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*Frequency Analysis of Geomagnetic Micropulsations Associated with ssc and pi 2**

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Abstract: In order to make a frequency analysis of geomagnetic micropulsations associated with ssc and pi 2, the micropulsation signals recorded on magnetic tapes at Onagawa (Japan), College (Alaska), and Maui (Hawaii) are reproduced with the transport speed faster than the recording speed. Dividing into several channels of band pass filters, these signals corresponding to the original periods from 3 to 250 seconds are recorded by a multi-channel pen-writing recorder.

The micropulsations associated with ssc are most predominant with the longest period band (~200 sec), in which the waveform shows very clear damped type oscillations. The two sets of the micropulsation signals observed simultaneously at Onagawa and College exhibit quite similar waveforms to each other in every period band notwithstanding the difference of the two stations in both latitude and local time. On the other hand, the pi 2 waveform only for the 100 sec band shows distinct resonant oscillations with quite similar pattern at both stations. Impulsive type oscillations are found at the beginning part of the pi 2 pulsations.

It is concluded that the shock front of the plasma cloud from the solar flare impacts first the outer boundary of the sunlit side of the magnetosphere, where a damped type hydromagnetic oscillation is excited and is propagated partly along the geomagnetic field lines to the high latitudes and partly normally to the night side magnetosphere. The source of pi 2 pulsations is assumed to be located at a vicinity of about $L=5.5$ on the night side magnetosphere. The hydromagnetic burst which is excited by an instability due to a particle pressure overcoming the magnetic pressure at the vicinity of the partial ring current in the night side magnetosphere will impact first the magnetic field line on the plasmapause. Therefore the impulsive type of the hydromagnetic perturbation is observed first at the beginning part of pi 2 and then the resonant oscillation of the magnetic field line through the vicinity of the auroral zone, whose period is about 100 sec, is observed distinctly.

1. Introduction

The author carried out a frequency analysis of geomagnetic micropulsations associated with ssc and pi 2 to clarify their characteristics. The micropulsations detected by induction magnetometers were recorded on magnetic tapes at Onagawa (Japan), College (Alaska), and Maui (Hawaii). The micropulsation signals reproduced with the transport speed faster than the recording speed are devided into several channels by band pass filters and recorded with a multi-channel pen-writing galvanometer. These filtered waveforms are compared with the dynamic spectra obtained by the missilyzer. Based on the analysis with these instruments, a model

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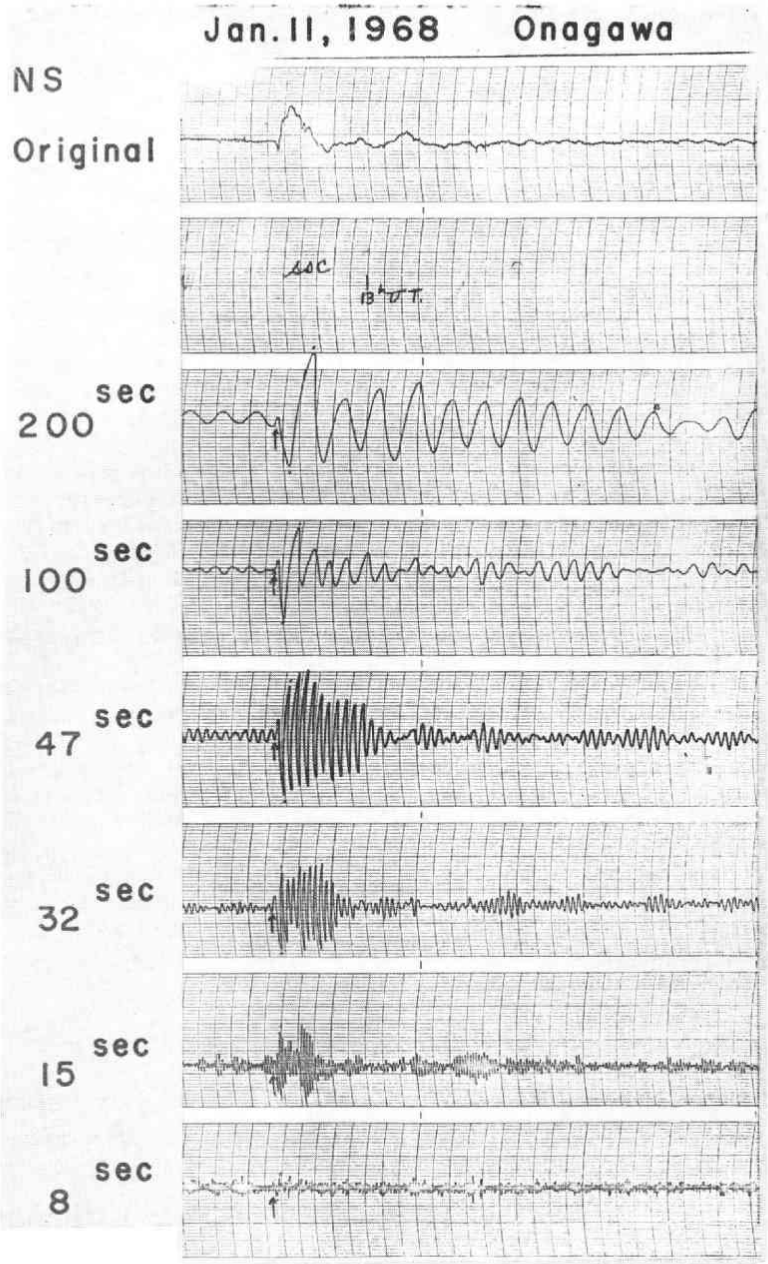

Fig. 1. Frequency analysis of ssc of Jan. 11, 1968 observed at Onagawa (NS component).

on the occurrence mechanism of the micropulsations associated with ssc and pi 2 will be proposed and discussed.

2. Characteristics of Geomagnetic Micropulsation Associated with ssc

Original record of the micropulsation associated with ssc of January 11 (U.T. 12^h

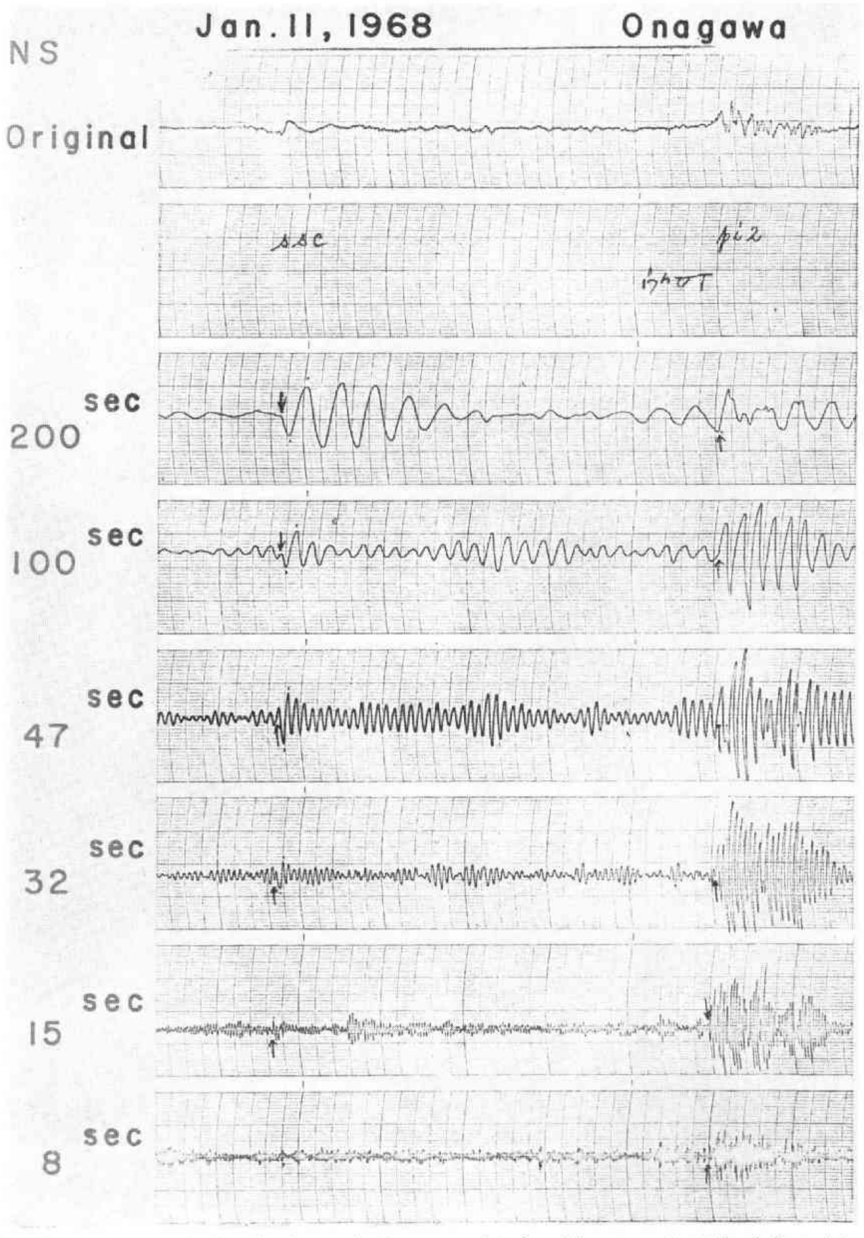

Fig. 2. Frequency analysis of micropulsation associated with ssc and pi 2 of Jan. 11, 1968 observed at Onagawa (NS component).

50^m), 1968, observed with the induction magnetometer at Onagawa is shown at the top of Figure 1. The filtered waveforms of the oscillations corresponding to the original periods of 200. 100, 47, 32, 15 and 8 seconds are separately recorded as shown in Figure 1. The top of the figure indicates northward increase for the original waveform, while southward for the filtered waveforms.

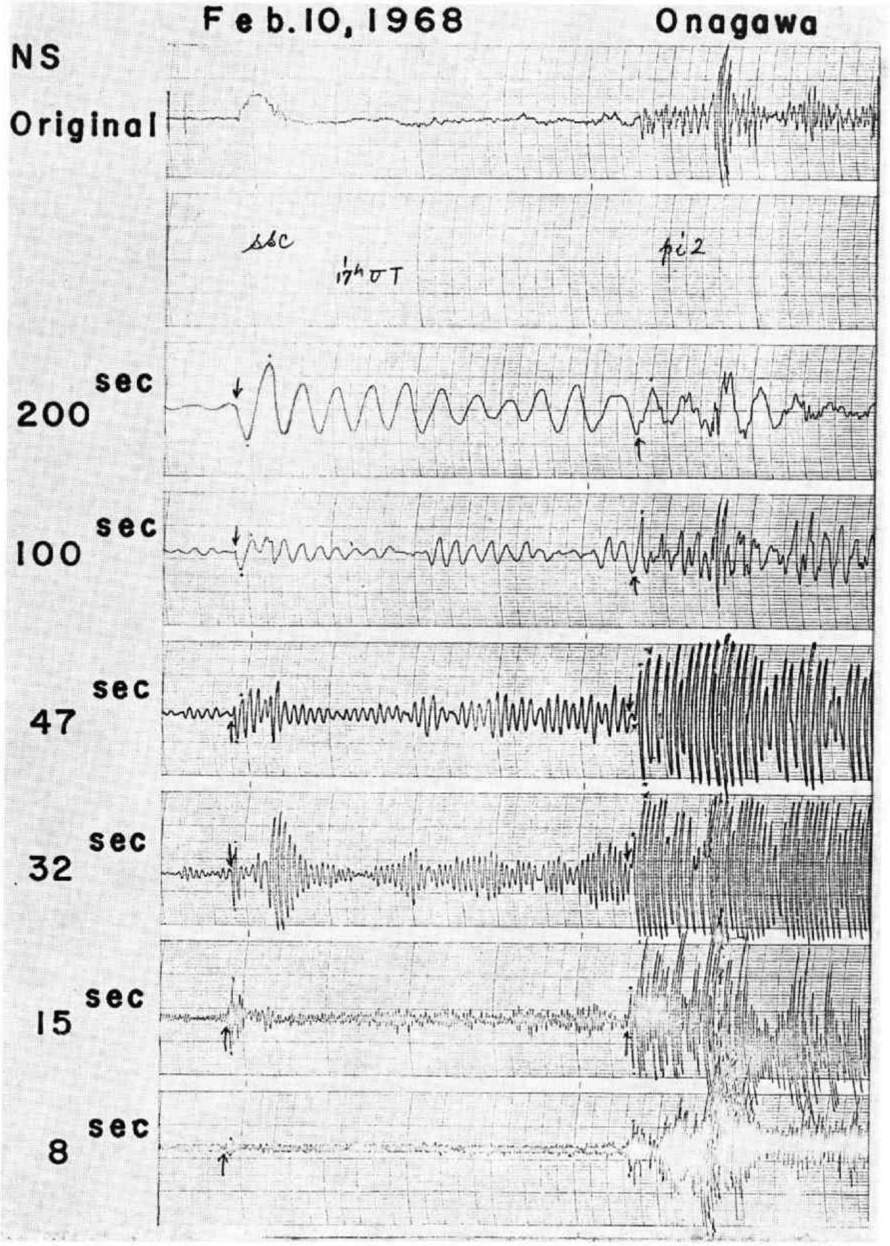

Fig. 3. Frequency analysis of ssc and pi 2 of Feb. 10, 1968 observed at Onagawa (NS component).

The waveform in the 200 sec band is most predominant and shows very clear damped type oscillation. This character is one of the most distinct characteristics of the micropulsation associated with ssc. Figures 2 and 3 are other examples of the micropuslations associated with ssc's which occurred on January 11 (U.T. 16^h20^m), 1968 and February 10 (U.T. 16^h50^m), 1968, respectively. Clear damped type oscillations

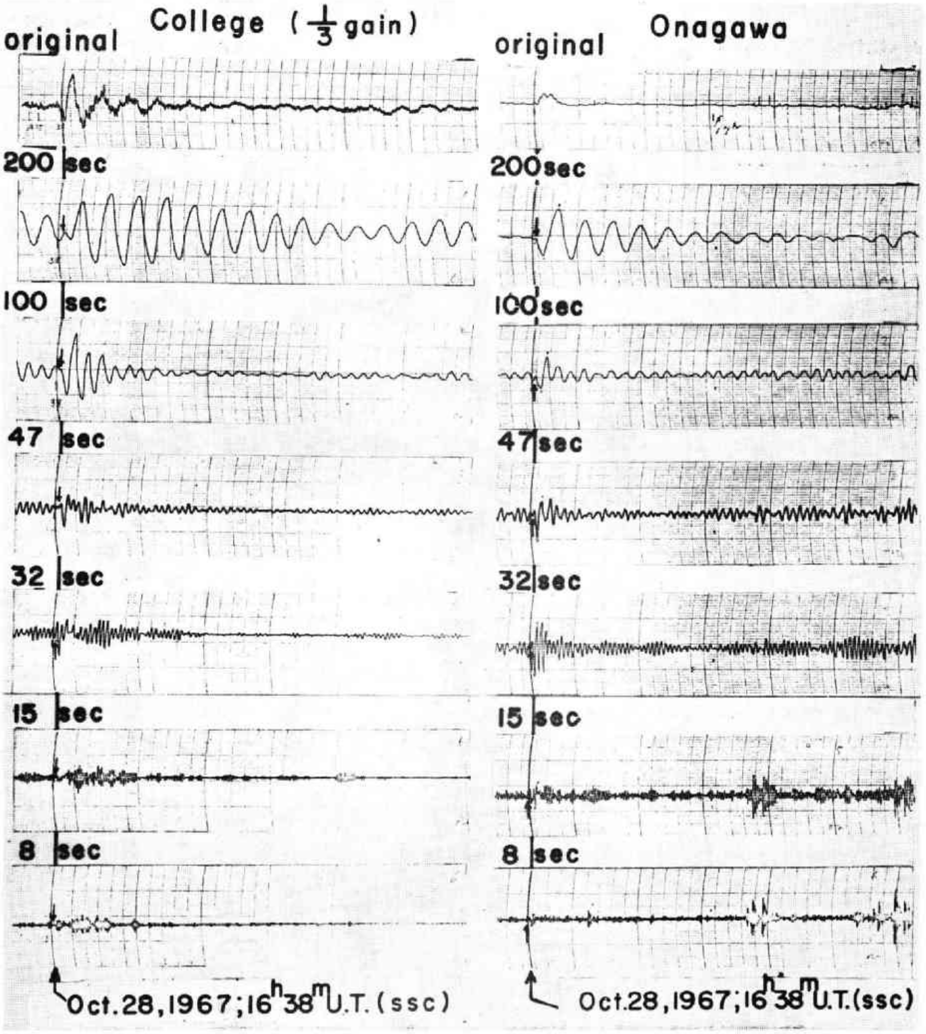

Fig. 4. Frequency analysis of micropulsation associated with ssc of Oct. 28, 1967 observed with the induction magnetometers at College, and Onagawa simultaneously. Origina record of NS component is at the top and the waveforms of oscillations of different perid bands are shown below. Upward is positive for original record and downward is positive for each waveform of different periods.

with the period of 200 sec are very distinctly observed also in both cases. These characteristics are always seen in every ssc without exception. The results of the frequency analysis of ssc micropulsations simultaneously observed at College and Onagawa on October 28, 1967 are intercompared in Figure 4. The original waveforms at both stations show different appearances; the so-called daytime ssc pulsation at College (the local time is 6^h38^m in Alaska), while the nighttime ssc pulsation at Onagawa (the local time is 1^h38^m). On the other hand, the filtered waveforms at the two stations show quite similar to each other notwithstanding the difference in the

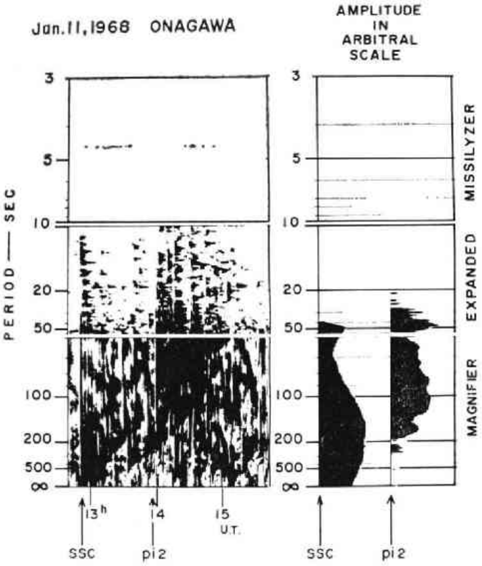

Fig. 5. Dynamic spectum and a-f diagram of ssc and pi 2 of Jan. 11, 1968 observed at Onagawa (NS component).

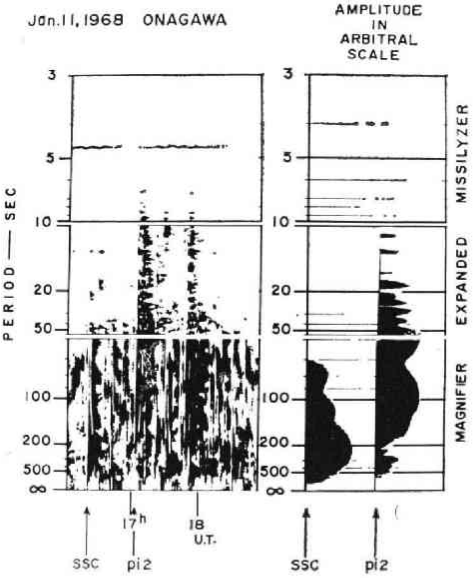

Fig. 6. Dynamic spectum and a-f diagram of ssc and pi 2 of Jan. 11, 1968 observed at Onagawa (NS component).

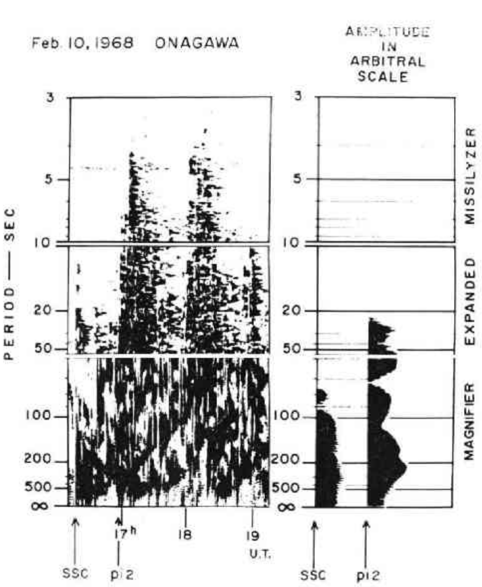

Fig. 7. Dynamic spectum and a-f diagarm of ssc and pi 2 of Feb. 10, 1968 observed at Onagawa (NS component).

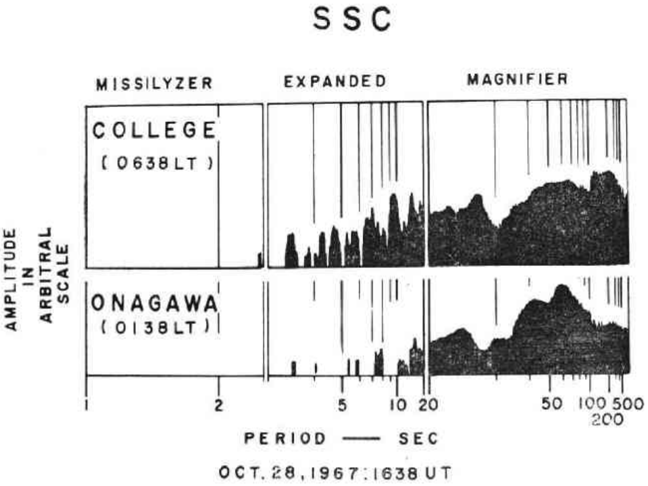

Fig. 8. Comparison of a-f diagram of micropulsation associated with ssc of Oct. 28, 1967 observed at College and Onagawa (NS component).

latitude and the local time at both stations, suggesting that the micropulsation associated with ssc is a global scale oscillation. These characteristics of the ssc micropulsations deduced from the filtered waveforms are confirmed by the dynamic spectra as seen in Figures 5, 6 and 7. As the figures show the amplitudes of the long period component above 200 sec are most predominant and quite different from those of pi 2's. Amplitude-frequency diagrams of an ssc micropulsation simultaneously observed at College and Onagawa are compared in Figure 8. The general feature of these dynamic spectra of the records at both stations is almost similar as discussed already.

It is concluded from these frequency analyses that the shock front of the plasma cloud from the solar flare will first impact the outer boundary of the magnetosphere and the hydromagnetic perturbations excited by this impact will propagate to the high latitudes along the magnetic field lines and also to the night side magnetosphere. The above-mentioned damped type hydromagnetic perturbation of 200 sec, found by the frequency analysis, is a global scale perturbation which is excited at the outer boundary of the magnetosphere.

3. Characteristics of Geomagnetic pi 2 Micropulsations

As seen in both Figures 2 and 3, pi 2 micropulsations are also recorded about one hour after the ssc's. As shown in the figures, the pi 2 waveforms of the long period component in the 200 sec band shows no resonant oscillations in contrast to the ssc micropuslations while those in the 100 sec band show very distinct resonant oscillations. Dynamic spectra of pi 2 in Figures 5, 6 and 7 show also that the amplitude of the oscillation with the period of about 100 sec is most predominant. The filtered waveforms of a pi 2 event observed simultaneously at College and Onagawa are intercompared in Figure 9. It is very interesting that the waveform of the period of 100

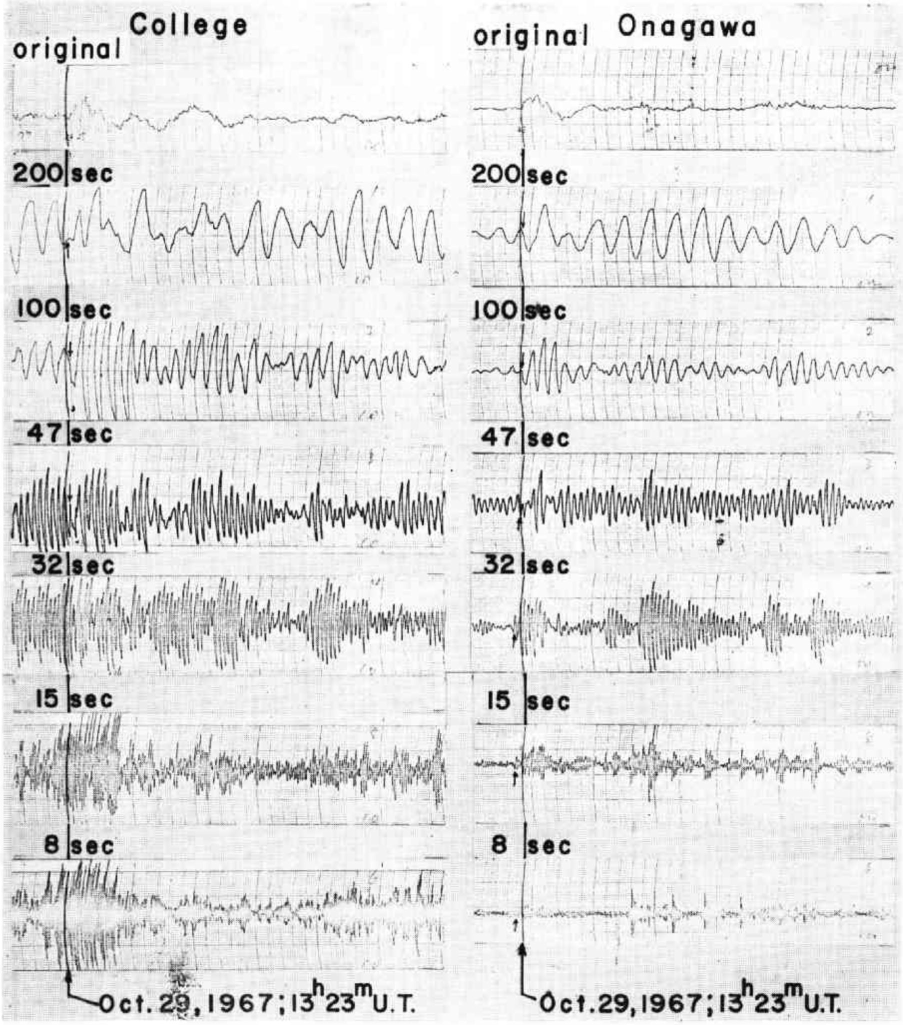

Fig. 9. Comparison of frequency analysis of pi 2 of Oct. 29, 1967 observed at College and Onagawa simultaneously.

sec is quite similar at College and Onagawa, notwithstanding the difference of latitude and local time of both stations. This means that the oscillation of 100 sec is the global scale or fundamental oscillation of pi 2. At College the short period oscillation ($T \approx 8$ sec) is predominant and is due to the precipitation of the auroral particles into the auroral zone.

Figures 10 and 11 show frequency analyses of pi 2 observed at Maui, Hawaii on May 18 and May 25, 1965, respectively. It is very interesting that the impulsive type oscillations are recorded at the beginning part of the oscillations. This type of oscillations are clearly found on the waveform in the period bands shorter than 20 sec as shown by the arrows. This suggests that some kind of shock type pulse occurred abruptly at the beginning of the pi 2 pulsation.

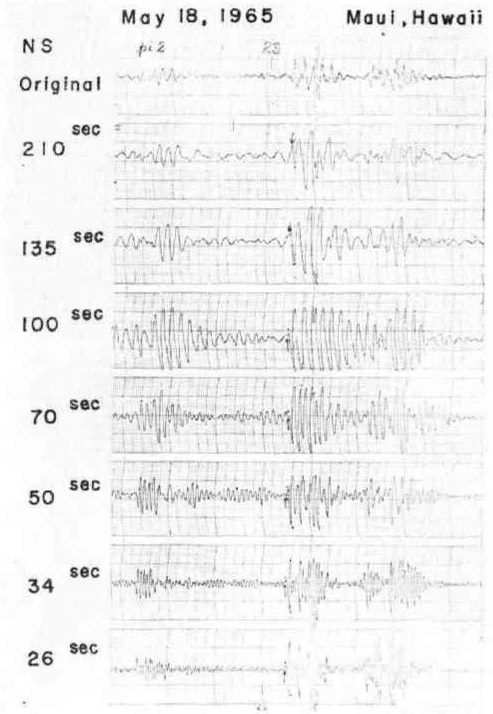

Fig. 10a. Frequency analysis of pi 2 of May 18, 1965 observed at Maui, Hawaii (NS component).

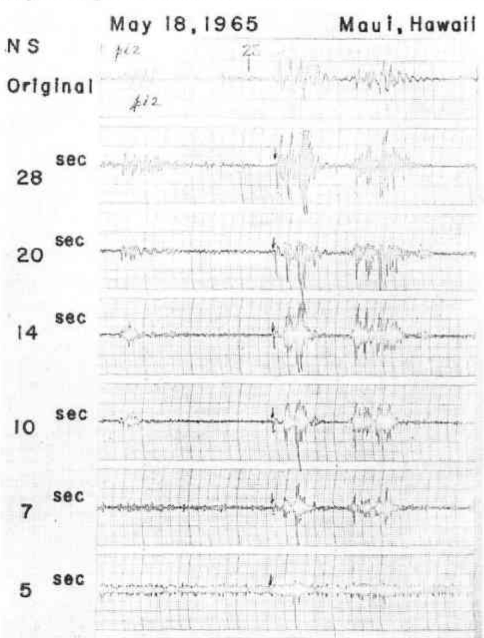

Fig. 10b. Frequency analysis of pi 2 of May 18, 1965 observed at Maui, Hawaii (NS component).

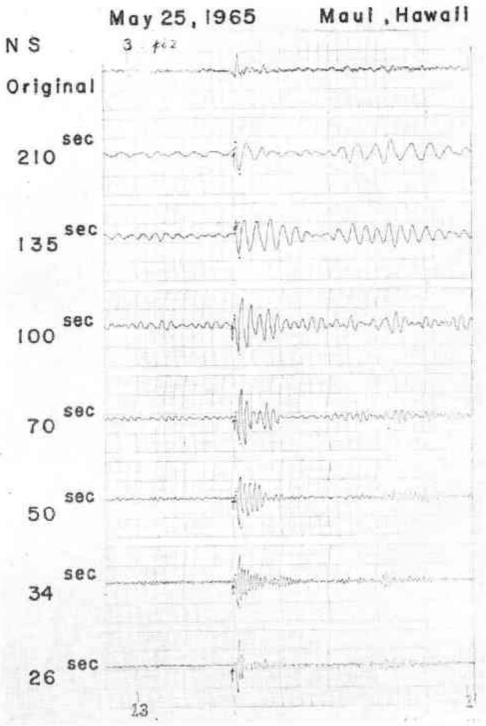

Fig. 11 a.

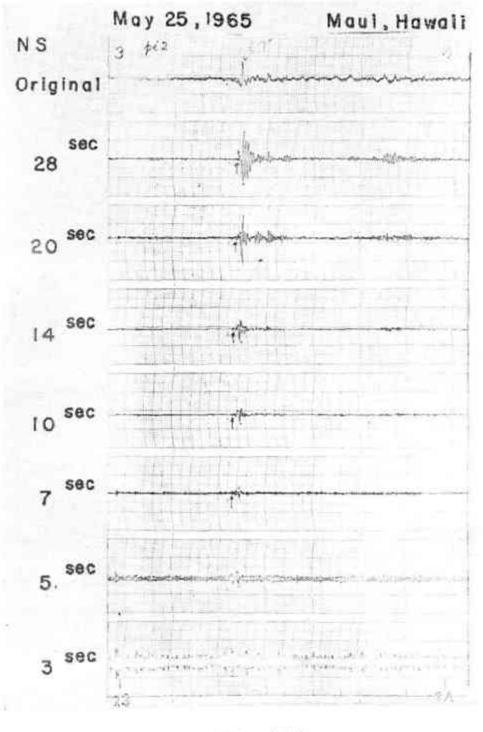

Fig. 11 b.

Fig. 11 c.

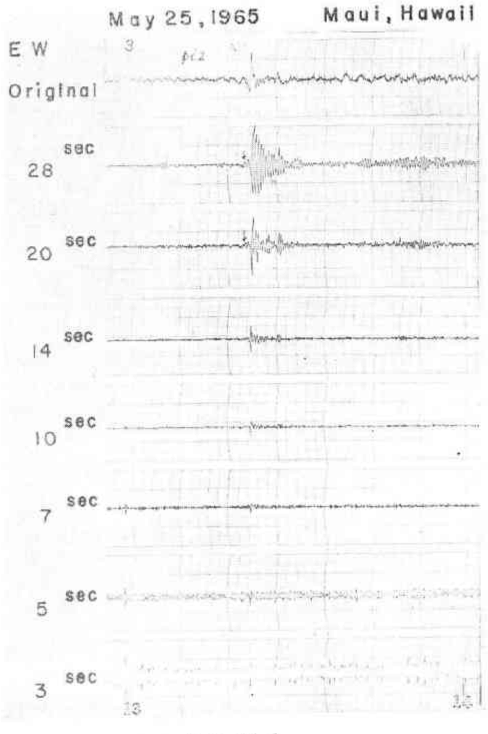

Fig. 11 d.

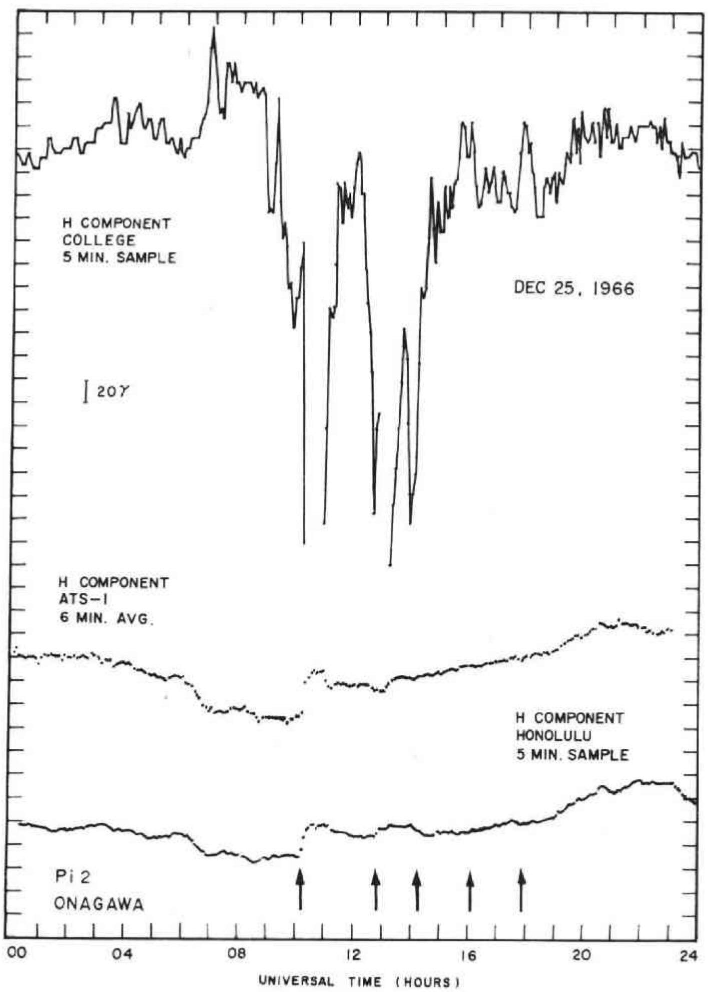

Fig. 12. Magnetospheric substorm observed at the synchronous orbit (after W.D. Cummings et al.) and comparison with occurrence of pi 2 observed at Onagawa (which is shown by the arrows).

It is concluded by this frequency analysis that pi 2 pulsation is excited first by some kind of burst and then a semi-global scale oscillation with the period of about 100 sec is excited in the night side magnetosphere. According to the observations by ATS satellite, the decreasing of the magnetic field observed at the vicinity of the partial ring current at the time of the magnetospheric substorm corresponds to the increasing of the groundbased magnetic field which precedes the bay disturbance. This is the

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Fig. 11a. Frequency analysis of pi 2 of May 25, 1965 observed at Maui, Hawaii (NS component).

Fig. 11b. Frequency analysis of pi 2 of May 25, 1965 observed at Maui, Hawaii (NS component).

Fig. 11c. Frequency analysis of pi 2 of May 25, 1965 observed at Maui, Hawaii (EW component).

Fig. 11d. Frequency analysis of pi 2 of May 25, 1965 observed at Maui, Hawaii (EW component).

precursor event of auroral substorm. Pi 2 occurs just at the beginning part of the bay disturbance. Actually pi 2 pulsations are recorded at Onagawa as shown by the arrows in Figure 12.

Density of particles in the plasma flow in the night side magnetosphere will first increase at the time of the magnetospheric substorm and then the intensity of the partial ring current becomes to increase as observed by ATS. Then the intensity of the magnetic field near the partial ring current in the magnetosphere becomes to decrease. An instability will grow up due to the increasing of particle pressure of the plasma flow against the decreasing of the magnetic pressure at the vicinity of the partial ring current and then some kind of hydromagnetic burst will be excited by this instability. The hydromagnetic burst will first impacts the magnetic field line inside the partial ring current. The hydromagnetic oscillations with the period of 100 sec will be excited and propagate to the auroral zone along the magnetic field line. The impulsive pulsations also first propagate at the beginning part of pi 2. The sense of the polarization of the field vector of pi 2, observed at College shows the counterclockwise rotation when pi 2 occurs before midnight and shows clockwise rotation when it occurs after midnight as shown in Figure 13. This is consistent with the above-discussed mechanism of the occurrence of pi 2. The sense of the polarization of the magnetic vector of pi 2 pulsation does not show a distinct characteristics at Point Barrow, because the source of pi 2 is located inside the partial ring current. The magnetic field lines through the

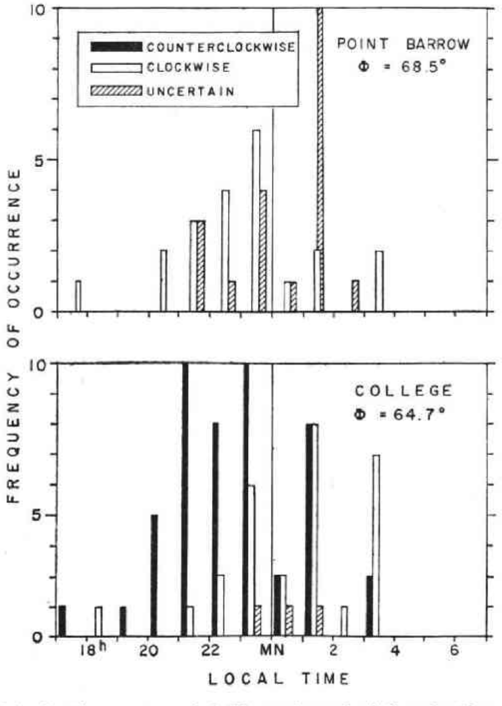

Fig. 13. Polarization sense of field vector of pi 2 pulsation at College.

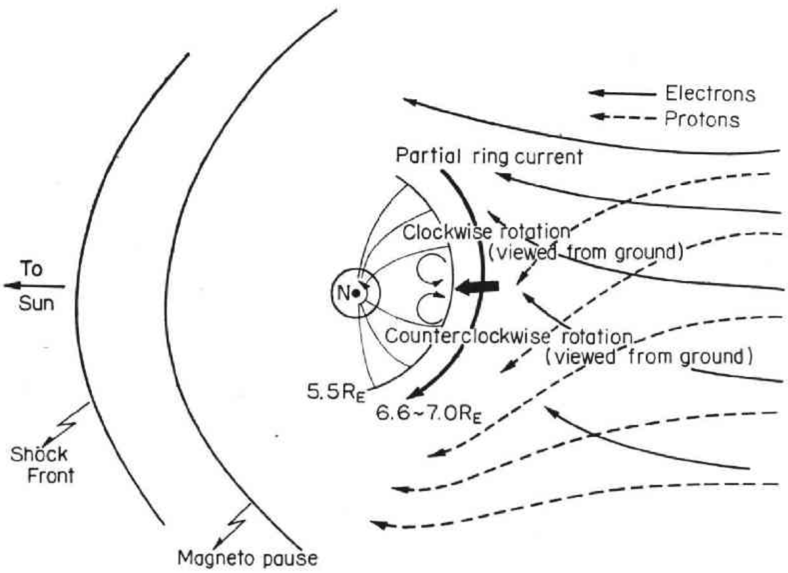

Fig. 14. Schematic representation of the excitation source of pi 2 pulsation.

vicinity of Point Barrow pass outside the partial ring current. Figure 14 shows the schematic diagram of the occurrence mechanism of the pi 2 pulsation.

4. Conclusion

The frequency analysis of the geomagnetic micropulsations associated with ssc and pi 2 was carried out in order to clarify the characteristics of these micropulsations. The micropulsation signals recorded on the magnetic tapes are reproduced by the speed faster than the recording speed through the band pass filters corresponding to the original periods of 200, 100, 47, 32, 15 and 8 seconds. The filtered waveforms of the micropulsations associated with ssc and pi 2 are registered individually by the multichannel pen-writing recorder.

The frequency analysis of micropulsations associated with ssc clarified the following characteristics. The wave spectrum of long period of 200 sec is most predominant and shows very clear damped type oscillation. This is the fundamental mode of oscillation of the pulsations associated with ssc and these waveforms in each period are quite similar at both stations of College (Alaska) and Onagawa (Japan), notwithstanding a difference in latitude and local time. It is concluded that the shock front of the plasma cloud from solar flare will first impact the outer boundary of the magnetosphere on the sunlit side and a hydromagnetic oscillation excited by this impact will propagate along the magnetic field line to high latitudes and also propagate normally to the night side magnetosphere. Thus the oscillations with the period longer than 200 sec are fundamental mode and show very clear damped type oscillations. These oscillations show quite similar waveforms at both stations, College and Onagawa.

On the other hand the frequency analysis of the micropulsation pi 2 clarified the following characteristics. The waveform of long period of 200 sec does not show any resonant oscillation, while the waveform with the period of about 100 sec shows very clear resonant oscillation, suggesting that this is the fundamental mode of the micropulsation pi 2. Another interesting characteristics of pi 2 is that the impulsive shock type pulsations are observed at the beginning part of pi 2 and this impulsive shock is supposed to be excited by some kind of hydromagnetic burst.

It is concluded that the intensity of the plasma flow in the night side magnetosphere will increase at the time of magnetospheric substorms and the instability is growing up by this increasing of particle pressure of the plasma flow against the magnetic pressure at the vicinity of the ring current found by ATS. Thus the hydromagnetic burst excited by this instability will first impact the magnetic field lines in the vicinity inside the partial ring current. Therefore the impulsive shock type pulsation is observed first at the beginning part of pi 2 and then the resonant oscillation of the period of about 100 sec is observed as a fundamental mode of pi 2, and this mode is observed at both stations College and Onagawa simultaneously as a quite similar oscillation. Other short period oscillation observed at high latitude is excited by precipitation of auroral particles. The polarization of field vector of pi 2 is also explained by the above-discussed mechanism.

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