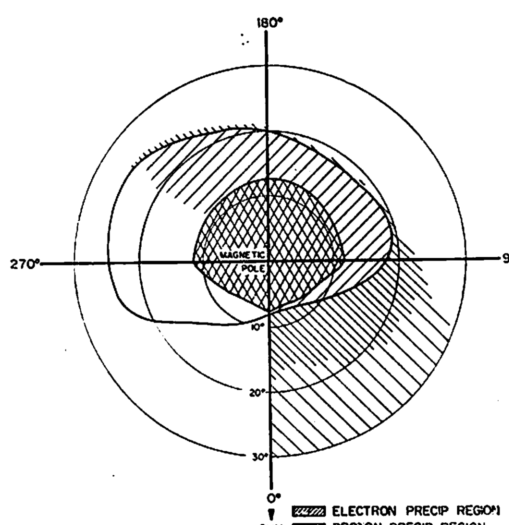


Fig. 6. Summary of regions where the assumed fields will cause solar wind particles to precipitate. (quoted from Taylor and Hones, 1965)

magnetospheric surface, by using the adiabatic motion of charged particles in the magnetic and electric fields. Their magnetic field model includes the effects of the solar wind compression on the sunward side and the newly discovered current in the magnetic tail. The electric field used is a projection of the one deduced in the ionosphere from the average DS-field of magnetic bay (Silsbee et al 1942)[2] into the magnetosphere along the magnetic lines of force. The solar particles trapped once are accelerated due to the projected electric field. The summary of their calculated precipitation zones is reproduced in Fig. 6. It should be noted that the precipitation zones are very sensitive to the pattern of magnetic bay disturbance.

Thus, the above result by Taylor and Hones (1965)[17] should be compared with our analysis of the magnetic bay disturbances and their associated f_{min} increases. The f_{min} increase regions between the mid-night and the early morning meridian (04h LT) coincide rather well with the computed precipitation zone of electrons.

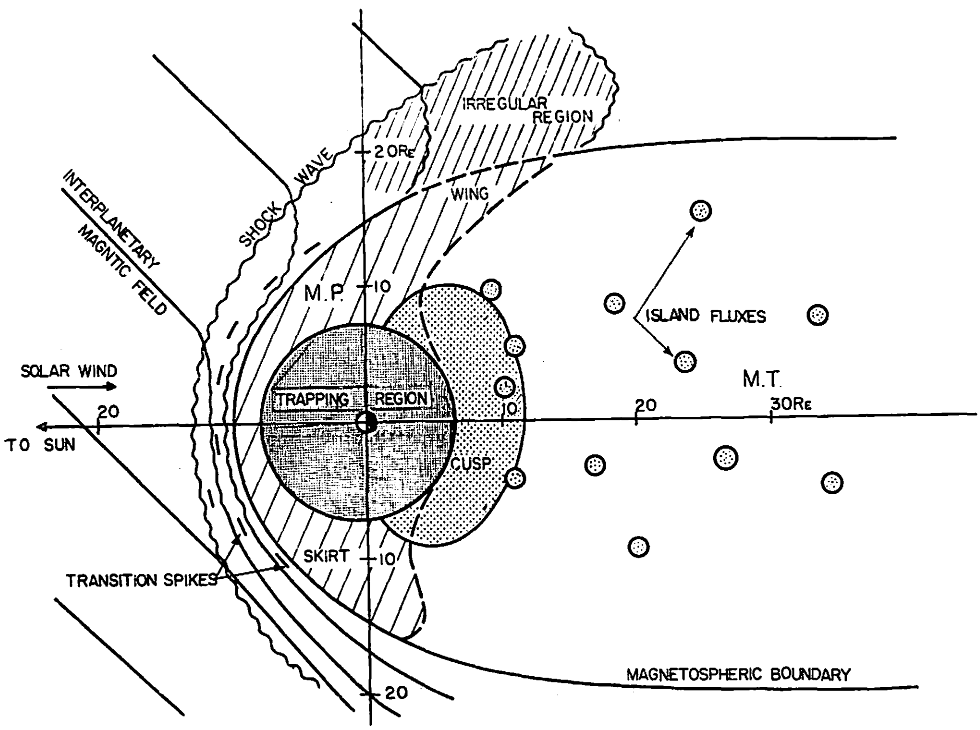


Fig. 7. The main existing regions of the terrestrial energetic particles are shown (After Anderson 1965). And the configuration of the magnetic field outside the magnetospheric boundary is shown schematically (After Ness 1965 and Piddington 1965).

The precipitation zone of protons cannot be compared with our results since energy of protons causing f_{min} increases are above several hundreds Kev. In the night sector (19h—24h LT), the f_{min} increase regions are also appreciably similar to the electron precipitation zone. But the most active f_{min} increase regions in the morning sector (04h—12h LT) cannot be predicted by the electron precipitation zone by Taylor and Hones. This precipitation zone computed in this sector, especially in the day time, is very higher in latitude than the f_{min} increase regions observed.

In Fig. 7, we summarize the recent observations of energetic particles in the distant space (Anderson 1965)[15] together with the model of the magnetic field configuration in the upper atmosphere (after Piddington 1965 and Ness 1965)[12][14]. As shown in the figure, the distribution of energetic particles is divided into the Van Allen trapping region and the distant radiation zone (Anderson 1965)[15]. The distant radiation zone is further divided into the transition spikes, the skirt, the cusp and the island fluxes (Anderson 1965)[15]. The skirt region extends into the transition region on the dawn hemisphere. This extension of the skirt region may be an entrance of the energetic particles (40~50 Kev electrons) from the transition region into the magnetosphere or vice-versa.

Hence, the f_{min} increase region in the dawn or morning hemisphere in our analysis may be explained by the invasion of energetic electrons from the above entrance as suggested by Piddington (1965)[12]. Some of the invading energetic particles may be trapped in the trapping region and may contribute to the main origin of enhancement of the ring current which accompanies with the broad negative bay and the positive bay as will be discussed in the next section. It should be also taken into consideration to explain these phenomena that there are other invasions of energetic particles from the neutral points or lines (Piddington 1965)[12]. In addition, it is easily inferred that the daytime f_{min} increase regions may be due to the proper precipitation of energetic particles from the magnetosphere compressed with the solar wind, or due to the invasion of particles from the neutral points or lines on the sun-lit side.

5. Other Studies on New Morphological Features of Bay Disturbance.

(1) Development of Dst-field associated with the magnetic bay disturbance.

It is well known that developments of Dst-field and Dp-field (DS-field) in the cases of magnetic storms have a good correlation (Chapman and Sugiura, 1958, Sano, Nagai and Yanagihara 1960, Akasofu 1963, et al)[19]~[21]. However, it is not so certain whether or not the Dst-field develops always corresponding to any magnetic bay disturbance (Dp-field). To answer the question there is an indirect suggestive evidence that a good negative correlation is found between $\sum$Kp (daily sum of Kp-index) and daily mean values of H-Component of the magnetic field in low latitudes (Banno, 1963)[22]. In order to confirm much directly this matter, the equatorial Dst-field during the bay disturbance is investigated statistically or individually. The equatorial Dst-field used here is that calculated for the whole period of the IGY by Sugiura (1963)[23].

In Fig. 8a are shown respective average bay disturbances at College and at Dixon Is and the corresponding average equatorial Dst-field change for 10 magnetic bay disturbances which are those discussed in the previous sections and commenced at about 10h UT (0h in the local time of College). The average variations of Ap-index and K-index for 20 stations in the auroral zone and polar cap zone are given

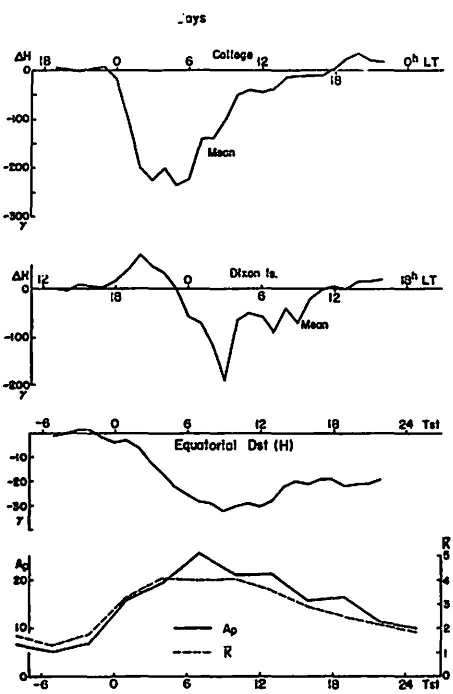


Fig. 8 a. The average magnetic bay disturbances at College and at Dixon Is for 10 disturbances each of which commenced at about 10h UT, the corresponding average equatorial Dst field change and the corresponding average Ap-index and K-index of 20 stations in the polar region.

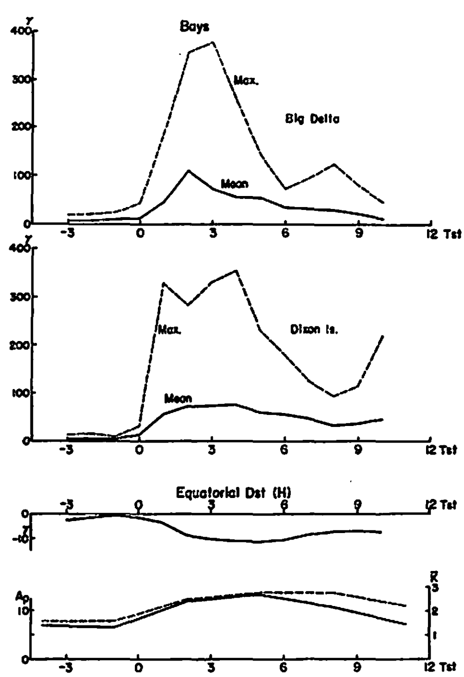


Fig. 8 b. The similar figure to Fig. 8 a for 20 much smaller disturbances commenced at random in UT. The magnetic bay disturbances are indicated by the average of absolute values of disturbance. The ones connected by broken lines are each hourly maximum value of the absolute values.

in the lowest part of the figure. Fig. 8 b represents the similar curves for 20 bay disturbances with much smaller amplitudes and shorter durations in the same manner as Fig. 8 a. But, the average bay disturbance curves in Fig. 8 b are what are averaged for absolute values of the disturbances at Big Delta and at Dixon Is, since these disturbances commenced at random in the universal time. Some examples of such bay disturbances are reproduced in Fig. 9.

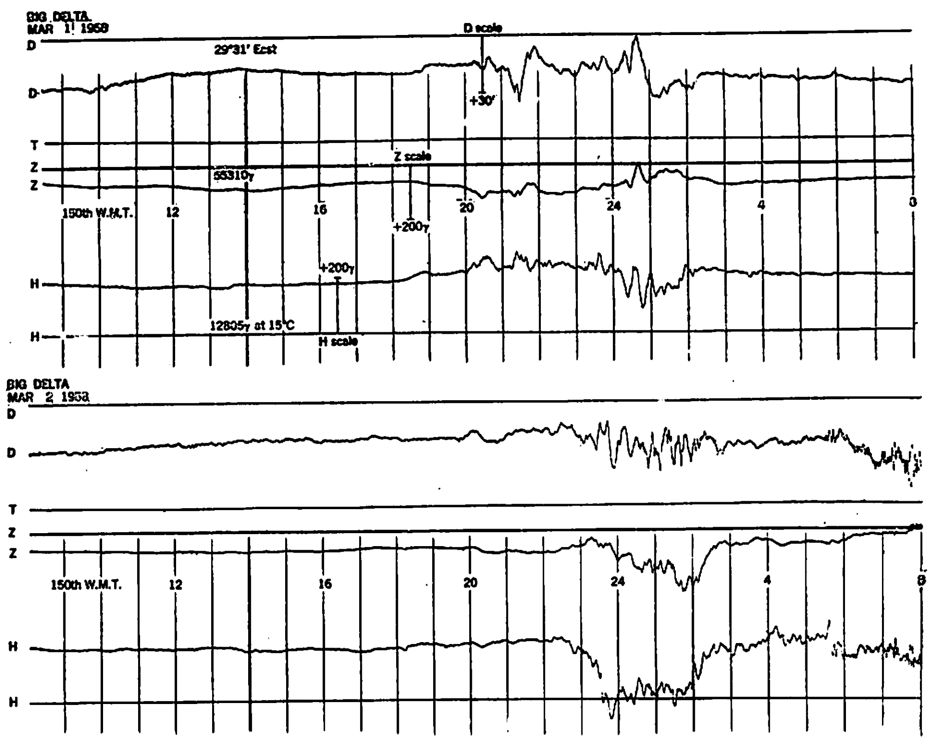


Fig. 9. Examples of magnetograms from Big Delta recording the smaller bay disturbances used in Fig. 8 b. (quoted from Magnetograms and Hourly Values, Big Delta, Alaska, 1957–58)

From these figures it is seen that each equatorial Dst-field curve decreased distinctly corresponding to each development of the magnetic bay disturbances in the auroral zone. The feature is quite similar to the magnetic storms although the bay disturbance is much smaller. In addition to the above fact, it is interesting that both the Dst-field curves indicate a small increase before the beginning of bay disturbances as if each of them is caused by the compression due to the solar wind or cloud. These morphological characteristics are confirmed for almost all of the individual cases.

After the above investigation it becomes certain that decreases of Dst-field develop always to some extent during the course of magnetic bay disturbance. The conclusion that the morphological feature of magnetic bay disturbances is quite similar to that of magnetic storms, at least of gradually commenced storms (Sg-storms) can be led. Thus, it is undoubtful that the magnetic bay disturbances are not a purely proper phenomenon in the dark hemisphere, but are caused by a solar plasma flows as the case of magnetic storms. This is also concluded in our other study on "Solar cycle variation in occurrence of geomagnetic bays" (Ondoh and Sano 1966)[24].

(2) Occurrence correlations of bay disturbances between College and Honolulu.

The correlations of occurrence between three kinds of bay disturbance at College and corresponding isolated positive and negative bays at Honolulu for the years 1956 and 1958, are investigated. Namely, when each kind of bay disturbance occurs at College, it is examined whether or not corresponding bays occur at Honolulu. The results are shown in Fig. 10, where the frequency of the simultaneous occurrence and the frequency of no correlation are represented by open pillars and hatched ones, respectively. The upper, middle and lower parts of Fig. 10 are the

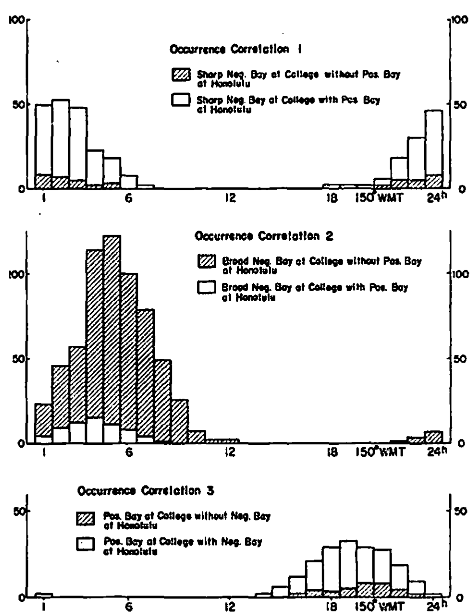


Fig. 10. Occurrence correlation between three kinds of magnetic bay disturbance at College and the corresponding negative and positive bays at Honolulu for the years 1956 and 1958.

occurrence frequencies for the sharp negative bay, broad negative bay and positive bay, respectively.

Fig. 10 indicates that the correlation of occurrence frequency is quite good between the sharp negative bays at College and the isolated positive bays at Honolulu, but it is very bad between the broad negative bays at College and the positive bays at Honolulu. It is moderate between the positive bays at College and the negative bays at Honolulu, though the latter bays are not clearly identified in many cases because of superposition of Dst-field decreases discussed already.

In conclusion, it is very notable that only the sharp negative bay at College accompanies almost always the typical positive bay at Honolulu. This fact is recognized from the statistical evidence that the characteristics of occurrence feature of sharp negative bays in the auroral zone are quite similar in occurrence local time or in frequency to those of positive bays in middle or low latitudes. From the above result, it should also be noted that the sharp negative bay is essentially different from the broad negative bay and positive bay disturbances in the auroral zone as discussed in the preceding sections.

Appendix

We received just before the printing a reprint of the paper "On the low latitude 'negative bays' in the afternoon sector" by Akasofu (1965)[25]. He has concluded that the low latitude negative bay in the afternoon sector is not caused by the return current from the polar electrojet, but is the field of the simultaneously growing asymmetric main phase decrease. This conclusion is essentially consistent with ours led on the Dst-field during the polar bay disturbance in the preceding section.

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地磁気湾型変化の発達とそれにともなう *f*min 増加について

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概　要

地磁気湾型変化の形態とそれに伴なう電離層の *f*min 増加領域との関係を調査した。結果は真夜中から日中にかけて起こる両現象は非常に対応がよく，一般に地磁気擾乱がかなり発達してから *f*min 増加領域が出現し，その領域は地磁気擾乱パターンに密接な関係を持って出現し変化する。地磁気湾型変化の3つの種類におのおの対応する *f*min 増加が比較的はっきりと区別され，その特性もある程度明らかになった。これらの結果と最近の磁気圏の磁場および高エネルギー粒子観測結果，報告されている理論的結果を比較し，これらの現象の概要について簡単に議論した。

最後に，地磁気湾型変化時の Dst-field の発達および高緯度湾型変化と低緯度湾型変化の出現の対応性についての簡単な統計結果について報告した。地磁気湾型変化の形態も地磁気嵐のそれとほとんど同じであることが明らかになった。

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