The Variation of the Atmospheric Electric Field at the time of Earthquake

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1. Introduction

It is known that the luminous phenomenon may appear at the time of earthquake, but the real existence of it seems to be very doubtful on the geophysical point of view. And a very few scientific papers have been reported on the occurrence of it and/or the research of it's origin.

Recently, when the Matsushiro earthquakes were active, some luminous phenomena were pictured photographicaly by Mr. Kuribayashi, dentist in Matsushiro Town. Then, the existence of this phenomenon is demonstrated using the pictures or other data by Y. Yasui (pp. 25 of this Journal).

Following the poinner works of Terada (1931) and Shimizu (1932), this phenomenon seems to be originated in some geoelectrical change caused by the earthquake. The purpose of the present study is to check it's origin using the observation of atmospheric electric field on the surface near the epicenter of earthquake. Unfortunately there was no report on the luminous phenomenon through the period of the observation, so we could not get the key of the search for it's origin. Here, the results of the observation are reported in connection with the earthquake.

2. The observation at Matsushiro

The atmospheric electric field on the surface was recorded with the field mill from October to November 1966 at the Matsushiro Seismological Observatory (138° 13′ E, 36° 33′ N, 400m hight). The observation site was not so flat, but the reduction to normal plane was not carried out.

Fig. 1 is the map of Matsushiro and it's neighbourhood. The observatory is in a bosom of hills and the north way of the bosom is open. In this direction there is the Matsushiro Town and Nagano City is situated far away on the other side of the Chikuma River.

I) The daily variation of atmospheric electric field at Matsushiro. The mean daily variation of 6 days is shown in Fig. 2. These days are picked up under the conditions that the weather is fairly calm, that the variation of the field is rather

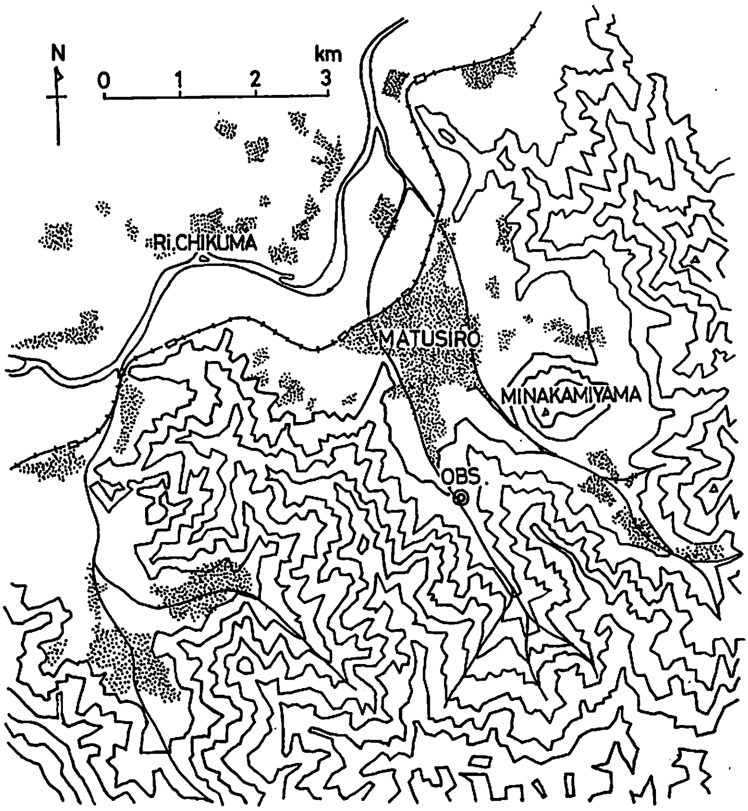

Fig. 1 The map around Matsushiro.

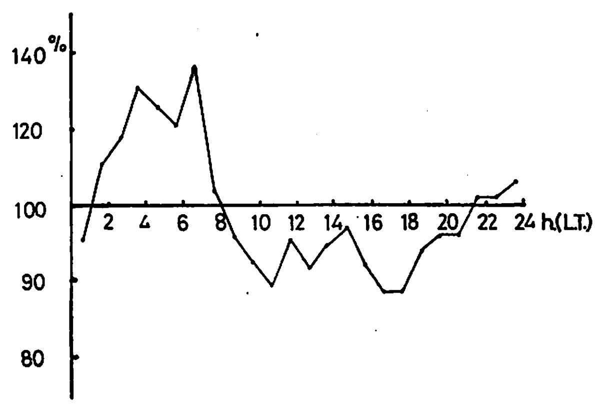

Fig. 2 The mean daily variation of atmospheric potential gradient at Matsushiro, Oct. Nov., 1966.

smooth and that the negative field is not observed. This variation seems to be similar to the Kakioka's variation, but sometimes negative field is observed during the period from about 10 to 17 o'clock in spite of the fine weather. It seems that the negative field is caused by the negatively charged exhaust gas coming from the industrial area near Nagano City. The atmospheric electric condition at the observatory seems to be almost normal except the time of such negative field.

II) The variation of the electric field at the time of earthquake. Fig. 3. shows the records of electric field obtained when the earthquakes of the intensity scale II or more occurred. These variations are classified according to the form of the change as follow.

The form of variation	Number of case
no change	22
decreased	46
increased	1
pulsive	2
other type	7
total	73

There are, of course, rather frequently fairly large variations of the electric field even if the earthquake did not occur. So, it can not be said that all of the listed variations are originated on the earthquakes, but at the least it can be said that if the earthquake produces the variations of the atmospheric electric field, the decreased type variation will be more frequent. The variation of the field is about 10~20 per-cent of normal level.

In order to see the change of occurrence probability of the decreased field, the ratio of n/N is shown in Fig. 4., where n is the number of the earthquake which follows the decrease of field and N is the total number of the earthquake of the intensity scale II or more in every 10 days. The total number of all earthquakes during every 10 days (ne) is shown in the figure too.

These two curves are almost parallel, so it can be said that the more earthquakes are active, the more frequently the decreased variations occur. Some exsamples of the clear decreased variations are shown in Fig. 3, such as 11-12 h, 3 rd Oct.; 16-17 h, 5 th Oct.; and 13-14 h, 2 nd Nov.

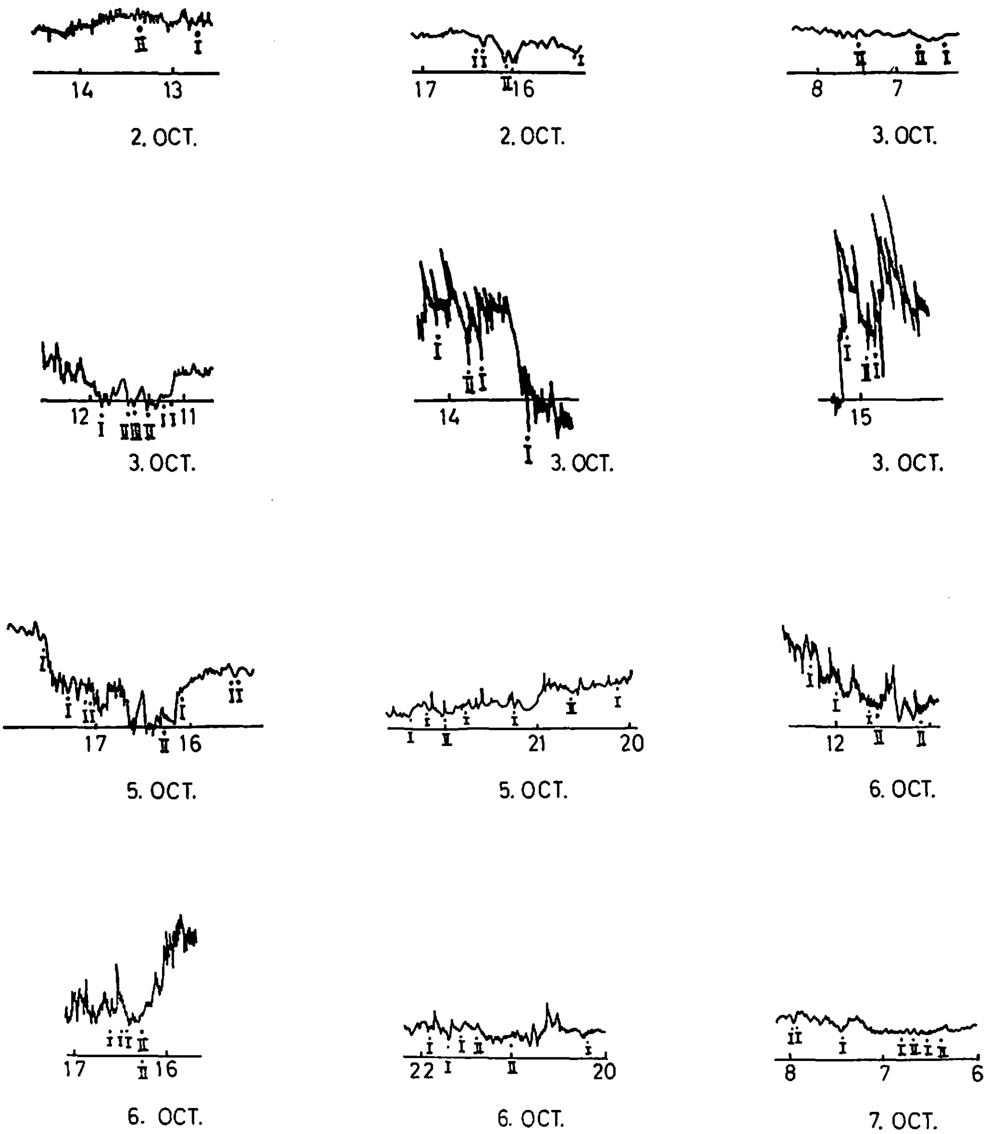

Fig. 3a Recrds of atmospheric potential gradient at Matsushiro.

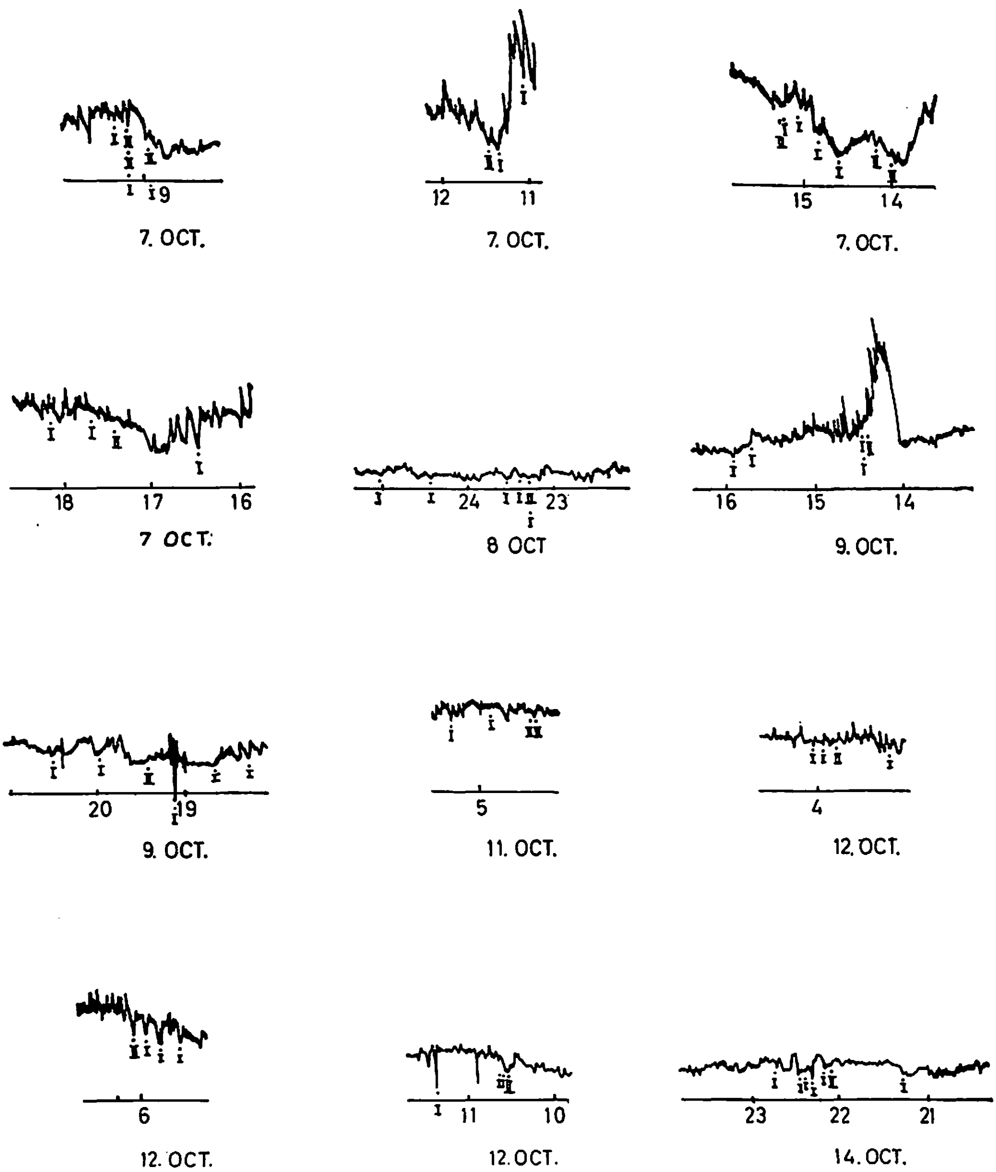

Fig. 3b Records of atmospheric potential gradient at Matsushiro.

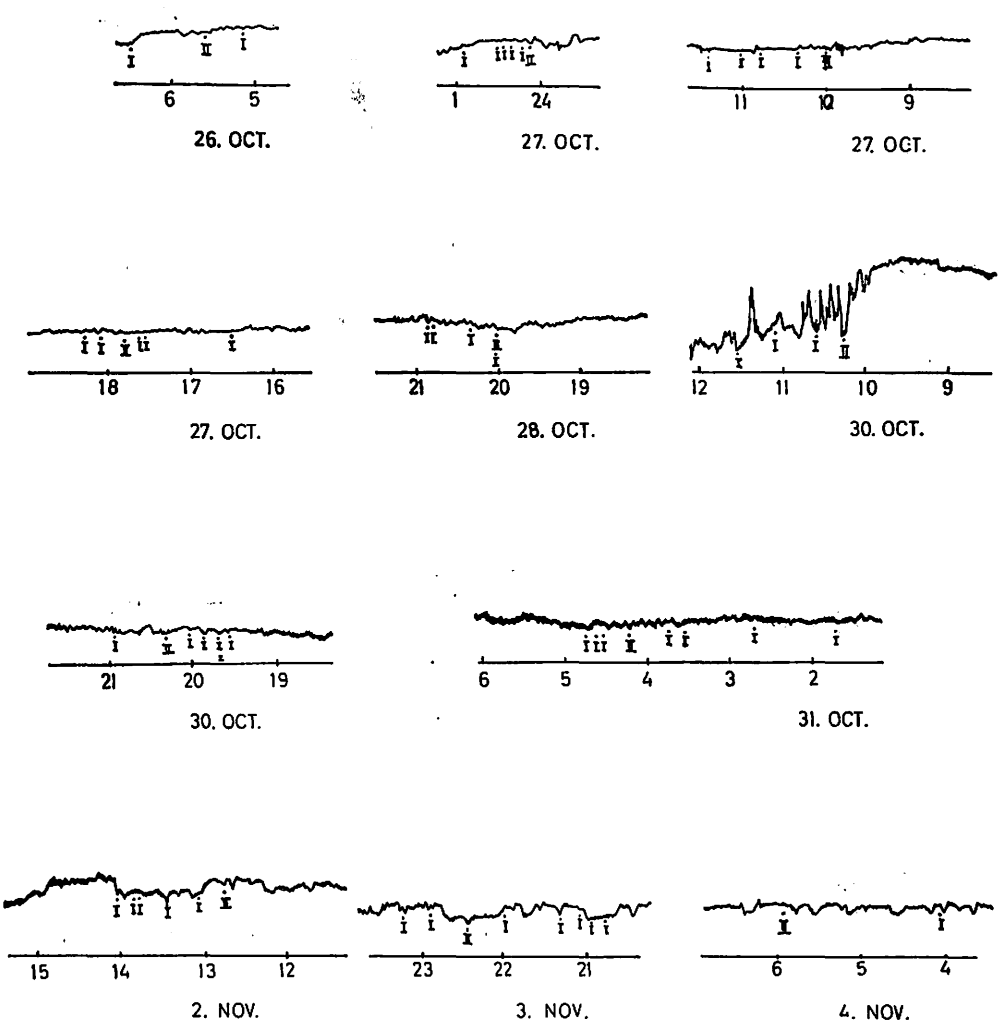

Fig. 3c Records of atmospheric potential gradieient at Matsushiro.

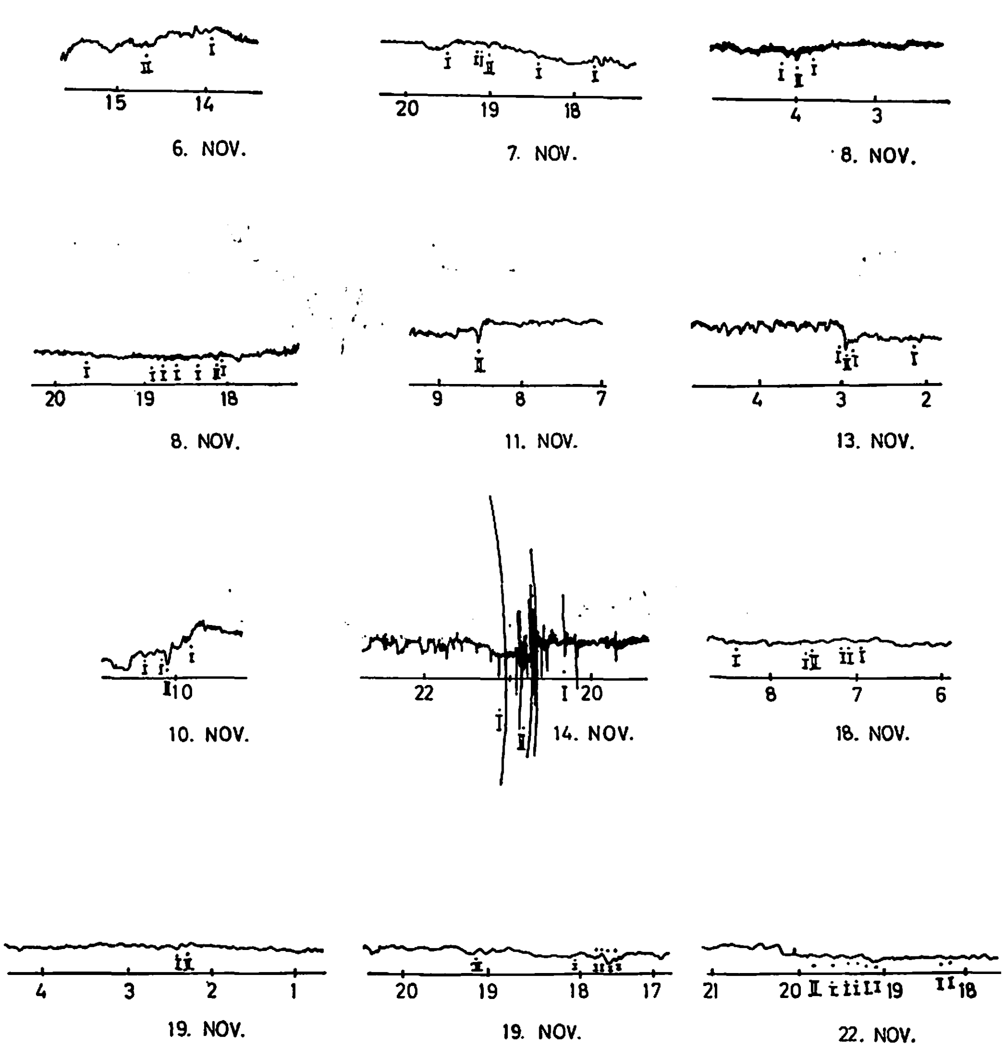

Fig. 3d Records of atmospheric potential gradient at Matsushiro.

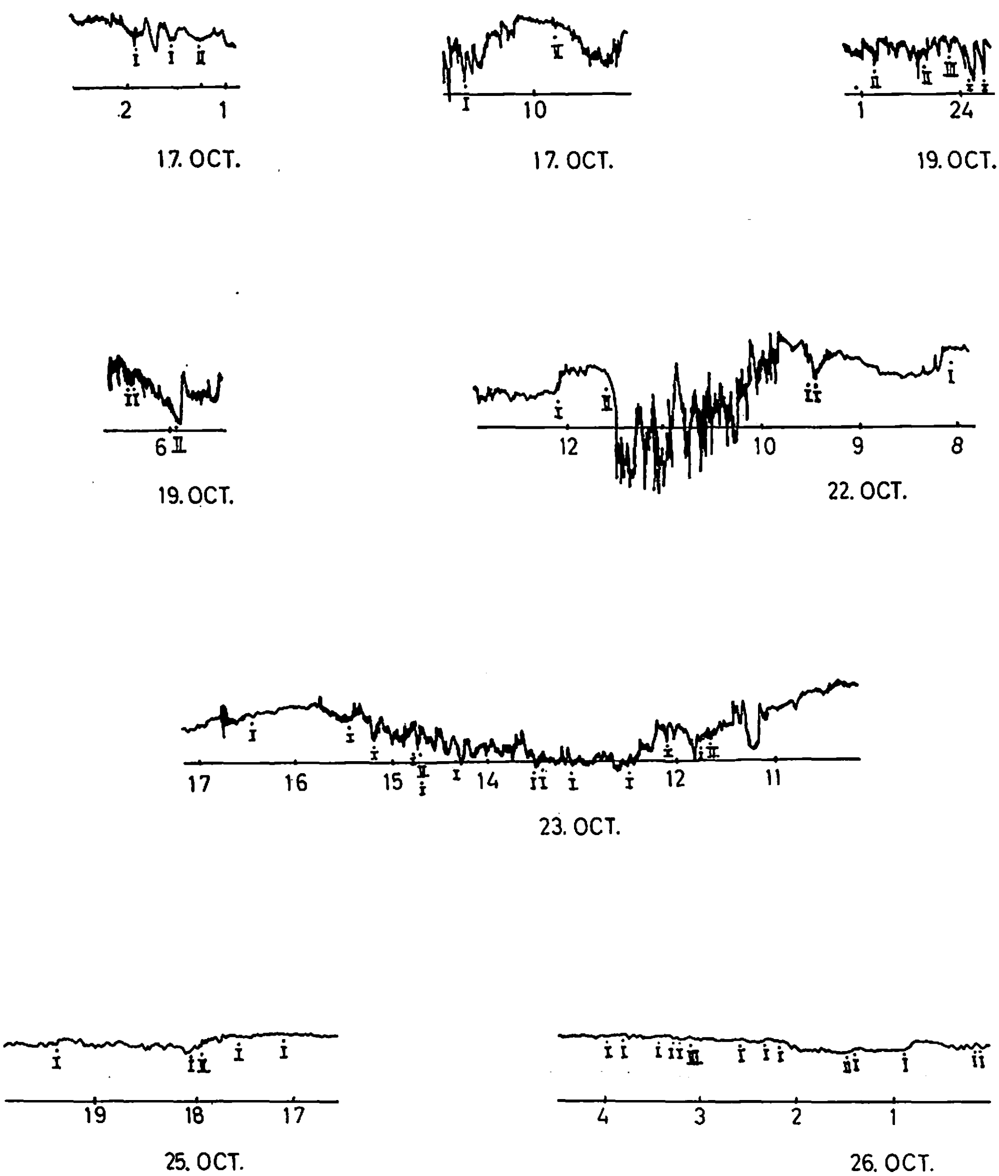

Fig. 3e Records of atmospheric potential gradient at Matsushiro.

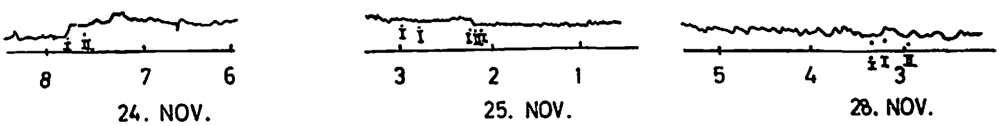

Fig. 3f Records of atmospheric potential gradient at Matsushiro.

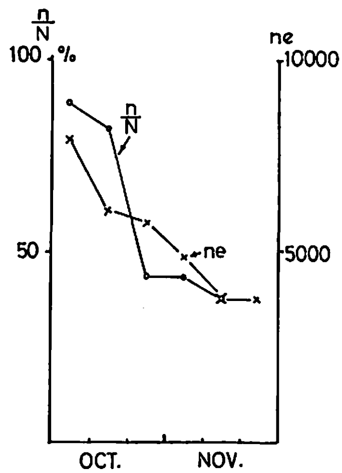

Fig. 4 The variation of occurrence probabaily of the decreasing variation of the potential gradient accompanied with earthquake.

3. The observation at the top of Mt. Tsukuba

By the Y. Yasui's report, most of luminous phenomena appear at the top of hill. The observation of the electric field was carried out at the Tsukuba Meteorological Observatory on the top of Mt. Tsukuba, which is situated at about 8 km westerly from Kakioka Obsĕrvatoy. The purpose of this observation is to study what change of the field will occur at the top of the hill when earthquake occurs and to check the results obtained at Matsushiro.

4. Discussion

In the normal electric condition, the Ohm's law connects the atmospheric electric field E to the atmospheric electric conductivity λ and air-earth current i; that is

$$E=\frac{i}{\lambda}$$

The air-earth current is changed by the ionospheric electric potential or by the columnar electric resistance from the ground to the ionosphere. In this case, the

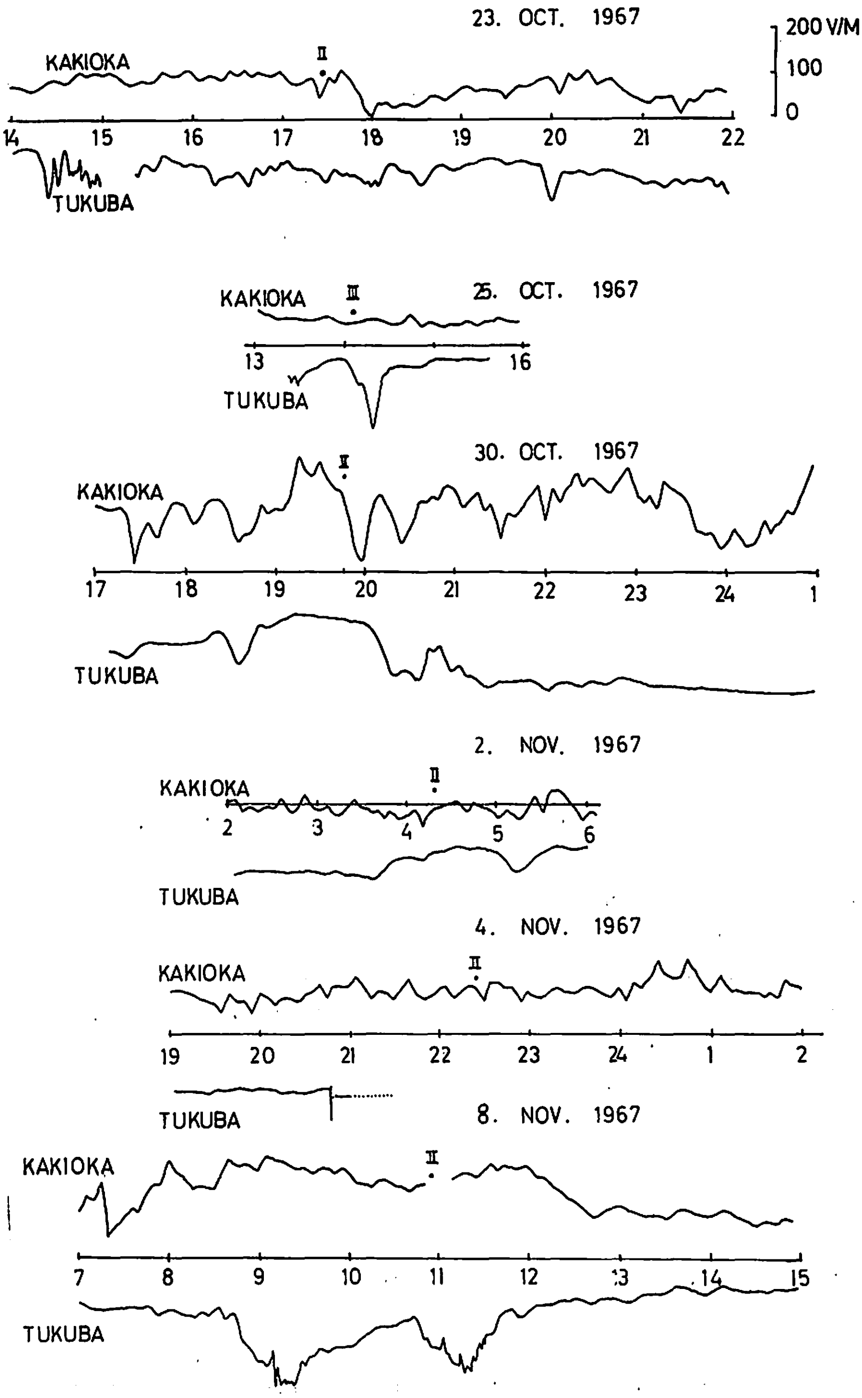

Fig. 5a Records of atmospheric potential gradient at Kakioka and Tsukuda.

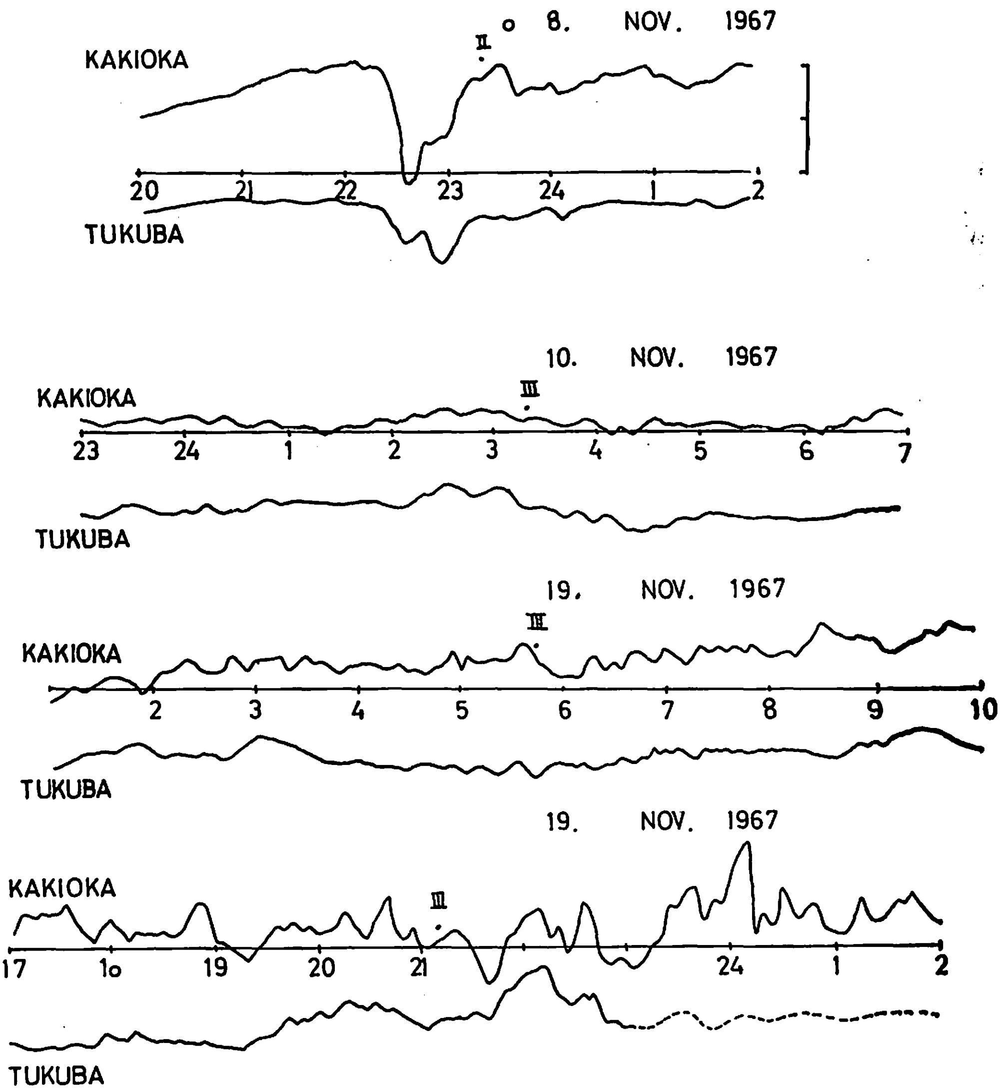

Fig. 5b Records of atmospheric potential gradient at Kakioka and Tsukuba.

air-earth current can be assumed to be unchanged by the earthquake. Then we get,

$$\frac{\Delta E}{E}=-\frac{\Delta\lambda}{\lambda}$$

According to the ebservation at Matsushiro $\frac{\Delta E}{E}$ is about$-10\sim20\%$. Then the $\frac{\Delta\lambda}{\lambda}$ in $+10\sim20\%$. If it is assumed that the mormal value of the conductivity is 2×10^{-14} $\mho$/m, $\Delta\lambda$ is $0.2\sim0.4\times10^{-14}$ $\mho$/m. Under the normal ion-equilibrium condition, this increase of conductivity is corresponding to the increase of ion-pair production rate which is estimated as 2∼4 ion-pair/cm^3/sec.

There is no evidence that the ion-pair production increases by the earthquake. But the increase of Radon contents suggests such increase of ion-pair production rate. J. Hatsuda (1953) reported that the Radon contents in the soil 2 m under the surface was increased from about 18 Eman te 22 Emen by the Tonankai Earthquake. 1 Eman is 10^{-13} curies/cm^3, then this increase of contents is 4×10^{-13} curies/cm^3. The relation between the ionization and the Radon cotents in the normal air is as follows;

$$1 \text{ ion-pair/cm}^3\text{/sec} = 49.8\times10^{-18} \text{ curies/cm}^3$$

The increase of ionization of 2∼4 ion-pairs/cm^3/sec is explained by the increase of Radon contents of about $1\sim2\times10^{-16}$ curies/cm^3. If the Radon in the soil is relased from the ground surface by the earthquake, the electric field variation will be explained by the relase of only a few percent of Radon in the soil from the ground surface.

5. Conclusion

a) As the luminous phenomenon was not reported during this observation period, the origin of it was not studied.

b) The electric field was decreased by the earthquake very often. The occurrence probability of this variation was varied with the activıty of the earthquake. The more earthquake was active, the more frequently the variations occurred.

c) This decrease of electric field will be explained by the increase of Radon contents in the air by earthquake.

From these results, it is concluded that the electric field is disturbed by earthquake in the special case. But this conculusion must be cheked by various observations, such as the Radon contents in the air and soil or the electrical conductivity of air.

Acknowledgement

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地震による大気電場の変化

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概　　要

松代地震に伴なう発光現象解明の一手段として，大気電場の観測を行った。この観測期間中に発光現象の報告はなく，資料を地震との関連において整理したので報告する。結果として（1）松代においては，地震活度が盛んなときほど，地震に伴なって電場が減少する場合が多い。（2）柿岡と筑波山頂での観測では，地震と対応するような変化はとくにみられなかった。これらのことは地下の構造によって地下のラドンガスが地震によって地上へ放出されると，仮定すれば説明出来る。