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Earthquake Prediction Research by Means of Telluric Potential Monitoring

Progress Report No. 1: Installation of Monitoring Network

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Abstract

In order to test the applicability of the VAN-method of short term earthquake prediction which has reportedly been extremely successful in Greece, a telluric potential monitoring network has been set up in Japan under a cooperative program with the Nippon Telegraph and Telephone Corporation (NTT). So far, 22 stations have been tested. Mainly due to logistic and financial constrainst, at all except two temporary stations existing NTT electrodes are used. At each station, telluric potential difference is sampled every 20 seconds on six dipoles set in different lengths and azimuths. Data stored at each station are transmitted to the central station at the Earthquake Research Institute (ERI) by telephone once a day. At several stations artificial noise is too high even to detect the potential changes due to geomagnetic variations but there are some stations yielding reasonably noise-free data.

1. Introduction

It has been reported that in Greece short term earthquake prediction based on telluric potential monitoring has been in practice for the last several years with astonishing success (VAROTSOS and ALEXOPOULOS, 1984, a, b; VAROTSOS and ALEXOPOULOS, 1987; VAROTSOS *et al.*, 1988). After close examination of their method by their publications and through several visits to Athens, we concluded that it is important to test if the method (VAN-method hereafter) works also in Japan. The present progress report presents some descriptions of the telluric potential monitoring networks so far installed for this purpose under a cooperative research program with the Nippon Telegraph and Telephone Corporation (NTT).

In the VAN-method, they install dipoles with different lengths, usually between one and ten hundred meters, in both the NS and EW directions at each station. The telluric potential changes due to geomagnetic variations, being global in nature, can be discriminated from seismic electric signals (SES hereafter, following VAN's terminology) because the former appear at all stations simultaneously. Clear appearances of changes due to geomagnetic variations are good indications that the station is free from excess man-made noise. On the other hand, very local noise or noise related to specific electrodes can be discriminted from SES through the ΔV/L-test, where ΔV is the amplitude of the anomalous potential difference and L is the dipole length. SES should have the same ΔV/L value for dipoles with the same azimuth but with different lengths at the same station. Starting from these short dipole systems, VAN now has several long dipole systems also, in which telephone company electrodes are utilized for dipoles with lengths of many kilometers. It is considered, in favorable conditions, that in such a long dipole system, local noise may cancel and SES may be enhanced to yield a better S/N ratio. In adverse conditions, the same effect may obliterate local SES's. VAN's experience shows that at least in some cases, long dipoles yield SES's as significant as those from short dipoles. In our case in Japan, logistic constraints, including poor availability of suitable sites and a small budget, make it difficult to operate short dipole systems by ourselves, so we decided to rely on existing NTT electrodes for long span dipoles. This makes the maintenance of the system much easier although the configurations of dipoles at stations are dictated by the availability of the NTT electrodes.

2. Measuring System

2-1. Establishment of Stations

Since 1987, we have established telluric potential monitoring stations as plotted in Fig. 1. They are the networks using the electrical grounds of NTT except for two stations, i. e. ERI (Earthquahe Research Institnte, Tokyo) and KAK (KAKIOKA, Ibaraki Pref.). These two stations were installed in order to test the stability and sensitivity of the VAN-type electrodes we have made following VAROTSOS's instructions (VAROTSOS, personal communication). As to the data obtained at ERI, however, even the changes

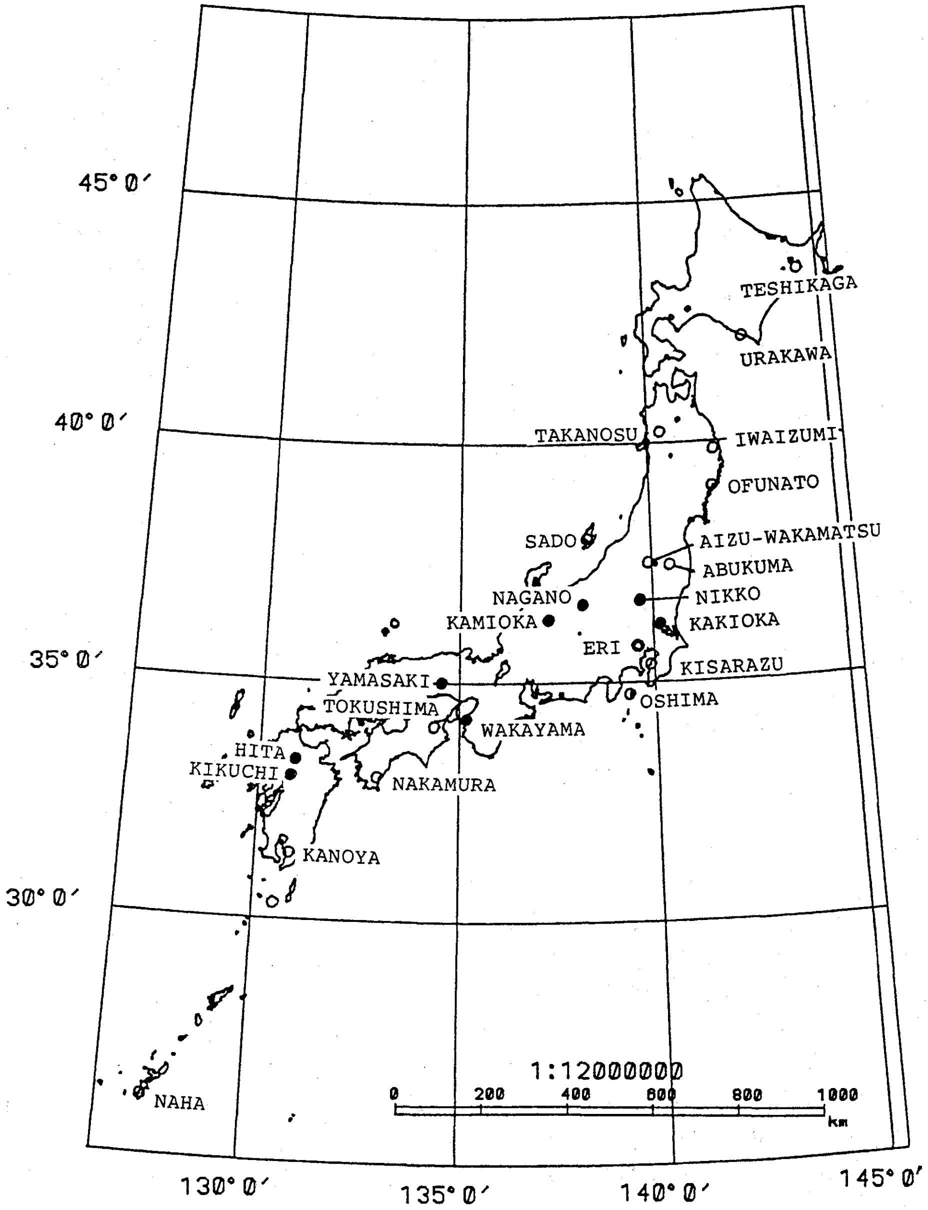


Fig. 1. The distribution of stations for telluric potential monitoring. Open circles: stations presently working, closed circles: stations already aborted.

induced by the geomagnetic variations (simply "geomagnetic variations" hereafter) were not detected due to the huge artificial noise. For this reason the ERI station was abandoned after a few months. On the other hand, station KAK, located close to the Kakioka Geomagnetic Observatory, JMA (Japan Meteorological Agency), is basically free from noise and it clearly shows "geomagnetic variations". We can also compare our records with the geomagnetic and geoelectric data collected at the nearby JMA Observatory.

We selected NTT's stations where artificial noise due to electric trains and other sources is small, and yet reasonably closely located to seismic areas. Unfortunately, at some stations the noise level was still too high even to detect the "geomagnetic variations". Those stations have been aborted and the instruments were moved to other locations in due course, i.e. stations NAG, NIK, WAK, YMS, HTA, KIK, KMO, and KAK have been terminated, and at present (April, 1989) 14 stations are working. At KAK, although the noise level was not high, the home-made electrodes were difficult to maintain in good condition because the lines were frequently damaged by animal bites.

2-2. Selection Policy of Electrode Pairs at Each Station

Every NTT station has, in its service district, three to eight available electrodes, from which we can set dipoles oriented in different directions. Because our data logger has six channels, some of the electrodes are shared among two or more dipoles. In order to check if a certain change ΔV detected at a station is an SES (which should cause changes, at the same station, on every channel in the same azimuth, ΔV being proportional to the length of dipoles, L), or a local noise (in this case the change is not proportional to L), it is necessary to have at least two pairs of dipoles with a different value of L in one direction at the station. But, according to VAN experience (Varotsos, personal communication), this $\Delta V/L$ test holds true only for short span dipoles ($L<1000$ m), and not always for long span dipoles as in the case for NTT stations ($L=10$–20 km). This is one of the weak points in our present system.

The configurations of dipoles at each station will be presented in the next section.

2-3. Electrodes

As mentioned already, in the initial stage of the measurement we used the Greek type dipoles. They are formed by a pair of non-polarized electrodes made of lead metal and lead-chloride in plaster of Paris buried at about 2 m depth (Fig. 2). The average contact resistance measured at

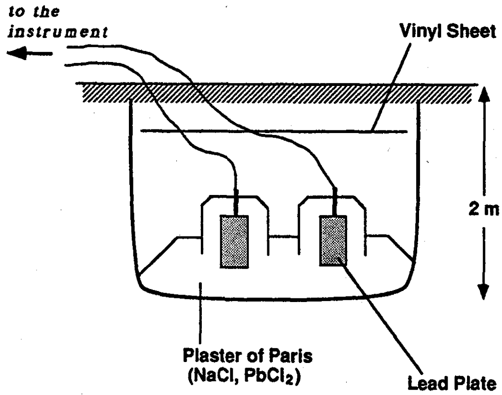


Fig. 2. The Greek type electrodes buried by ourselves at ERI and KAK.

ERI was 230 ohms, which was rather high.

In the case of NTT networks we used as the electrodes the electrical grounds for the telephone communication, buried at 2 m depth under their central or branch office buildings, with as many carbon rods or as much copper net as necessary to meet the standard that the contact resistance should be less than 10 ohms. The branch office building is usually unmanned.

2–4. Data Logging and Telemetry

The data logger we use was developed in cooperation with Iwatsu Electric Co., Ltd. It can measure the difference of the electrical potential between two electrodes (six channels). The input data are low-pass filtered at 0.1 Hz, A/D-converted in 12 bits with changeable full-scale ($\pm$10.24 mV to $\pm$10.24 V), and stored in an IC memory (RAM) every 20 seconds. This memory can keep data for two days. The station configuration and a schematic diagram of data logging and collection is shown in Fig. 3.

Through public telephone lines, this data logger can telemeter the data using a modem while it continues logging the data into a RAM, in response to an incoming telephone call. The transmission rate is fixed at 1200 bps.

The data logger is installed in the local NTT central office building of each network station. A photograph of the setting-up at station TES is shown in Fig. 4.

2–5. Data Reception and Storage at ERI

The data at each station are transmitted to ERI every day. The apparatus for this operation consists of a personal computer (NEC PC–

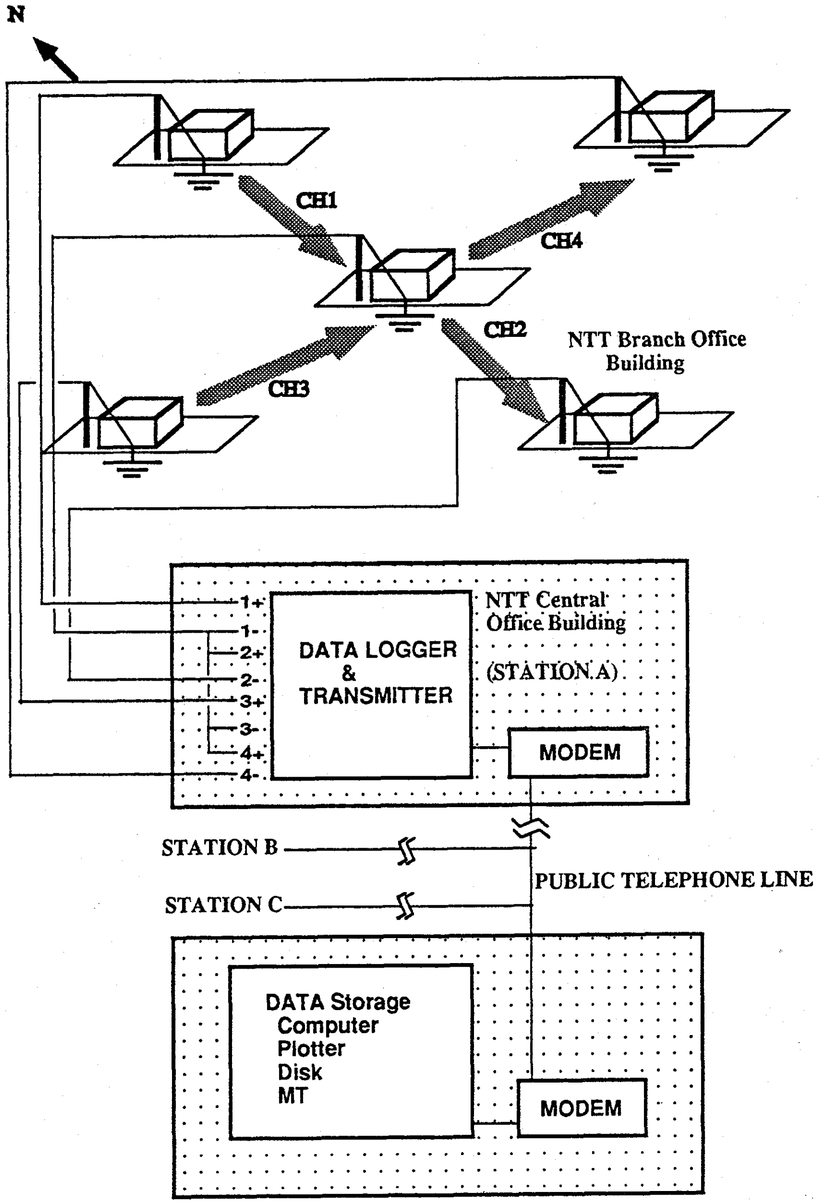


Fig. 3. Schematic diagram of data logging and collection. The upper part indicates the general policy to select dipoles, i.e., each dipole should be oriented in different directions or should have different length (see section 2-2 for detail).

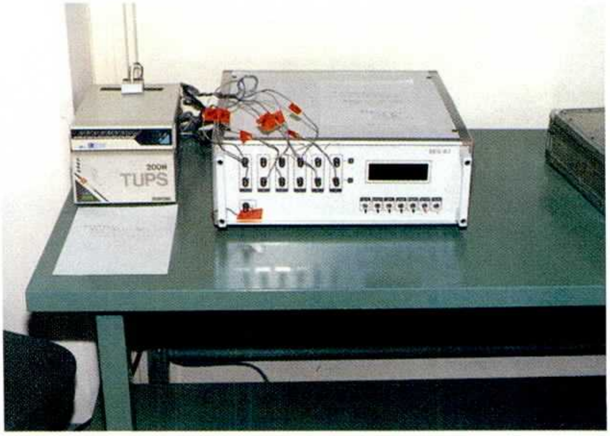


Fig. 4. A photograph of the setting-up at station TES. On the right hand side is the data logger, and on the left are the modem and the backup power supply.

9801 VX) with modem, 20 Mbyte hard disk, and a plotter. At night the system is awaken and sends commands, through telephone calls, to each station sequentially ; the logger at each station replies to this command and sends data to ERI (it takes about 15 minutes per day per station) ; at ERI the data are stored on a hard disk, and after all the data are received they are plotted automatically on a strip chart. Also, the system is connected to a main frame computer by Local Area Network, which makes quick upload of the data possible. Finally the data are stored on magnetic tapes.

2-6. Data Processing

The first step in detecting SES is to look at the raw data carefully with one's own eyes, which is performed routinely every day. The second is to do it in a more systematic manner, and for that purpose it is necessary to remove the "geomagnetic variations" using magnetogram records. This reduction process is important because it can also yield information useful for calculating the subterranean resistivity structure. At the same time, artificial noise comparable with SES in period or in amplitude should be discriminated.

3. General Features of Records

As mentioned in the preceding section, it is necessary to carefully examine the general data features in order to discriminate SES from other variations such as "geomagnetic variations" or artificial noise. An example of simultaneous record on one typical day is presented in Fig. 5(a–e), and the long-term variation (every thirty minutes for 100 days) after one hour low-pass filtering is presented in Fig. 6(a–h).

The differences in the "geomagnetic changes" among stations and channels are shown in Fig. 7. The changes should reflect the subterranean conductivity structure and the coast effect; they also depend on the dipole direction.

Fig. 8(a, b) shows differences in the "geomagnetic changes" due to the coast effect, which clearly indicates that most of the dipoles oriented parallel to the coast (a) have smaller changes than those oriented perpendicular to the coast (b).

Fig. 9(a, b) shows the differences in "geomagnetic variations" for different directions of dipoles (EW(a) and NS(b)). Differences are not so significant between these two directions.

At a few stations, some typical artificial signals come from telephone lines. These signals are used by NTT for telephone charging, and have a spike form appearing every 18 sec. (thus called '18 sec. noise'). This type of noise is especially large at OSM (Oshima, see section 4–12).

The noise level difference among stations and channels is shown in Fig. 10. As clearly recognized, stations NIK, NAG, KMO, WAK and YMS have much higher noise compared with others. All these stations have already been abandoned. A necessary condition for a station to be good enough for detecting SES is low noise level, which is conveniently evaluated by the ratio of the amplitude of "geomagnetic variations" to the amplitude of background noise (S/N ratio hereafter), because, according to VAN's experience, the amplitude of SES is of the same order of magnitude as that of the former. It is therefore unlikely that SES can be identified at stations where "geomagnetic variations" are obscured by high noise level. The distribution of S/N ratio is presented in Fig. 11, in which the azimuth of the line is parallel to each channel, and the length proportional to the S/N ratio. At TES, URK, AIZ, ABK and KNY the S/N ratio is very large, whereas it is especially small at WAK, HTH and KIK. It must be noted, however, that high S/N ratio is not a sufficient condition for SES detection, for only a small fraction of stations which are sensitive to magnetic variation are sensitive to SES (Varotsos, personal communication).

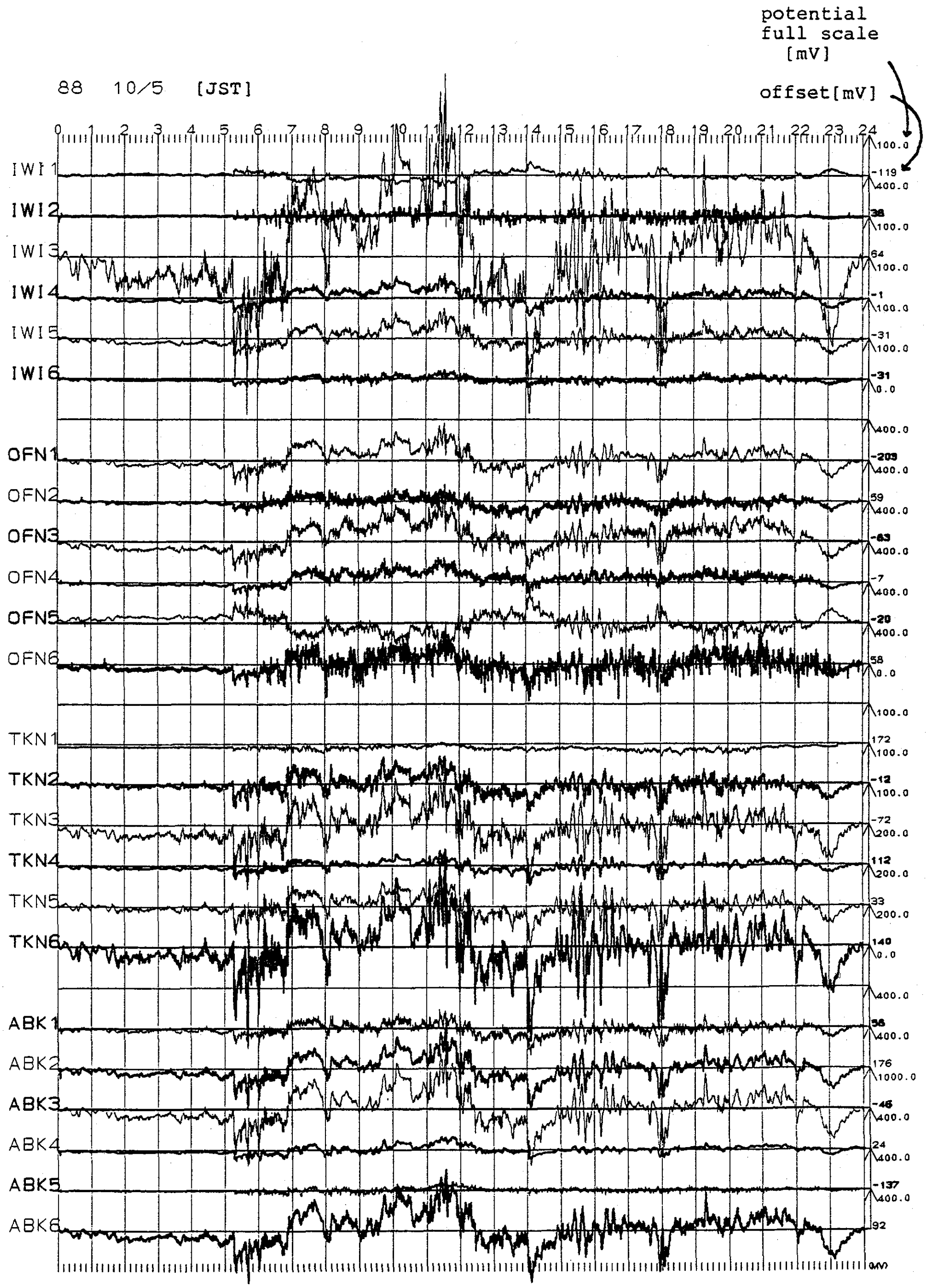


Fig. 5a

Fig. 5(a–e). Sample record showing the potential variation of one typical day (Oct. 5, 1988) at all stations. These are taken from the raw data output of the potential, whose full scale per division and offset value is indicated on the right-hand side of each channel (unit: millivolt). The horizontal divisions correspond to one hour.

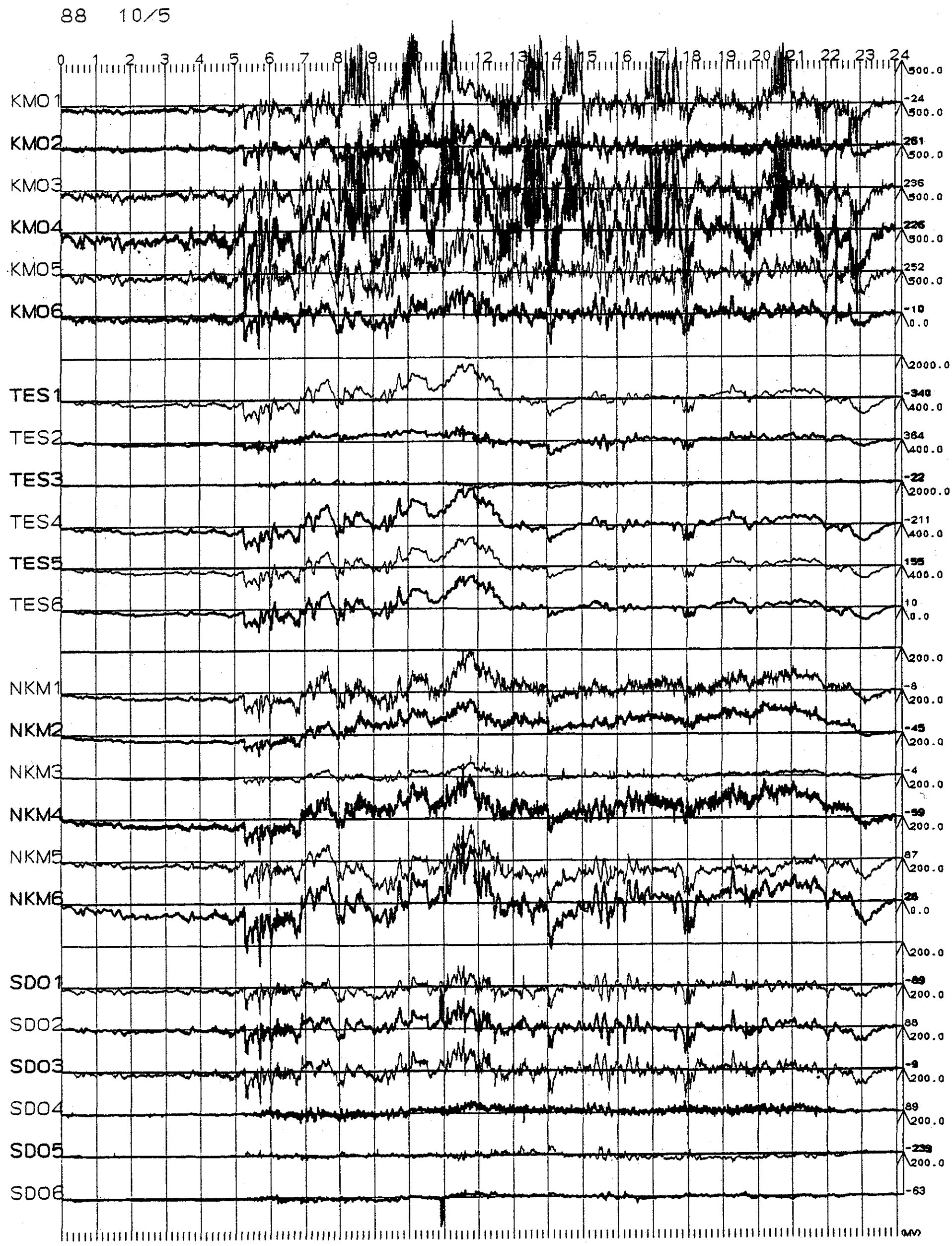

88 10/5
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
KMO1
KMO2
KMO3
KMO4
KMO5
KMO6
TES1
TES2
TES3
TES4
TES5
TES6
NKM1
NKM2
NKM3
NKM4
NKM5
NKM6
SDO1
SDO2
SDO3
SDO4
SDO5
SDO6
500.0
-24
500.0
261
500.0
236
500.0
226
500.0
252
500.0
-10
0.0
2000.0
-340
400.0
364
400.0
-22
2000.0
-211
400.0
155
400.0
10
0.0
200.0
-8
200.0
-45
200.0
-4
200.0
-59
200.0
87
200.0
26
0.0
200.0
-89
200.0
88
200.0
-9
200.0
89
200.0
-239
200.0
-63
(mV)

Fig. 5b

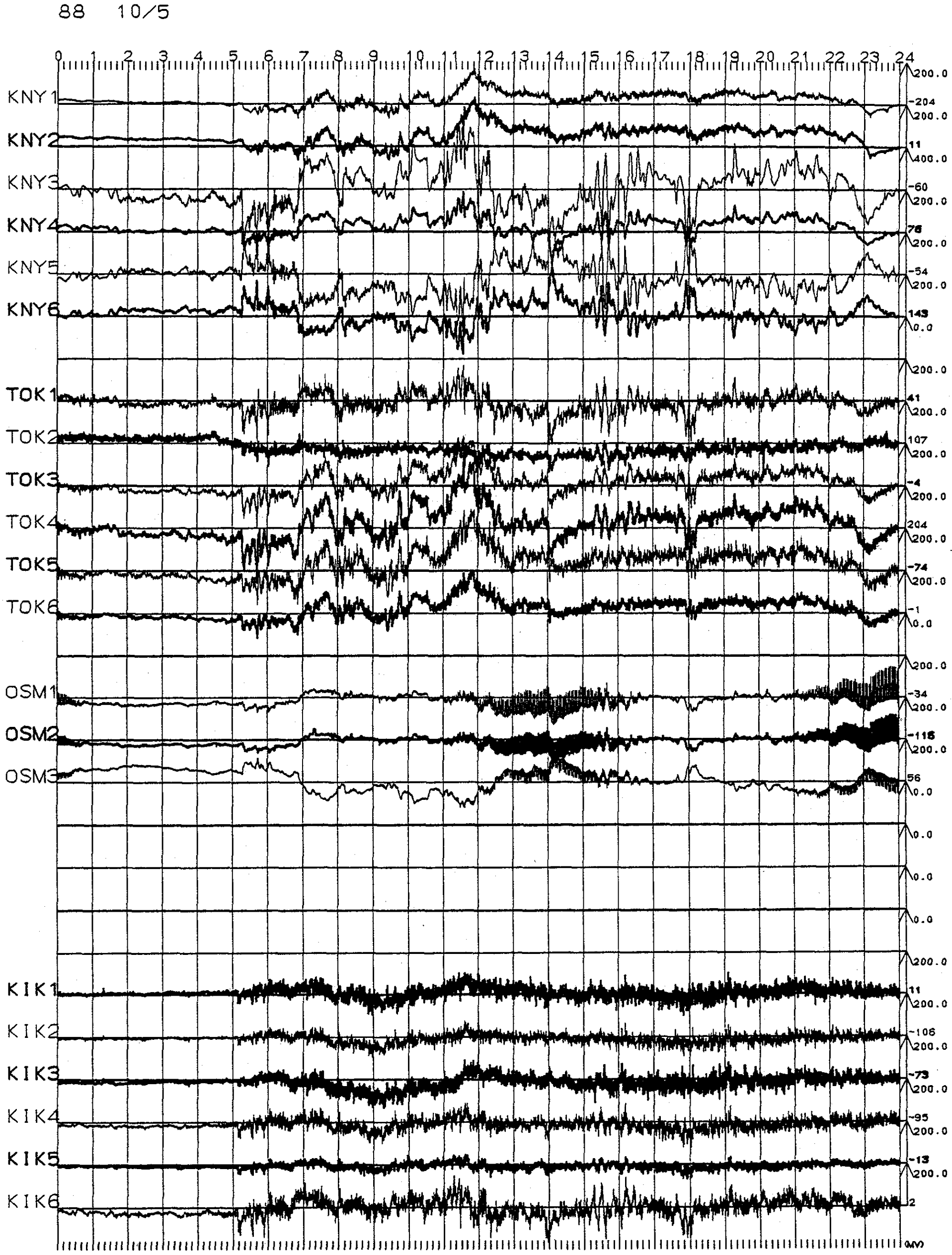
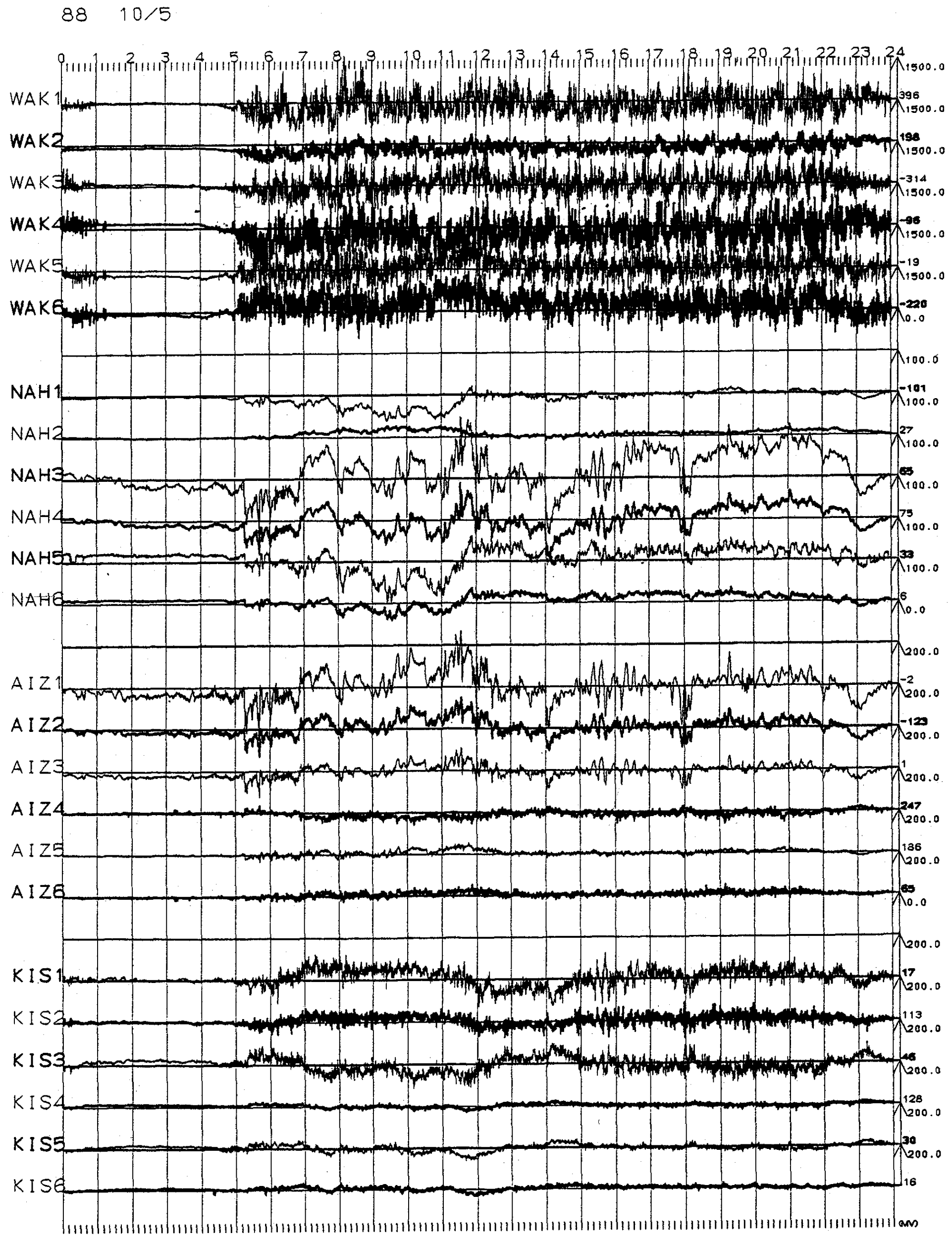

88 10/5
KNY1
KNY2
KNY3
KNY4
KNY5
KNY6
TOK1
TOK2
TOK3
TOK4
TOK5
TOK6
OSM1
OSM2
OSM3
KIK1
KIK2
KIK3
KIK4
KIK5
KIK6

Fig. 5c



88 10/5
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
WAK1
WAK2
WAK3
WAK4
WAK5
WAK6
NAH1
NAH2
NAH3
NAH4
NAH5
NAH6
AIZ1
AIZ2
AIZ3
AIZ4
AIZ5
AIZ6
KIS1
KIS2
KIS3
KIS4
KIS5
KIS6
1500.0
396
198
-314
-96
-19
-220
0.0
100.0
-101
27
65
75
33
6
200.0
-2
-123
1
247
186
65
17
113
46
128
30
16
(mV)

Fig. 5d

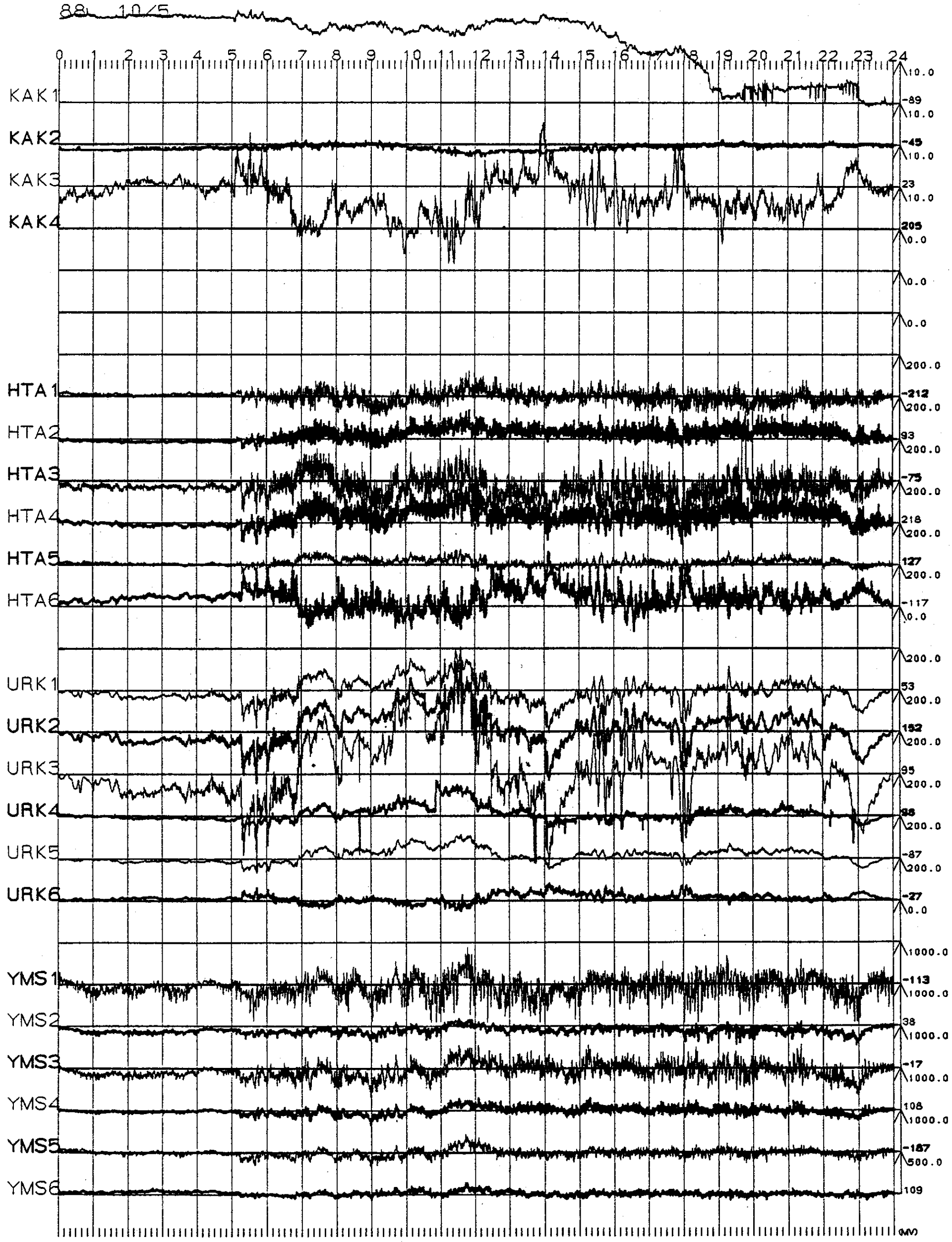

88 10/5
KAK1
KAK2
KAK3
KAK4
HTA1
HTA2
HTA3
HTA4
HTA5
HTA6
URK1
URK2
URK3
URK4
URK5
URK6
YMS1
YMS2
YMS3
YMS4
YMS5
YMS6

Fig. 5e

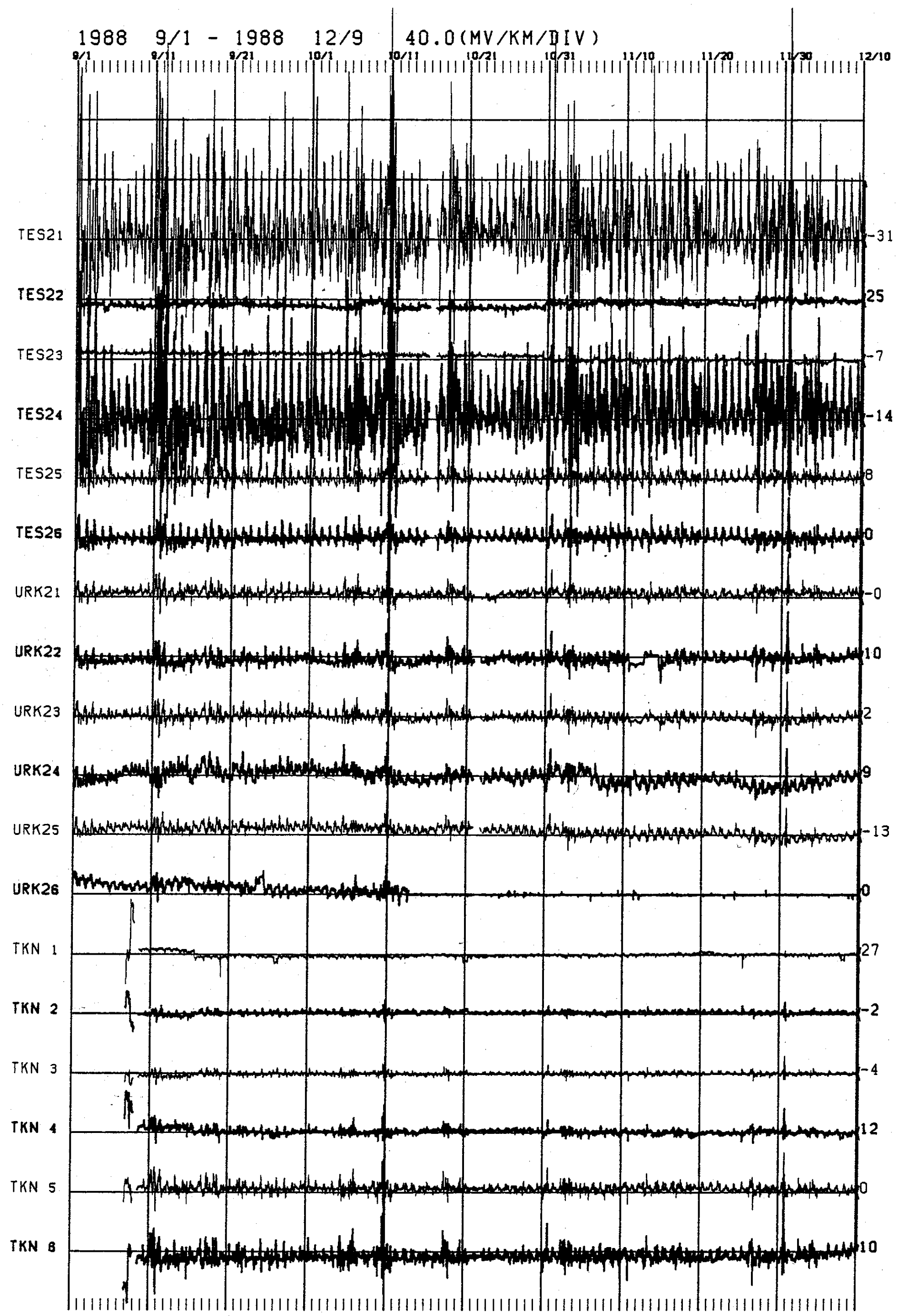


Fig. 6a

Fig. 6(a–h). Electric field data at all stations and magnetic data at Kakioka Magnetic Observatory, JMA (KAKM1: H, KAKM2: Z, KAKM3: D, KAKM4: F) for 100 days (Sep. 1, 1988–Dec. 9, 1988). These are results after one hour low-pass filtering

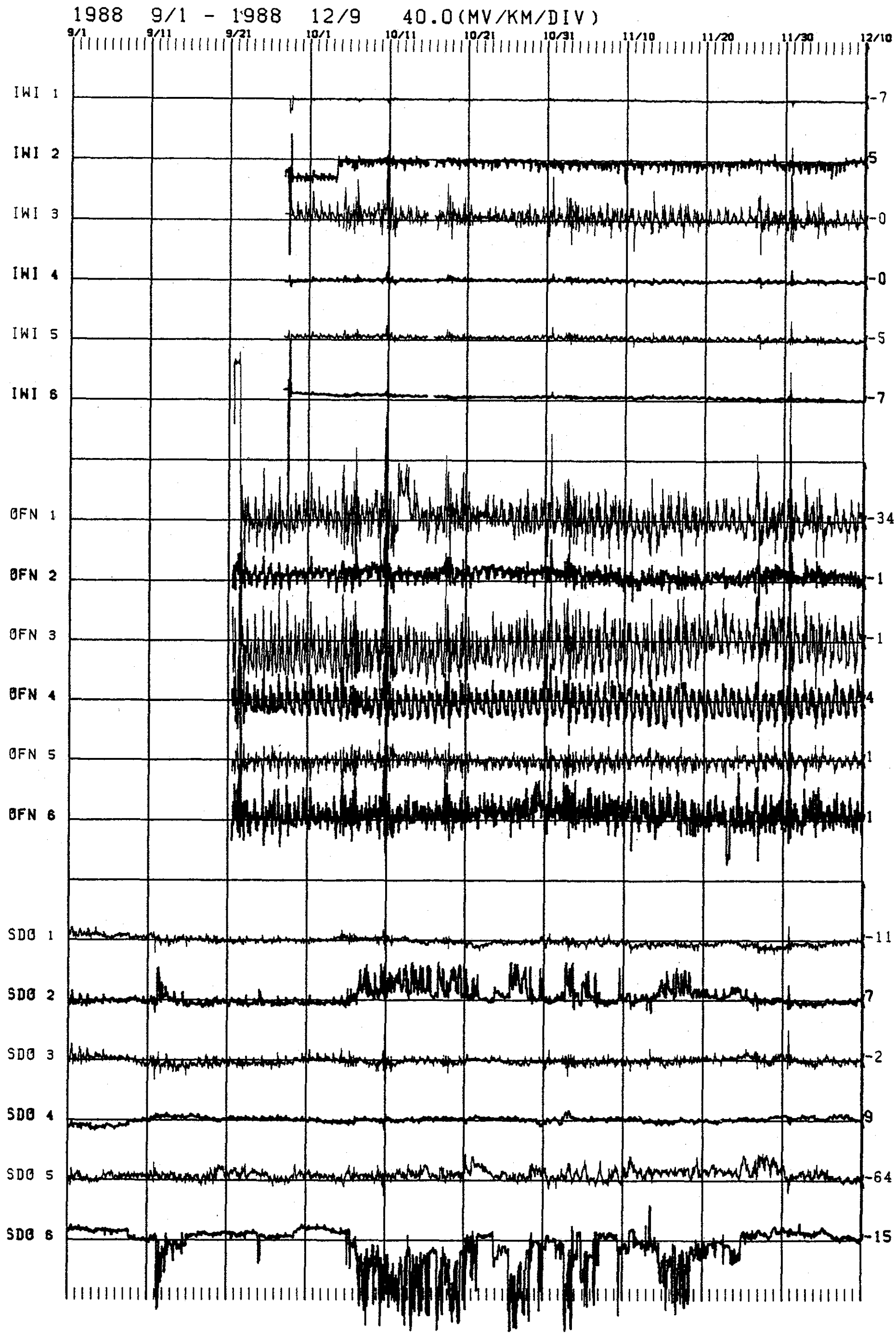


Fig. 6b

and sampling every 30 minutes of raw data, and divided by the length of each dipole, i. e. in term of the electric field. Polarities for records of some channels have been reversed because their dipole directions are opposite to other channels.

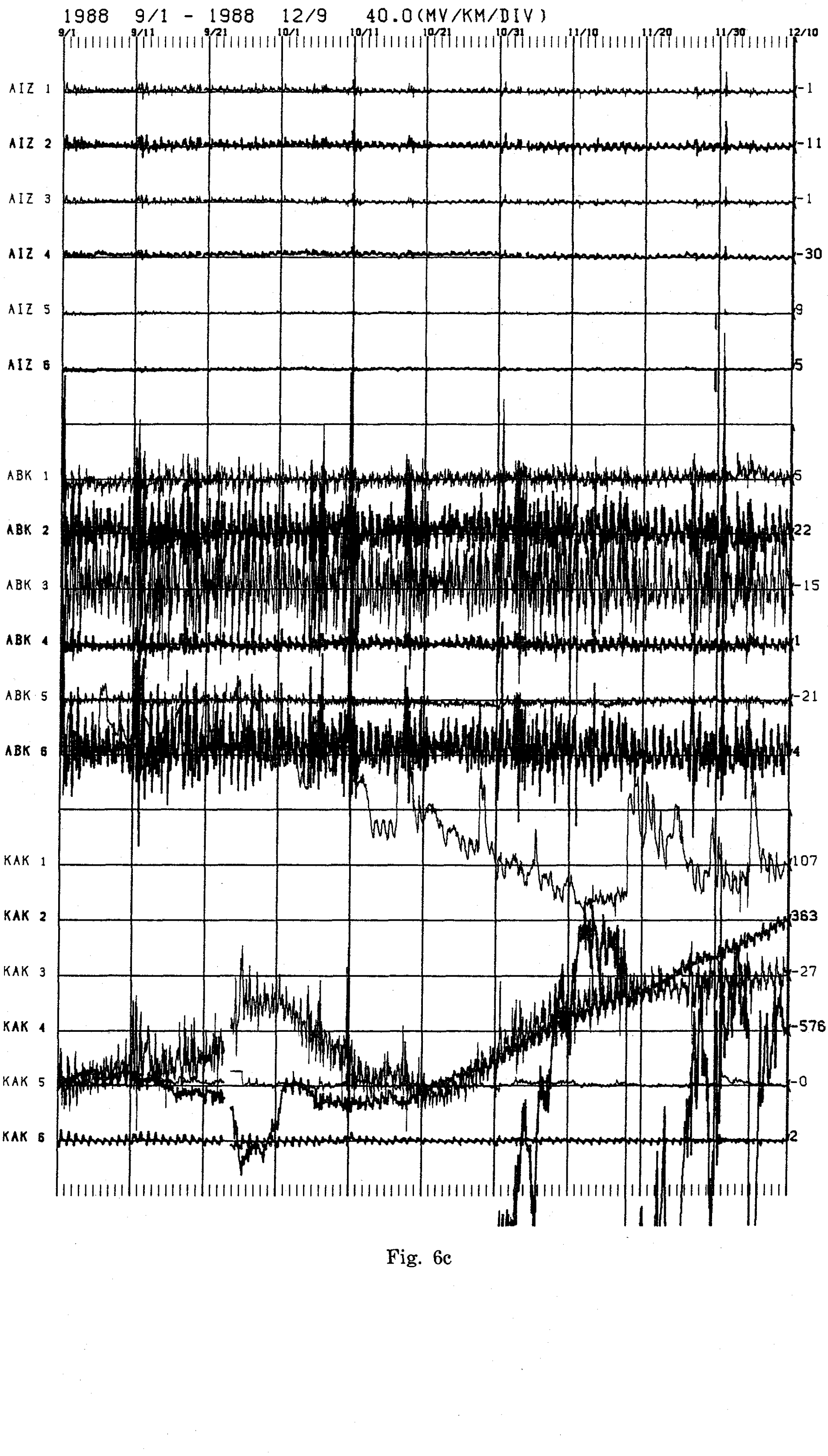
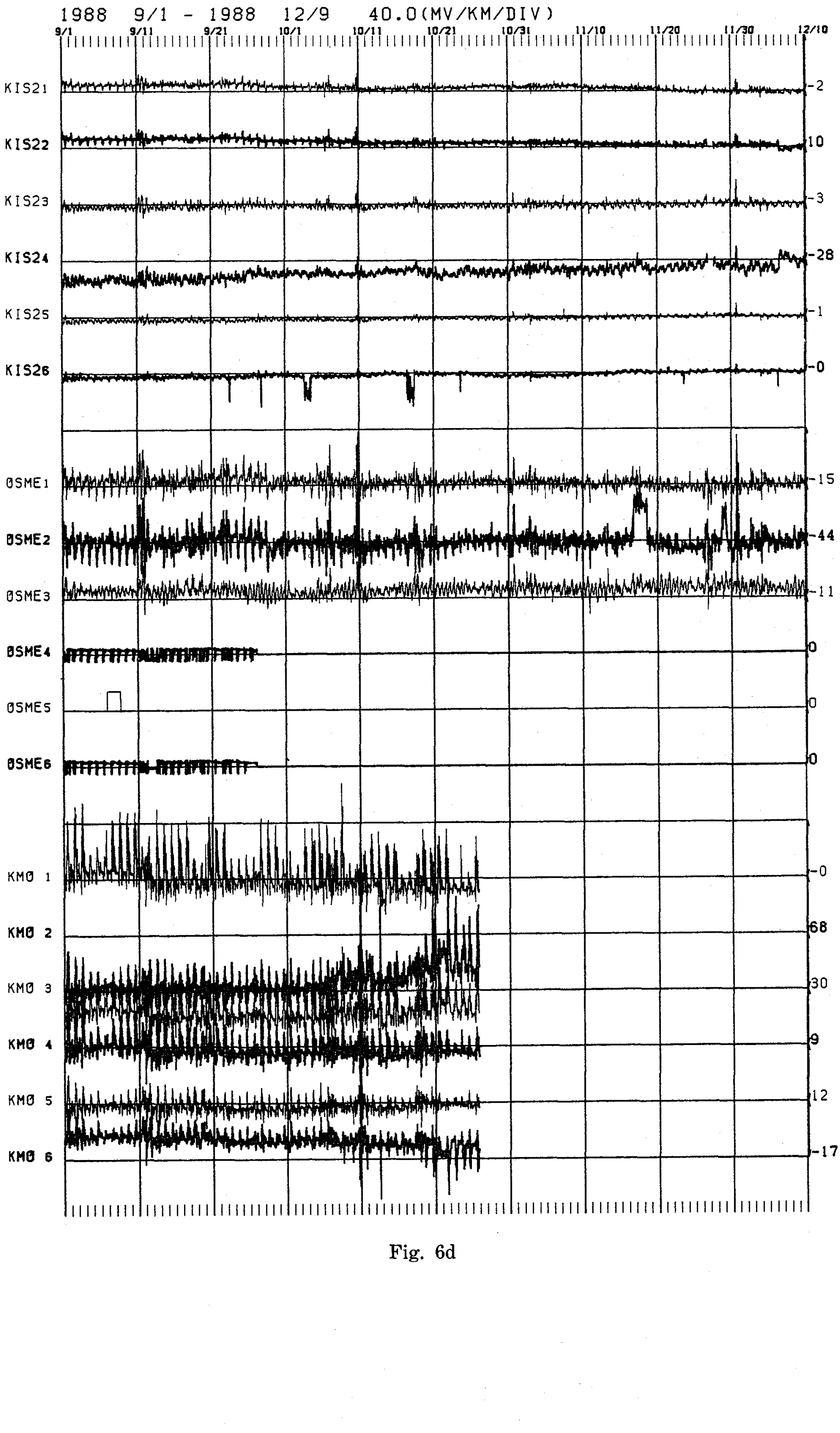

1988 9/1 - 1988 12/9 40.0(MV/KM/DIV)
9/1
9/11
9/21
10/1
10/11
10/21
10/31
11/10
11/20
11/30
12/10
AIZ 1
AIZ 2
AIZ 3
AIZ 4
AIZ 5
AIZ 6
ABK 1
ABK 2
ABK 3
ABK 4
ABK 5
ABK 6
KAK 1
KAK 2
KAK 3
KAK 4
KAK 5
KAK 6
-1
-11
-1
-30
9
5
5
22
-15
1
-21
4
107
363
-27
-576
-0
2

Fig. 6c



1988 9/1 - 1988 12/9 40.0(MV/KM/DIV)
9/1
9/11
9/21
10/1
10/11
10/21
10/31
11/10
11/20
11/30
12/10
KIS21
KIS22
KIS23
KIS24
KIS25
KIS26
OSME1
OSME2
OSME3
OSME4
OSME5
OSME6
KMO 1
KMO 2
KMO 3
KMO 4
KMO 5
KMO 6
-2
10
-3
-28
-1
-0
-15
-44
-11
0
0
0
-0
68
30
9
12
-17

Fig. 6d

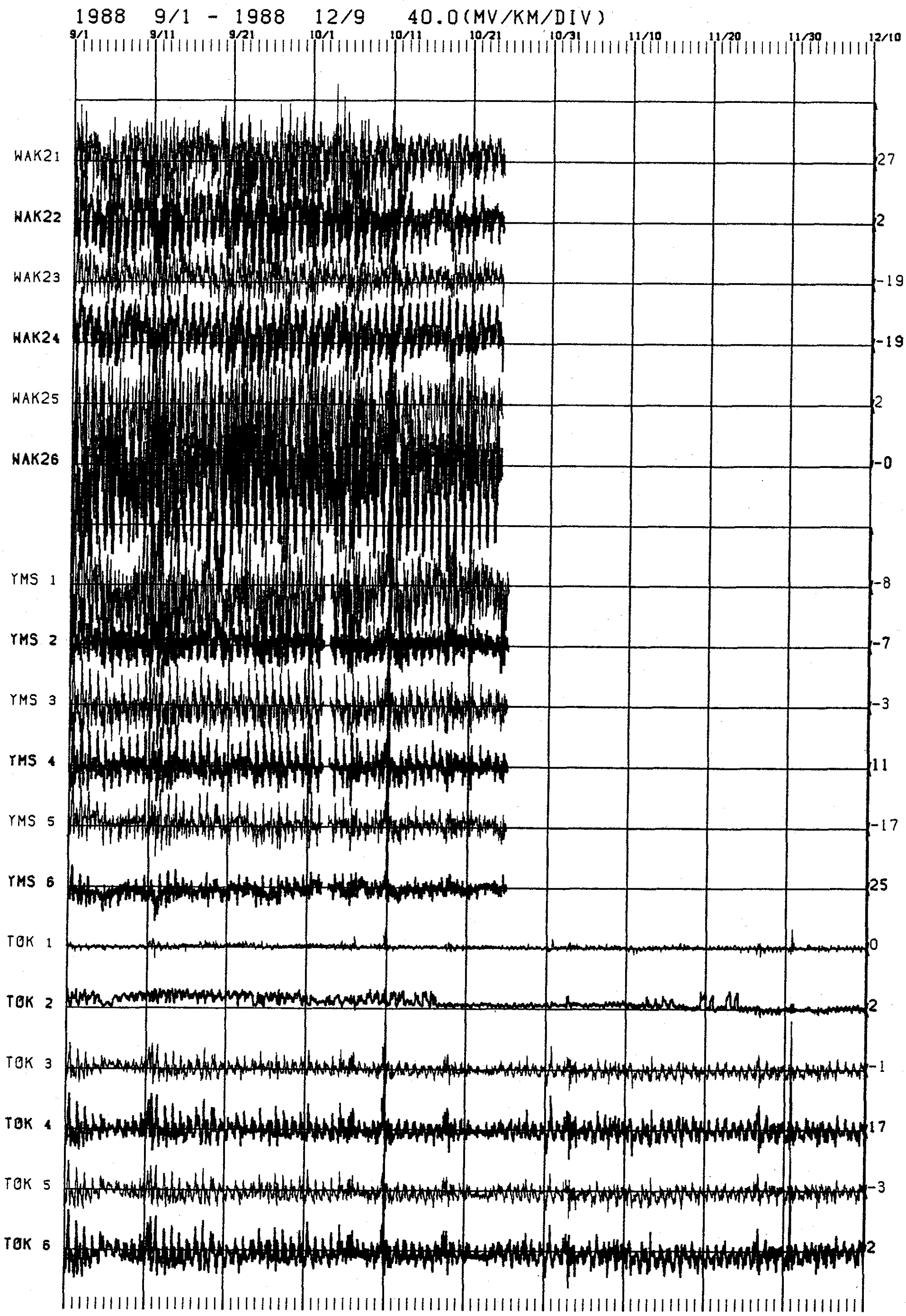

1988 9/1 - 1988 12/9 40.0(MV/KM/DIV)
9/1
9/11
9/21
10/1
10/11
10/21
10/31
11/10
11/20
11/30
12/10
WAK21
WAK22
WAK23
WAK24
WAK25
WAK26
YMS 1
YMS 2
YMS 3
YMS 4
YMS 5
YMS 6
TØK 1
TØK 2
TØK 3
TØK 4
TØK 5
TØK 6
27
2
-19
-19
2
-0
-8
-7
-3
11
-17
25
0
2
-1
17
-3
2

Fig. 6e

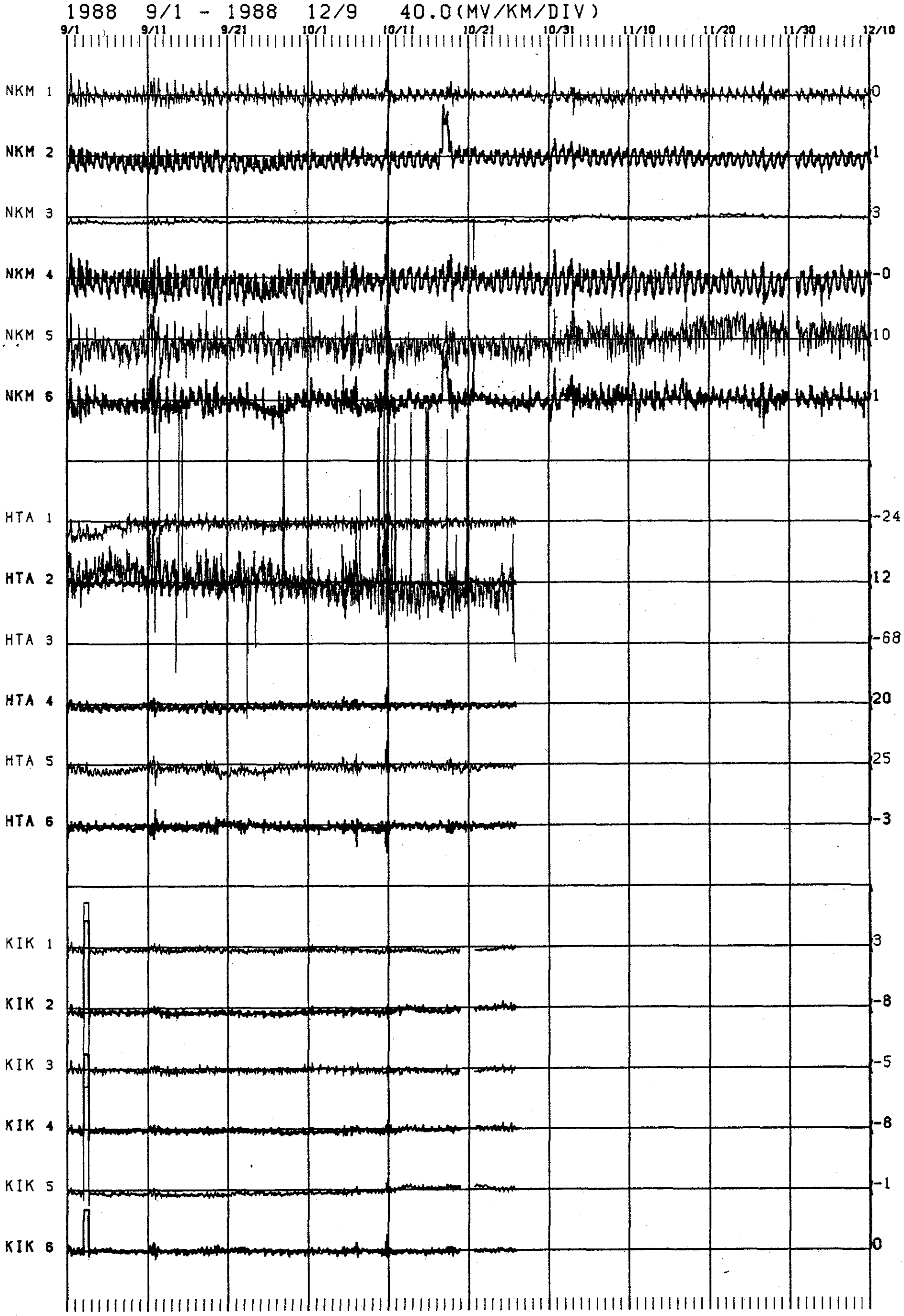

1988 9/1 - 1988 12/9 40.0(MV/KM/DIV)
9/1
9/11
9/21
10/1
10/11
10/21
10/31
11/10
11/20
11/30
12/10
NKM 1
NKM 2
NKM 3
NKM 4
NKM 5
NKM 6
HTA 1
HTA 2
HTA 3
HTA 4
HTA 5
HTA 6
KIK 1
KIK 2
KIK 3
KIK 4
KIK 5
KIK 6
0
1
3
-0
10
1
-24
12
-68
20
25
-3
3
-8
-5
-8
-1
0

Fig. 6f

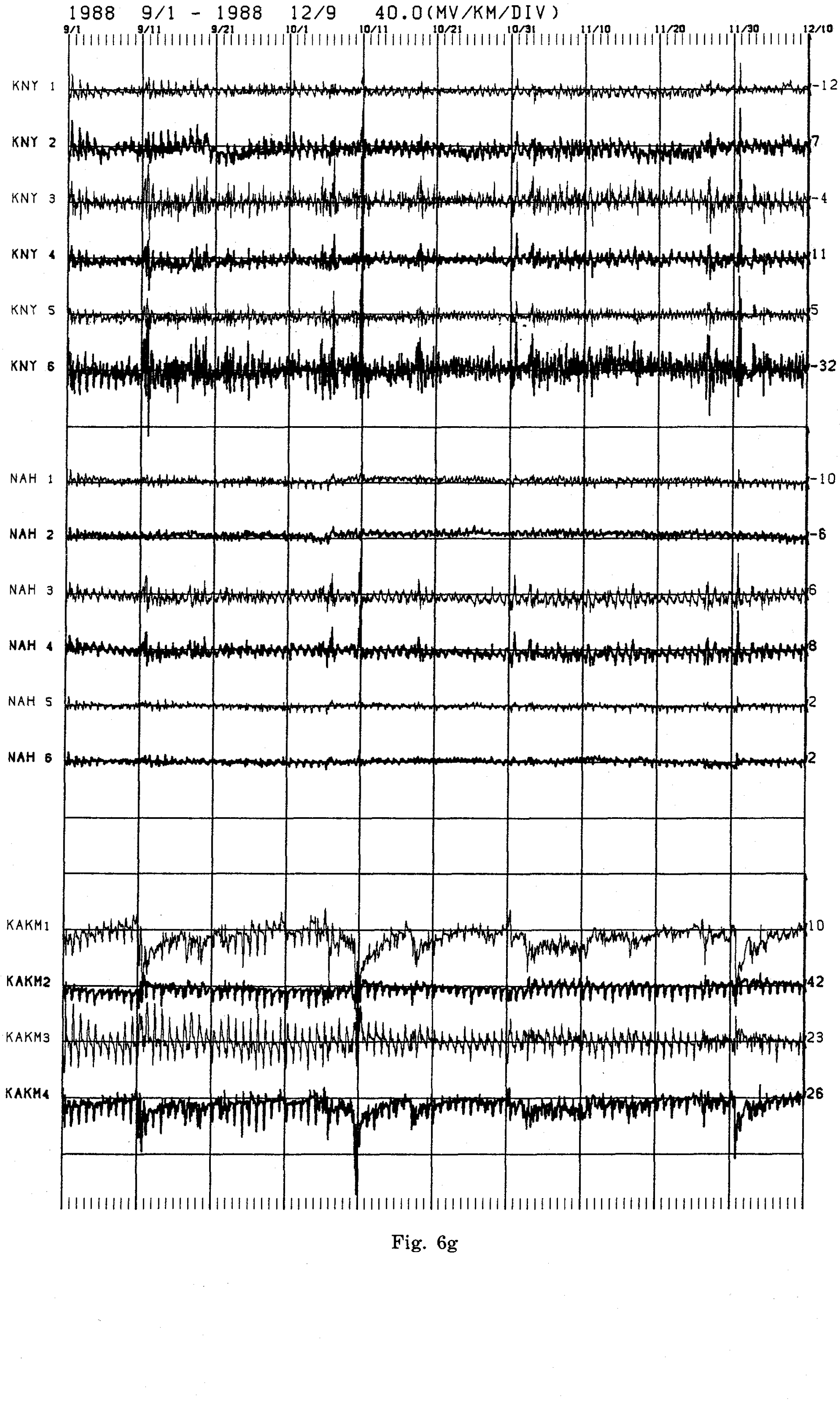

1988 9/1 - 1988 12/9 40.0(MV/KM/DIV)
9/1
9/11
9/21
10/1
10/11
10/21
10/31
11/10
11/20
11/30
12/10
KNY 1
KNY 2
KNY 3
KNY 4
KNY 5
KNY 6
-12
7
-4
11
5
-32
NAH 1
NAH 2
NAH 3
NAH 4
NAH 5
NAH 6
-10
-6
6
8
2
2
KAKM1
KAKM2
KAKM3
KAKM4
10
42
23
26

Fig. 6g

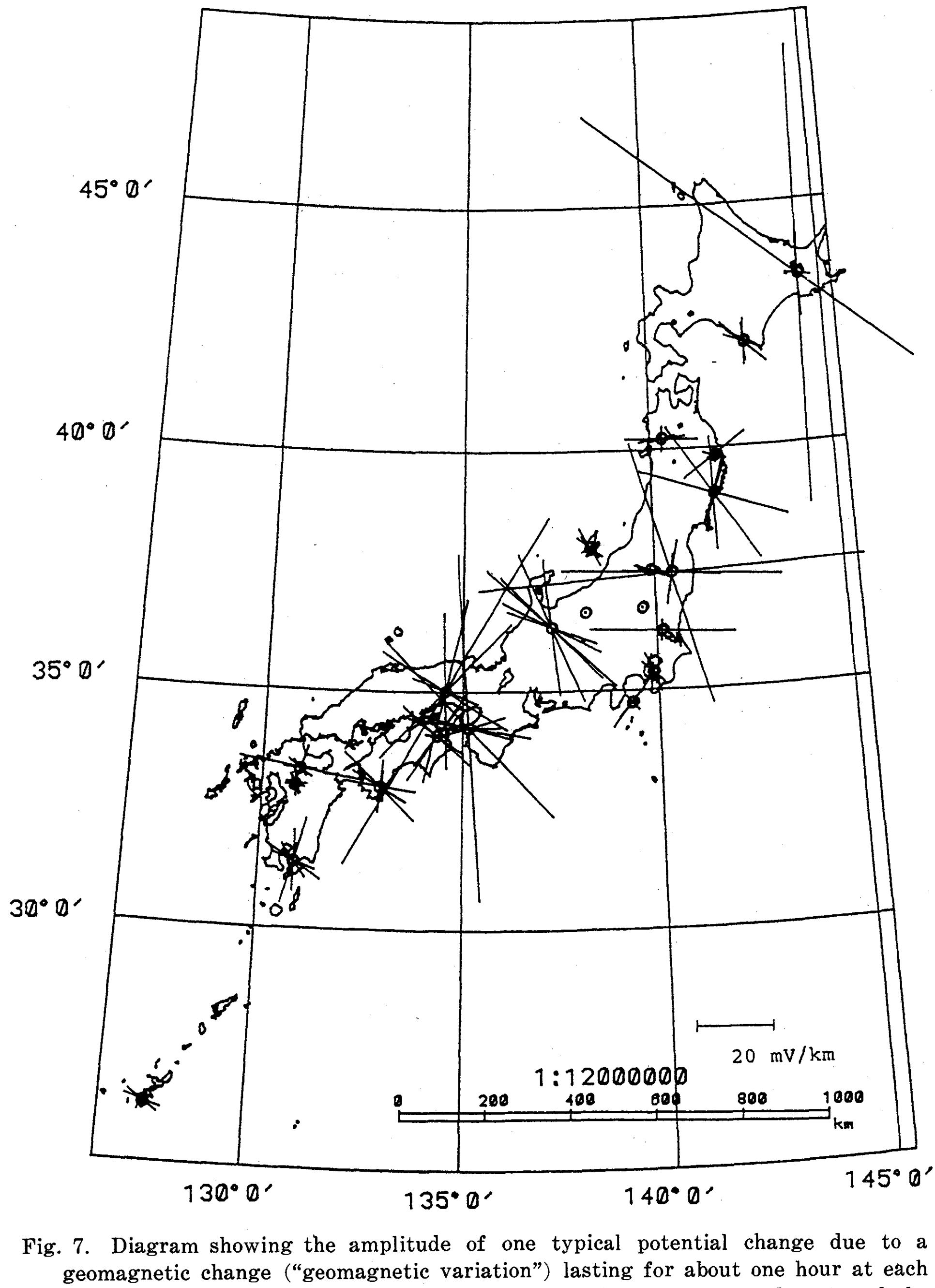


Fig. 7. Diagram showing the amplitude of one typical potential change due to a geomagnetic change ("geomagnetic variation") lasting for about one hour at each station. The amplitude is proportional to the response (i. e. impedance) and the azimuth of each line is parallel to each dipole. No data for stations NAG and NIK.

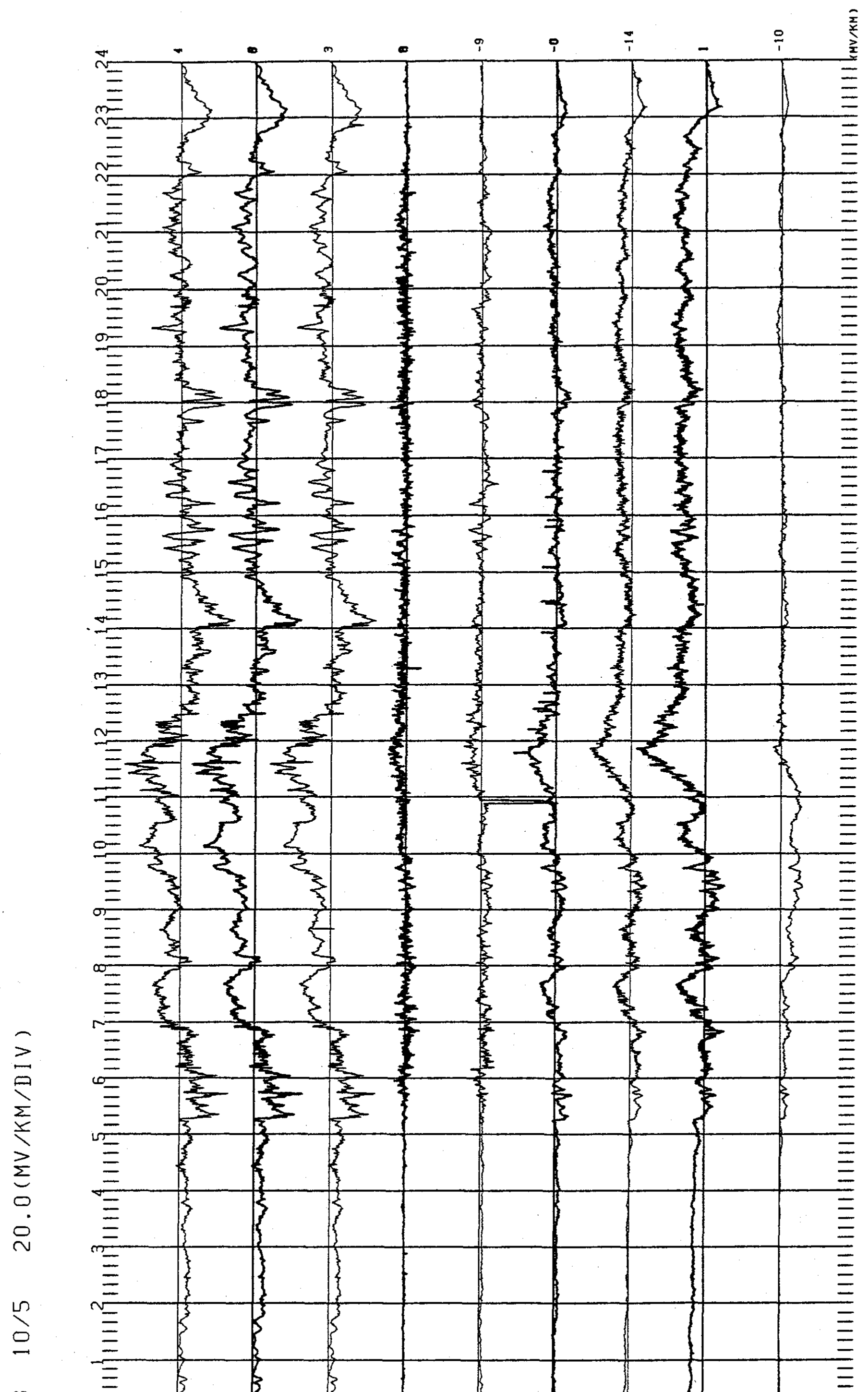


Fig. 8a

Fig. 8. Sample records showing the coast effect; (a; above) dipoles parallel to the coast, (b; below) perpendicular to the coast. It is clearly seen that changes in group (b) are larger than in (a).

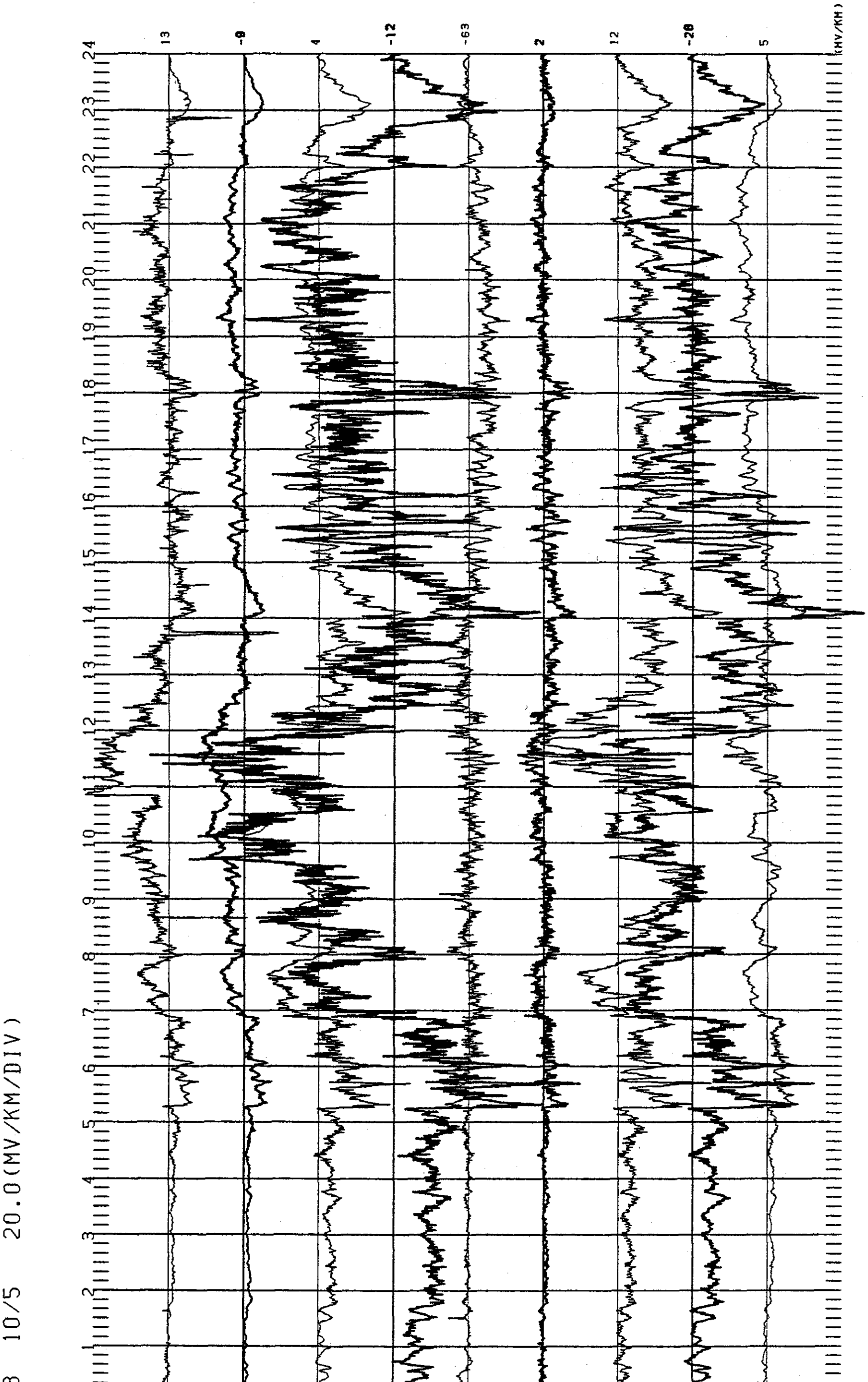

88 10/5 20.0(MV/KM/DIV)
URK4 13
URK5 -9
IWI3 4
ØFN3 -12
SDØ5 -63
TØK1 2
NKM5 12
KNY6 -28
NAH3 5
(MV/KM)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

Fig. 8b

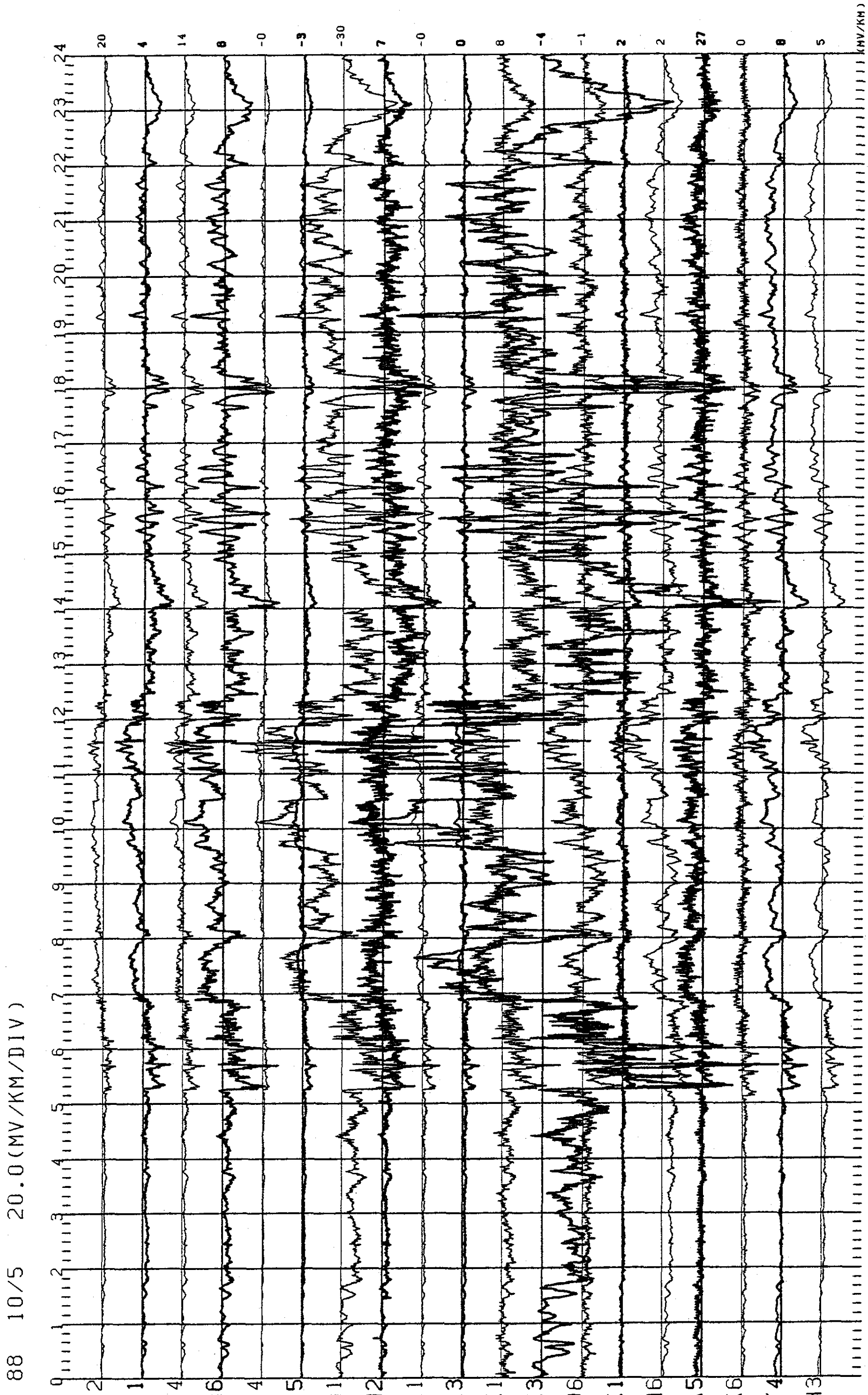


Fig. 9a

Fig. 9. Sample records showing the difference in the "geomagnetic variations" for (a; above) EW-oriented, and (b; below) NS-oriented dipoles.

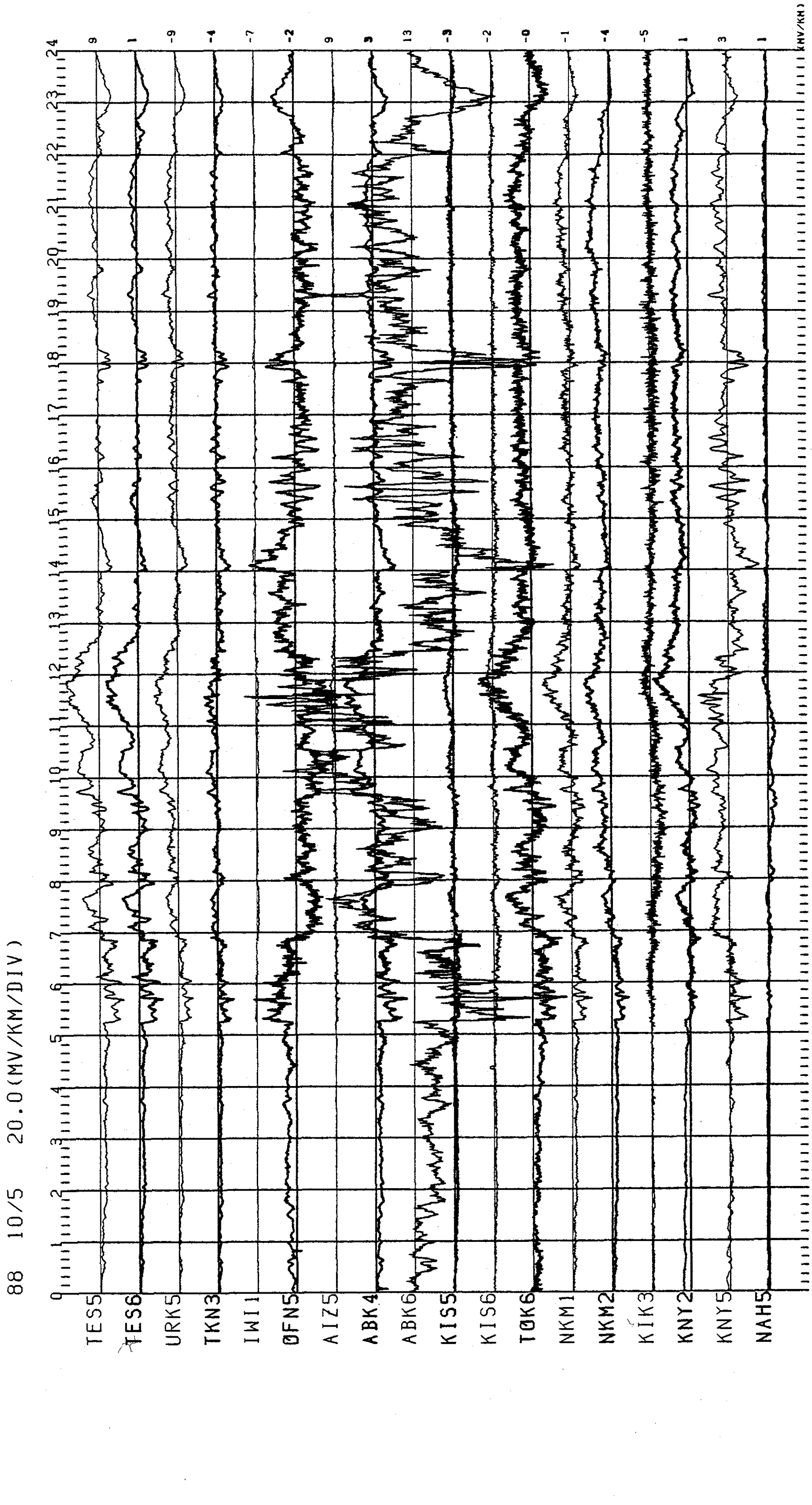

88 10/5 20.0(MV/KM/DIV)
TES5
TES6
URK5
TKN3
IWI1
ØFN5
AIZ5
ABK4
ABK6
KIS5
KIS6
TØK6
NKM1
NKM2
KIK3
KNY2
KNY5
NAH5
(MV/KM)

Fig. 9b

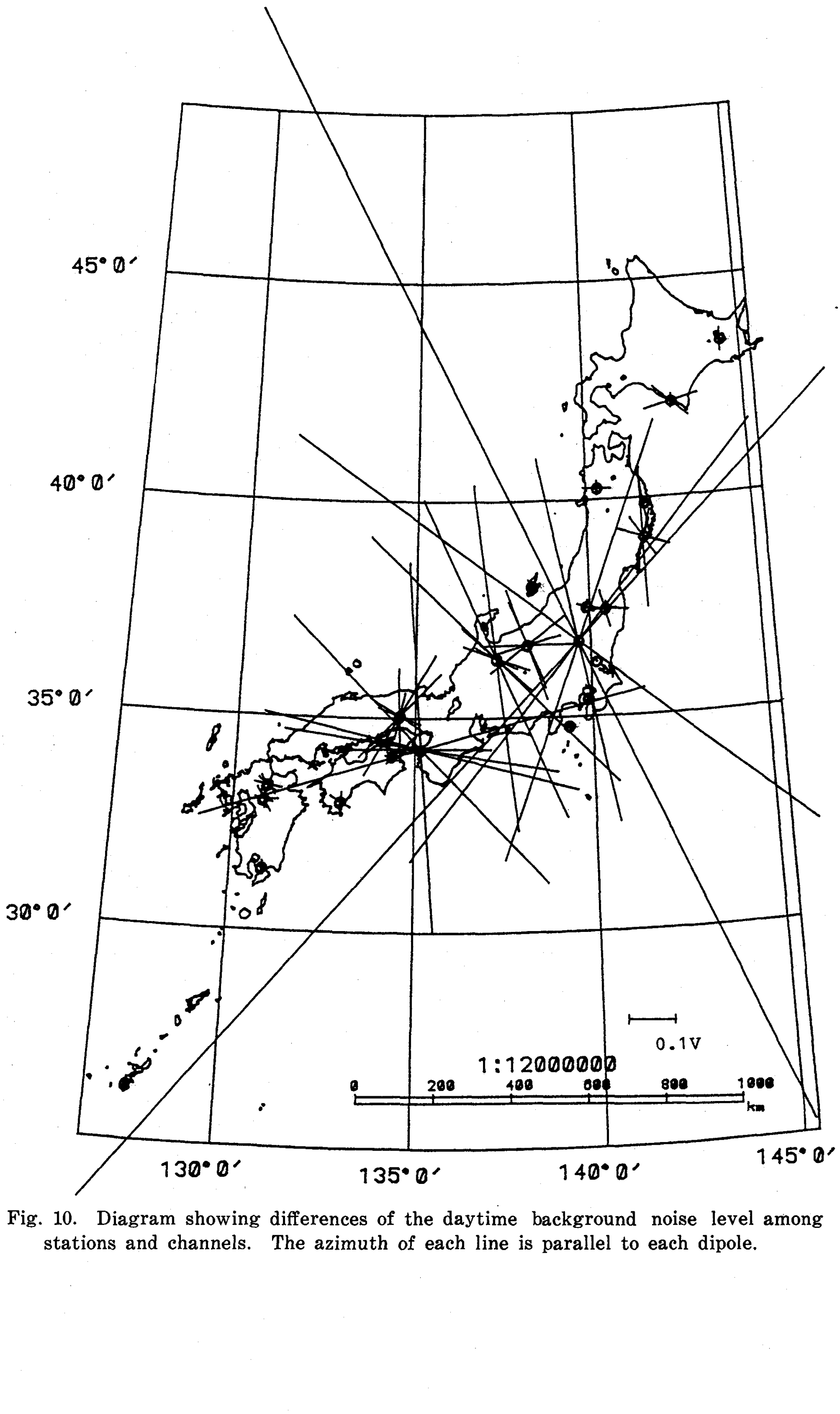


Fig. 10. Diagram showing differences of the daytime background noise level among stations and channels. The azimuth of each line is parallel to each dipole.

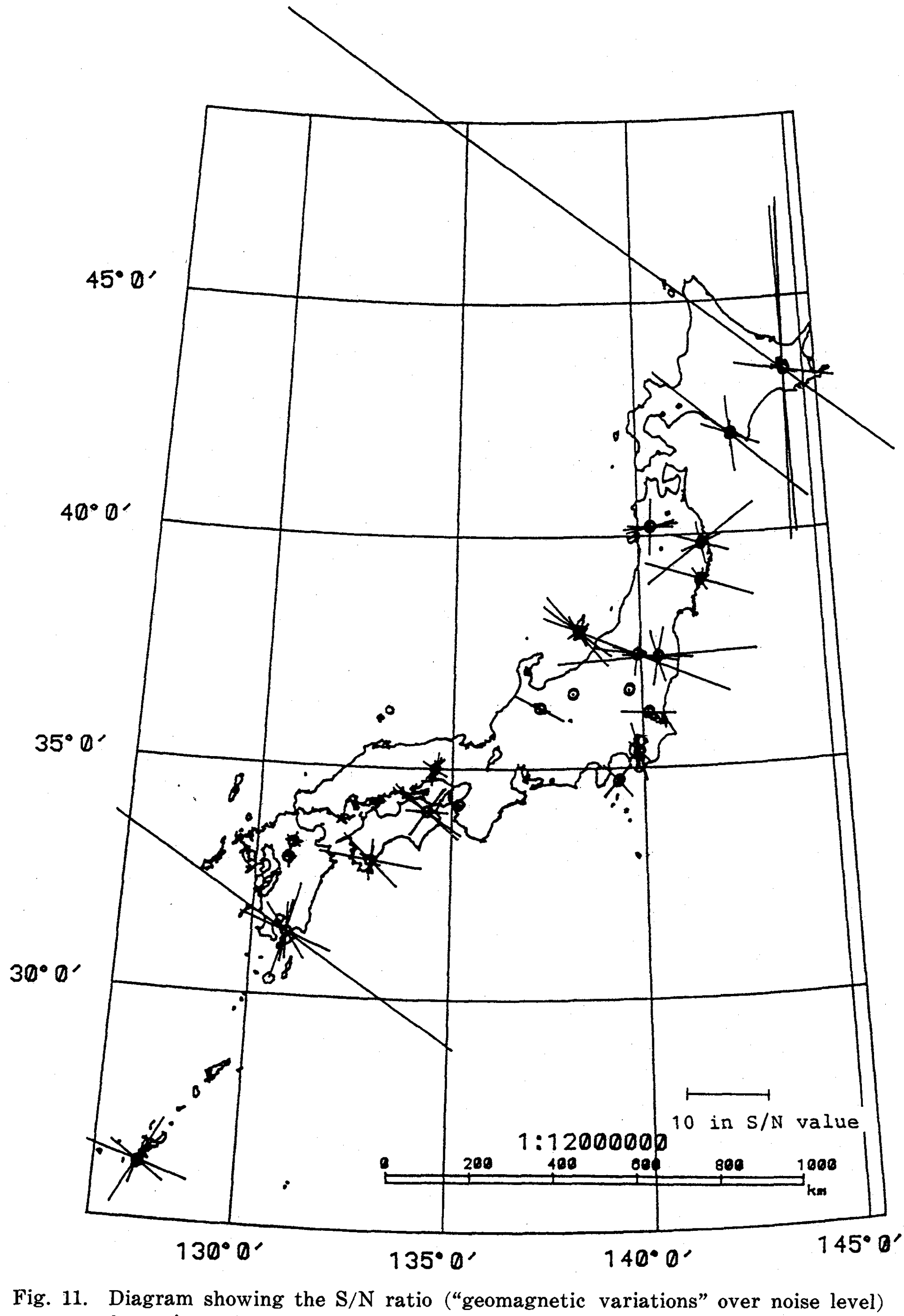


Fig. 11. Diagram showing the S/N ratio ("geomagnetic variations" over noise level) at each station. Actually this ratio has been obtained from Fig. 7 ("geomagnetic variations") and Fig. 10 (noise level). The azimuth of each line is parallel to each dipole.

4. Characteristics of Data at Each Station

In this section we introduce individually how the records at each station look like. The distributions of electrodes are shown on topographic maps (Figs. 12 to 38), and some details of each station are given in Tables 1 to 22. In these tables, the sign '+' and '−' (used as ch. 3+) represent the plus and minus side of each dipole.

4-1. TES (Teshikaga, Hokkaido; Fig. 12, Fig. 5b)

This station was selected with the hope of catching precursors for the earthquakes in eastern Hokkaido and off-Kushiro regions. Because of lower industrial activity and no electric trains running, obtained records are generally free from noise and the S/N ratio for the "geomagnetic variations" is quite high. The amplitude of "geomagnetic variations" on channels 1 and 4 are particularly large as compared with both other channels of the same station and most channels at other stations, indicating that the areas near electrodes 'Kutcharo' and 'Kawayu' show anomalously large response to geomagnetic changes. Channel 2 (hereafter ch. 2) sometimes shows characteristic transient changes lasting for from several minutes to an hour probably due to the changes at electrode 'Nijibetsu', as shown in Fig. 13. As will be discussed in the next report, these changes may be related to the seismicity in the off-Kushiro region. In case of Fig. 13,

Table 1. Station Data (TES)

Station name: TESHIKAGA		TES	43°28.98′N	144°27.91′E		
Obs. Started on: May. 11, 1988						
CH (+)	(−)	Dist(km)	Azm(°)	"GV"	NL(mV)	18s(mV)
1 Kutcharo	Teshikaga	13.593	125.8	++	10	0
2 Teshikaga	Nijibetsu	17.798	96.3	○	10	0
3 Osotsubetsu	Shibecha	9.871	106.7	−	10	0
4 Kawayu	Teshikaga	17.192	176.1	++	50	0
5 Teshikaga	Osotsubetsu	17.623	174.2	+	10	0
6 Osotsubetsu	Touro	19.376	176.0	+	10	0

Notes
Dist: Length of the dipole (km)
Azm: Azimuth of the dipole (deg, clockwise from north)
"GV": Indices of responses to geomagnetic changes "geomagnetic variations", represented by five classes of bar length in Fig. 7. (++, +, ○, −, −−)
NL: Artificial noise level (mV)
18s: 18 sec. noise level (mV)

that may possibly be the SES precedigg the M=3.5 event off-Kushiro region on July 15, 1988.

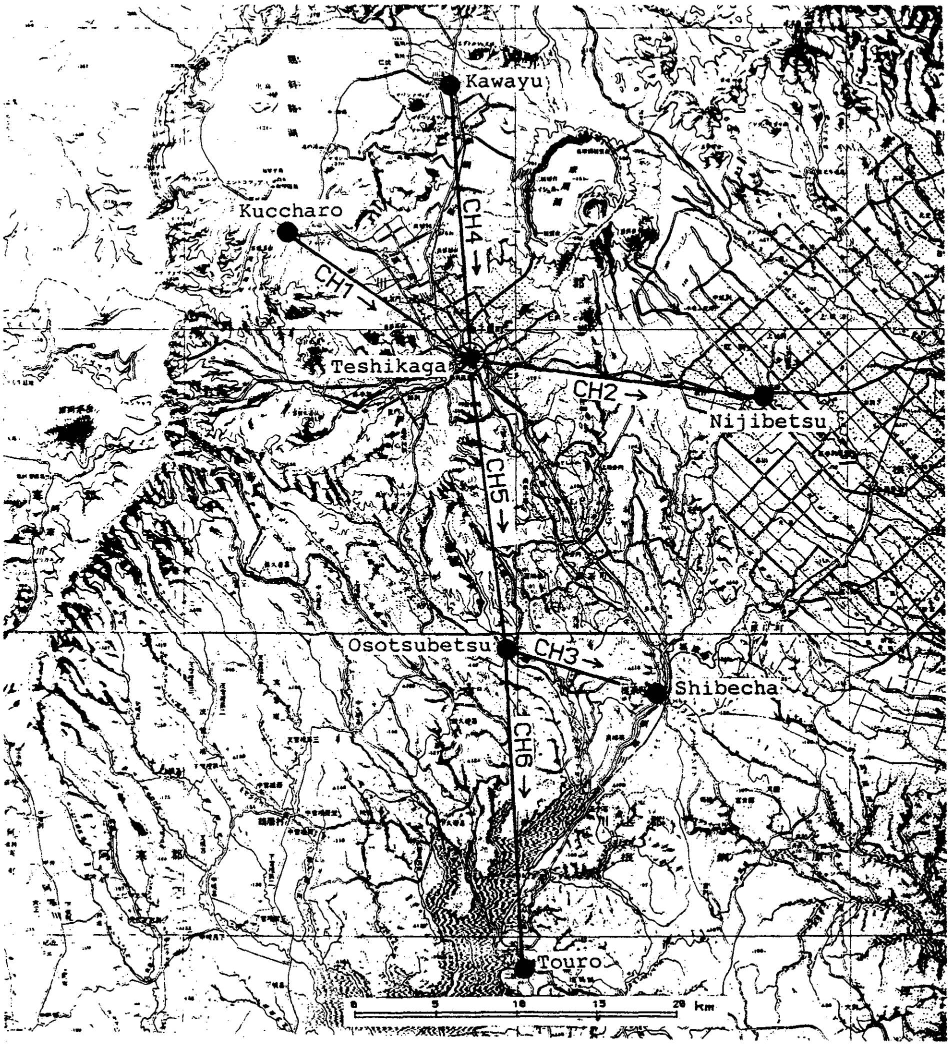


Fig. 12. Distribution of dipoles at station TES plotted on a topographic map. The arrows are drawn from the plus to minus side of dipoles.

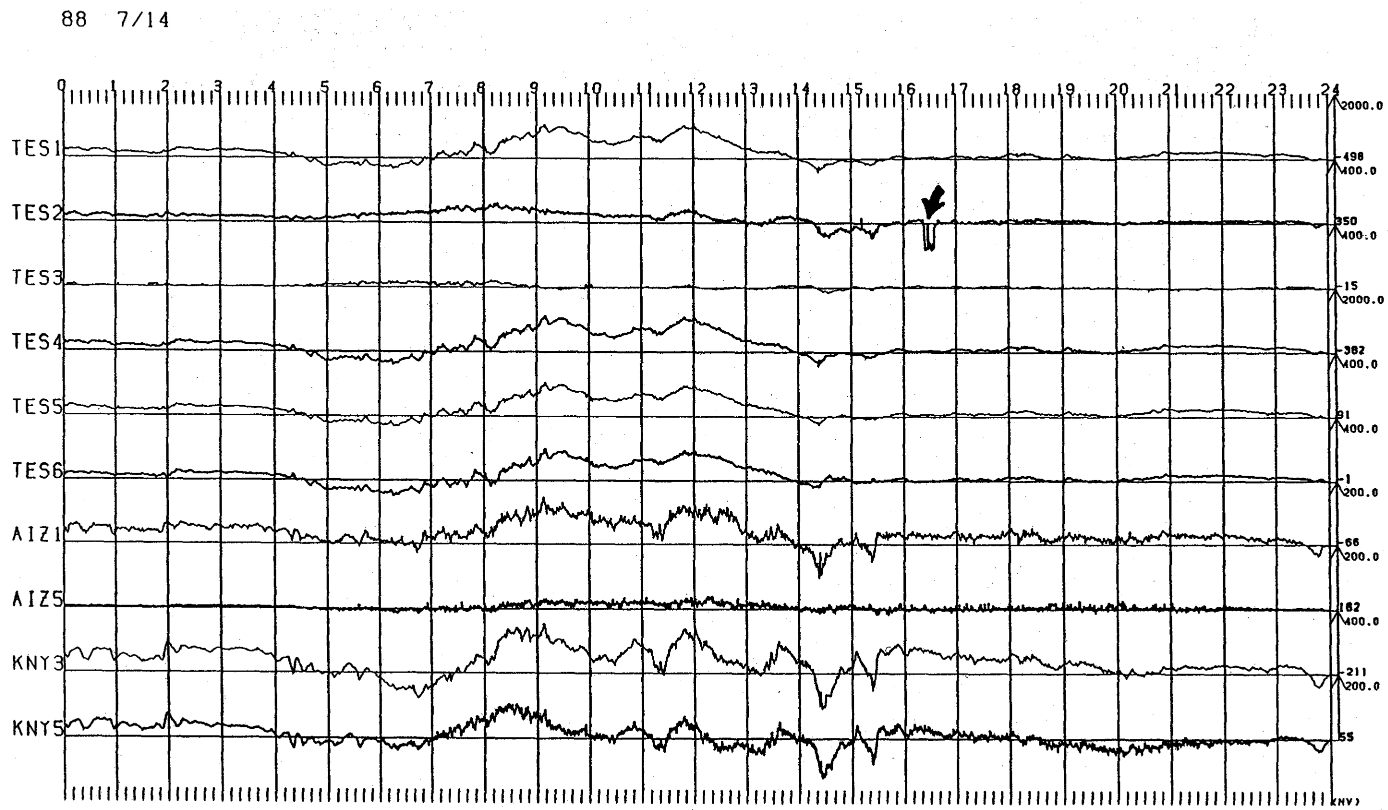


Fig. 13. Sample record lasting for one day (Jul. 14, 1988) showing an anomalous potential change (possible SES) at TES channel 2 (indicated by an arrow). Upper six records show potential changes at TES; the lower four are records at AIZ and KNY for reference. The amplitude of this anomaly is 200 mV. This may possibly be the SES preceding M=3.5 events off-Kushiro region on July 15, 1988.

4-2. URK (Urakawa, Hokkaido; Fig. 14, Fig. 5e)

Urakawa was selected because the area off Urakawa is a well-known seismic area, and the noise level is relatively low with low human activity and no electric train around. The correlation between some changes in electric potential at URK station and the seismicity has not been identified so far.

Table 2. Station Data (URK)

Station name: URAKAWA			URK	42°09.71′N	142°44.71′E		
Obs. Started on: Jun. 17, 1987							
CH	(+)	(−)	Dist(km)	Azm(°)	"GV"	NL(mV)	18s(mV)
1	Urakawa	Samani	14.023	107.8	○	20	0
2	Nissha	Horoman	19.169	127.5	+	100	0
3	Utabue	Horoman	36.434	127.2	○	20	0
4	Utabue	Ogifushi	7.681	176.8	○	30	0
5	Nobuka	Urakawa	9.565	171.2	○	10	0
6	Nissha	Urakawa	6.577	252.9		120	0

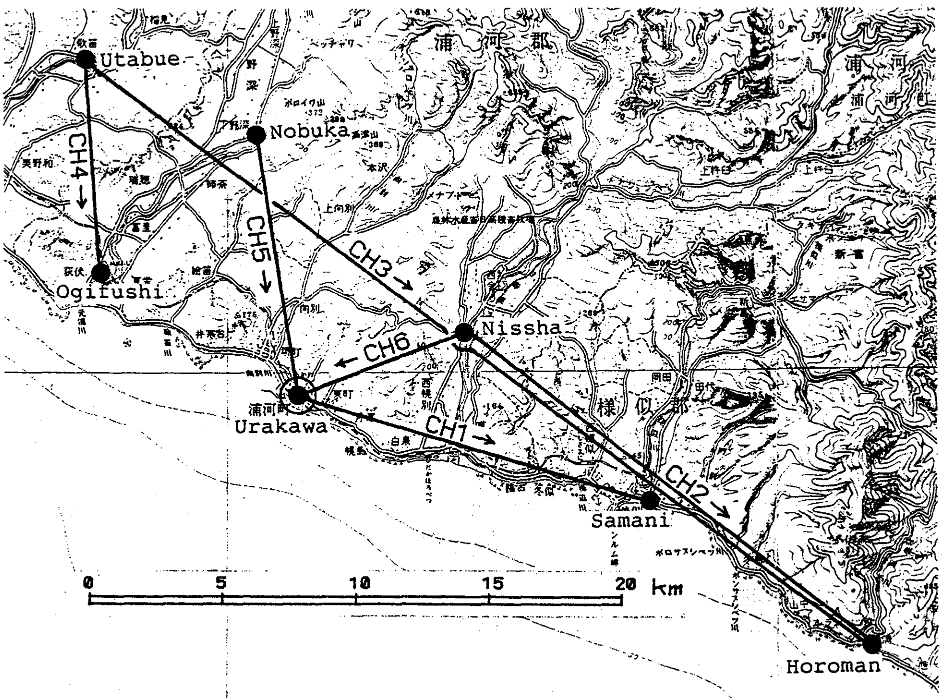


Fig. 14. Distribution of dipoles at station URK plotted on a topographic map.

4-3. TKN (Takanosu, Akita Pref.; Fig. 15, Fig. 5a)

We have five networks (TKN, IWI, OFN, AIZ, ABK) in NE-Japan, aiming at earthquakes related to the subduction along the NE-Japan Arc. At TKN, the EW-component of the electric field (ch. 4, 5, 6) is more sensitive to geomagnetic changes than the NS-component (ch. 1, 2, 3) (Fig. 7).

Table 3. Station Data (TKN)

Station name: TAKANOSU			TKN	40°03.67′N	140°24.84′E		
Obs. Started on: Sep. 7, 1988							
CH	(+)	(−)	Dist(km)	Azm(°)	"GV"	NL(mV)	18s(mV)
1	Takanosu	Nanokaichi	6.320	151.2	−	10	1
2	Nanokaichi	Maeda	12.613	178.1	○	30	0
3	Nanokaichi	Ani	20.364	180.6	○	20	0
4	Aikawa	Nanokaichi	8.035	73.6	○	10	0
5	Kamikoani	Maeda	10.507	81.0	○	20	0
6	Kamikoani	Moriyoshi	17.150	89.0	+	60	0

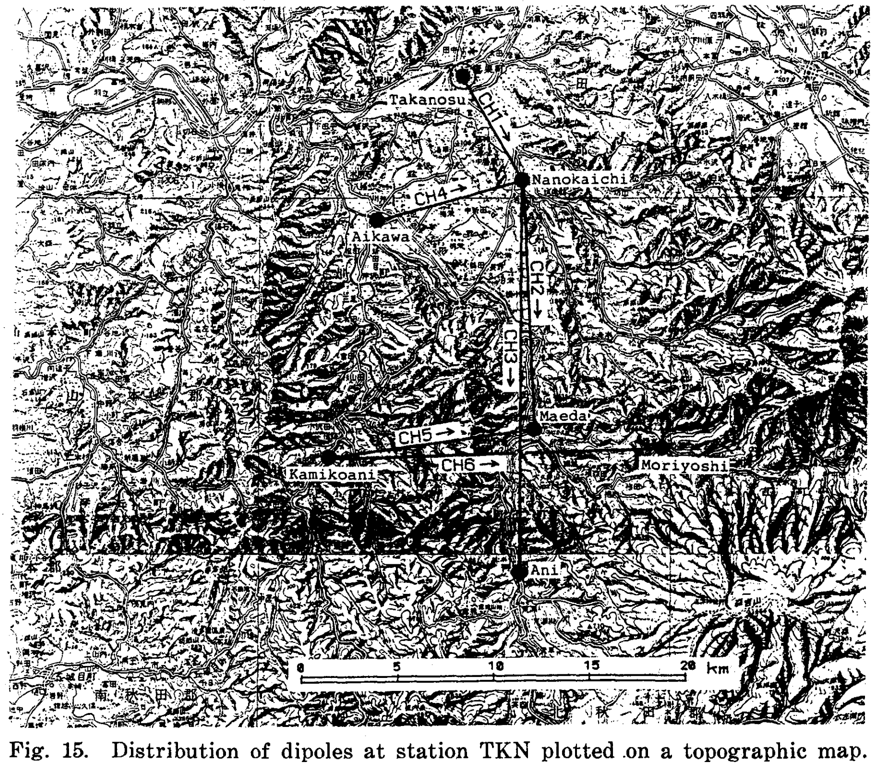


Fig. 15. Distribution of dipoles at station TKN plotted on a topographic map.

4-4. IWI (Iwaizumi, Iwate Pref.; Fig. 16, Fig. 5a)

Ch. 3 (electrode 'Tanohata') is quite sensitive to geomagnetic changes, and others are rather insensitive as compared with other networks. The Tohoku-Shinkansen super express line running about 60 km away seems to have no significant influence on the records. On ch. 2, short period (spike-shaped) transient changes are seen during the daytime (mainly from 6:00 to 21:00, Fig. 5a), which are somewhat strange because the electrode 'Ugei' is in a very quiet environment. One possibility is that these changes are caused by telephone calls at the 'Ugei' branch building, and it should be checked.

Table 4. Station Data (IWI)

Station name: IWAIZUMI IWI 39°50.63′N 141°47.59′E

Obs. Started on: Sep. 27, 1988

CH	(+)	(−)	Dist(km)	Azm(°)	"GV"	NL(mV)	18s(mV)
1	Akka	Iwaizumi	16.126	164.1	−	5	2
2	Iwaizumi	Ugei	8.520	168.9	○	160	7
3	Iwaizumi	Tanohata	15.890	51.4	+	20	0
4	Ogawa	Iwaizumi	11.925	65.4	○	10	0
5	Ogawa	Iwaizumi	11.209	103.3	○	10	0
6	Ogawa	Ogawa	7.540	179.5	−	20	0

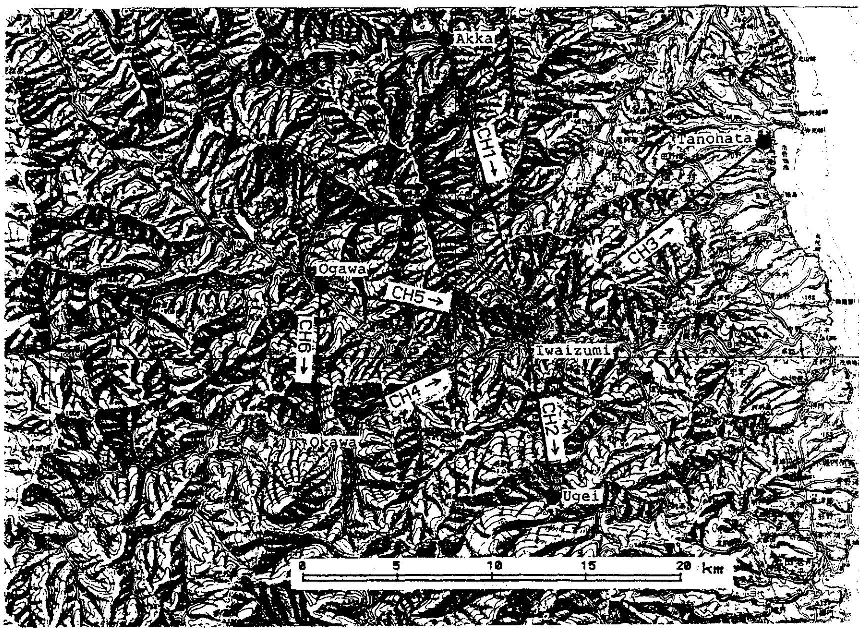


Fig. 16. Distribution of dipoles at station IWI plotted on a topographic map.

4-5. OFN (Ofunato, Iwate Pref.; Fig. 17, Fig. 5a)

"Geomagnetic variations" are similar among all channels. However, it is very strange that the response of ch. 5 has a polarity opposite to other NS-oriented lines. In general the S/N ratio is so low that "geomagnetic variations" are not easy to detect; especially ch. 6 (electrode 'Kesen-Yokota') is quite noisy.

Table 5. Station Data (OFN)

Station name: OFUNATO		OFN	39°08.32′N	141°34.78′E		
Obs. Started on: Sep. 20, 1988						
CH (+)	(−)	Dist(km)	Azm(°)	"GV"	NL(mV)	18s(mV)
1 Shimo-Omata	Sumita	6.663	105.3	++	20	0
2 Sumita	Higoroichi	8.436	105.5	+	120	0
3 Higoroichi	Ofunato	7.130	143.4	++	100	0
4 Kamiarizumi	Sumita	6.372	191.4	+	120	0
5 Sumita	Yahagi	12.733	197.1	+	80	0
6 Sumita	Kesen-Yokota	7.488	175.8	++	300	10

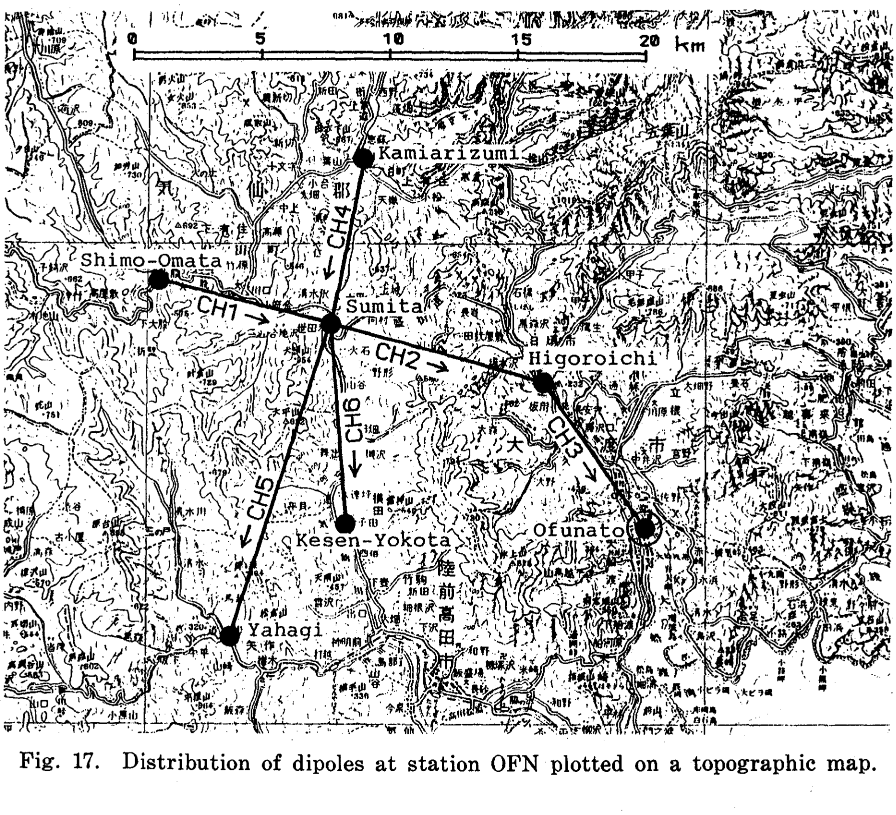


Fig. 17. Distribution of dipoles at station OFN plotted on a topographic map.

4-6. AIZ (Aizu-Wakamatsu, Fukushima Pref.; Fig. 18, Fig. 5d)

The EW-component of the electric field (ch. 1, 2, 3, 4) is more sensitive to geomagnetic changes than the NS-component (ch. 5, 6). An electric train (alternating current) runs through and to the north of Aizu-Wakamatsu City, but this does not seem to have any significant influence on the records. Some changes at this station seem worth closer examination for their possible correlation with seismicity in the Kanto area.

Table 6. Station Data (AIZ)

Station name: AIZU-WAKAMATSU AIZ 37°29.40′N 139°55.90′E

Obs. Started on: Sep. 16, 1987

CH	(+)	(−)	Dist(km)	Azm(°)	"GV"	NL(mV)	18s(mV)
1	Nishiaizu	Seaburiyama	31.752	110.9	○	10	0
2	Niitsuru	Seaburiyama	13.795	106.4	○	20	0
3	Nishiaizu	Aizu-Bange	15.696	97.5	○	10	0
4	Aizu-Wakam.	Niitsuru	8.909	286.9	○	40	4
5	Aizu-Bange	Omata	20.566	187.8	—	10	5
6	Niitsuru	Omata	15.448	193.8	—	30	0

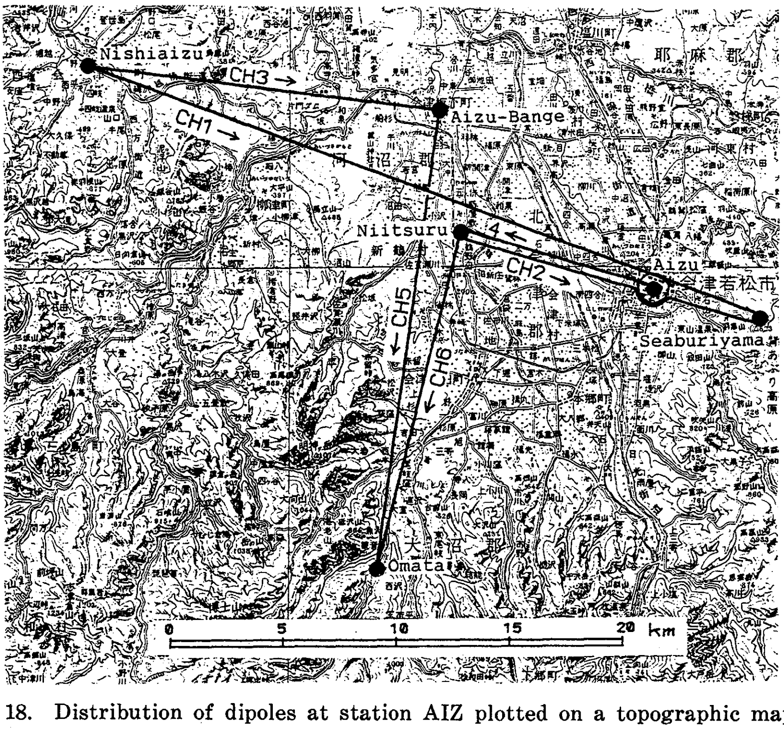


Fig. 18. Distribution of dipoles at station AIZ plotted on a topographic map.

4-7. ABK (Abukuma, Fukushima Pref.; Fig. 19, Fig. 5a)

The Abukuma network is located close to the Aizu-Wakamatsu network (about 70 km apart). However, the former is more sensitive to geomagnetic changes than the latter. Particularly, ch. 3 and ch. 6 are quite sensitive. On the other hand ch. 5 shows almost no "geomagnetic variation". This implies that electrodes 'Tokiwa' (ch. 5+, 3+) and 'Ogoe' (ch. 5−, 6+) are electrically well connected and are relatively insulated from 'Miyakoji' (ch. 3−) and 'Takine' (ch. 6−).

Table 7. Station Data (ABK)

Station name: ABUKUMA			ABK	37°26.17′N	140°38.43′E		
Obs. Started on: Sep. 1, 1988							
CH	(+)	(−)	Dist(km)	Azm(°)	"GV"	NL(mV)	18s(mV)
1	Miharu	Funahiki	7.013	91.6	+	100	0
2	Funahiki	Tokiwa	5.889	90.9	++	40	0
8	Tokiwa	Miyakoji	11.831	84.1	++	50	0
4	Utsushi	Tokiwa	8.436	188.2	+	20	0
5	Tokiwa	Ogoe	6.298	184.1	○	30	0
6	Ogoe	Takine	7.049	161.6	++	80	0

Fig. 19. Distribution of dipoles at station ABK plotted on a topographic map.

4-8. SDO (Sado Is., Niigata Pref.; Fig. 20, Fig. 5b)

It was expected that this network would be free from artificial noise, because all electrodes are isolated from the mainland. Although the noise level is low, channels 2 and 6 often show strange changes that are not obviously of natural origin (Fig. 6b). Channels 4, 5 and 6 (both electrodes facing the sea) show rather small "geomagnetic variations", probably due to the coast effect.

Table 8. Station Data (SDO)

Station name: SADO SDO 37°59.97′N 138°19.60′E

Obs. Started on: Apr. 19, 1988

CH	(+)	(−)	Dist(km)	Azm(°)	"GV"	NL(mV)	18s(mV)
1	Himetsu	Kanai	12.194	125.6	○	10	0
2	Kanai	Tada	15.562	137.9	○	10	0
3	Mano	Akadomari	10.961	148.2	○	30	0
4	Takachi	Himetsu	11.881	212.3	—	40	0
5	Kanai	Sawada	3.783	238.1	○	10	0
6	Tada	Akadomari	6.833	234.4	○	10	0

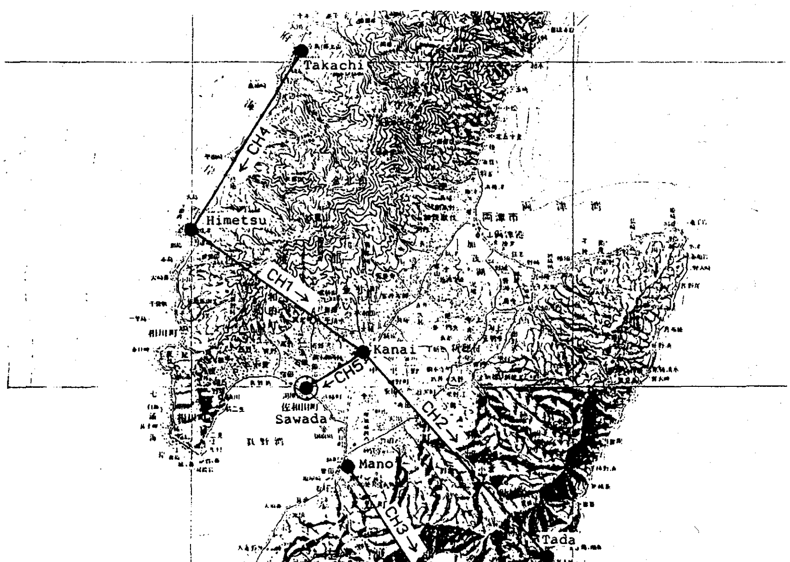


Fig. 20. Distribution of dipoles at station SDO plotted on a topographic map.

4-9. NIK (Nikko, Tochigi Pref.; Fig. 21)

This station was installed to see if we could detect signals for shallow earthquakes occurring frequently in the vicinity (Ashio area, MIZOUE *et al.*, 1982). As was feared, however, almost all the channels showed huge noise from electric trains (direct current) and even the "geomagnetic variations" could not be seen. The station was abandoned on Dec. 11, 1987.

Table 9. Station Data (NIK)

Station name: NIKKO			NIK	36°43.12′N	139°41.50′E		
Obs. Started on: Jul. 18, 1987			Stopped on: Dec. 11, 1987				
CH	(+)	(−)	Dist(km)	Azm(°)	"GV"	NL(mV)	18s(mV)
1	Yunishigawa	Chuzenji	26.196	198.9		1000	0
2	Yunishigawa	Kuriyama	10.888	166.3		800	0
3	Kuriyama	Chuzenji	18.015	217.9		1200	0
4	Yunishigawa	Osawa	33.596	153.8		3800	0
5	Chuzenji	Okorogawa	14.423	126.0		1500	0
6	Imaichi	Okorogawa	8.674	222.5		4000	0

Fig. 21. Distribution of dipoles at station NIK plotted on a topographic map.

4-10. KAK (Kakioka, Ibaraki Pref.; Fig. 22, Fig. 5e)

This station was installed by ourselves, without using NTT's electrodes. The changes in the EW-direction are predominant, as is the case with the data obtained by the nearby Kakioka Magnetic Observatory, JMA (Japan Meteorological Agency). Due to line trouble (cuts by animals, e. g. channel 4 in Fig. 5e), we were obliged to abort the observation.

Table 10. Station Data (KAK)

Station name: KAKIOKA KAK 36°13.75′N 140°11.38′E

Obs. Started on: Aug. 21, 1987 Stopped on: Dec. 26, 1988

CH	(+)	(−)	Dist(km)	Azm(°)	"GV"	NL(mV)	18s(mV)
1	NS-long		0.425	0.0		2	0
2	NS-short		0.190	0.0	○	1	0
3	EW-long		0.340	270.0	++	2	0
4	EW-short		0.180	270.0		1	0
5	KAKIOKA (magnetogram)			H			
6	KAKIOKA (magnetogram)			D			

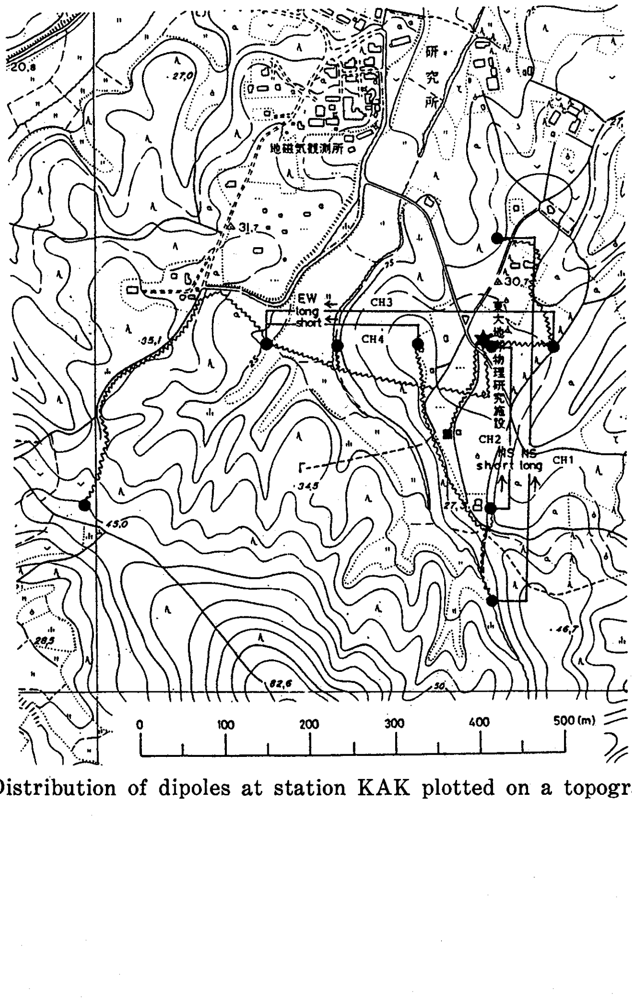


Fig. 22. Distribution of dipoles at station KAK plotted on a topographic map.

4-11. KIS (Kisarazu, Chiba Pref.; Fig. 23, Fig. 5d)

The Kisarazu network is surrounded by many possible noise sources such as electric train and industries. However, the noise level is not so high as compared with other stations. This may be because all those noise sources are located along the sea and leakage current goes away into the sea. Immediately before a disastrous earthquake of M=6.7 occurred on Dec. 17, 1987 east off Chiba Pref. (35°22.3′N, 140°29.8′E and 57.9 km focal depth according to the JMA Preliminary Earthquake Origin Report), ch. 1, 2, 5 and 6 showed a long period transient change lasting for one week (electrode 'Sueyoshi' must be responsible) like the Sobolev efiect (SOBOLEV, 1975) as shown in Fig. 24. It was also noted that the noise level changed abruptly at the time of the earthquake (Fig. 25). No clear SES was detected, however, at any station.

Table 11. Station Data (KIS)

Station name: KISARAZU		KIS	35°19.78′N	140°03.38′E		
Obs. Started on: Jul. 25, 1987						
CH (+)	(−)	Dist(km)	Azm(°)	"GV"	NL(mV)	18s(mV)
1 Minekami	Sueyoshi	17.383	33.0	—	30	0
2 Seiwa	Sueyoshi	8.302	34.4	○	20	0
3 Kameyama	Tsukahara	12.724	309.0	○	30	0
4 Seiwa	Tsukahara	3.793	334.0	○	20	3
5 Kameyama	Sueyoshi	11.981	342.8	○	10	0
6 Hirooka	Sueyoshi	8.688	356.2	○	10	0

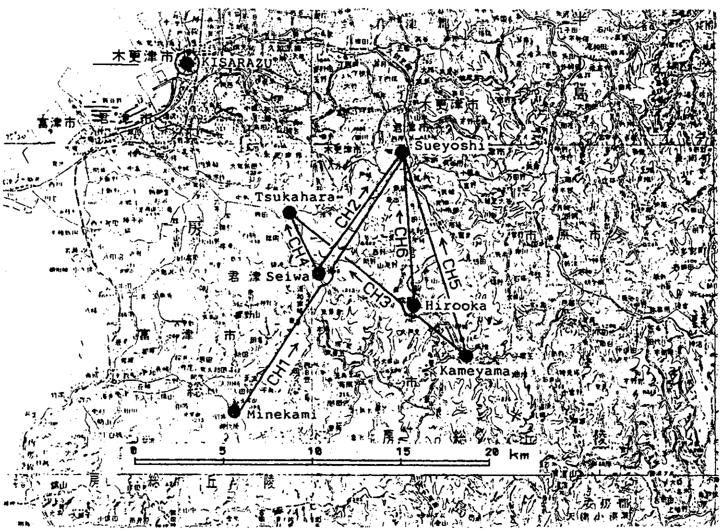


Fig. 23. Distribution of dipoles at station KIS plotted on a topographic map.

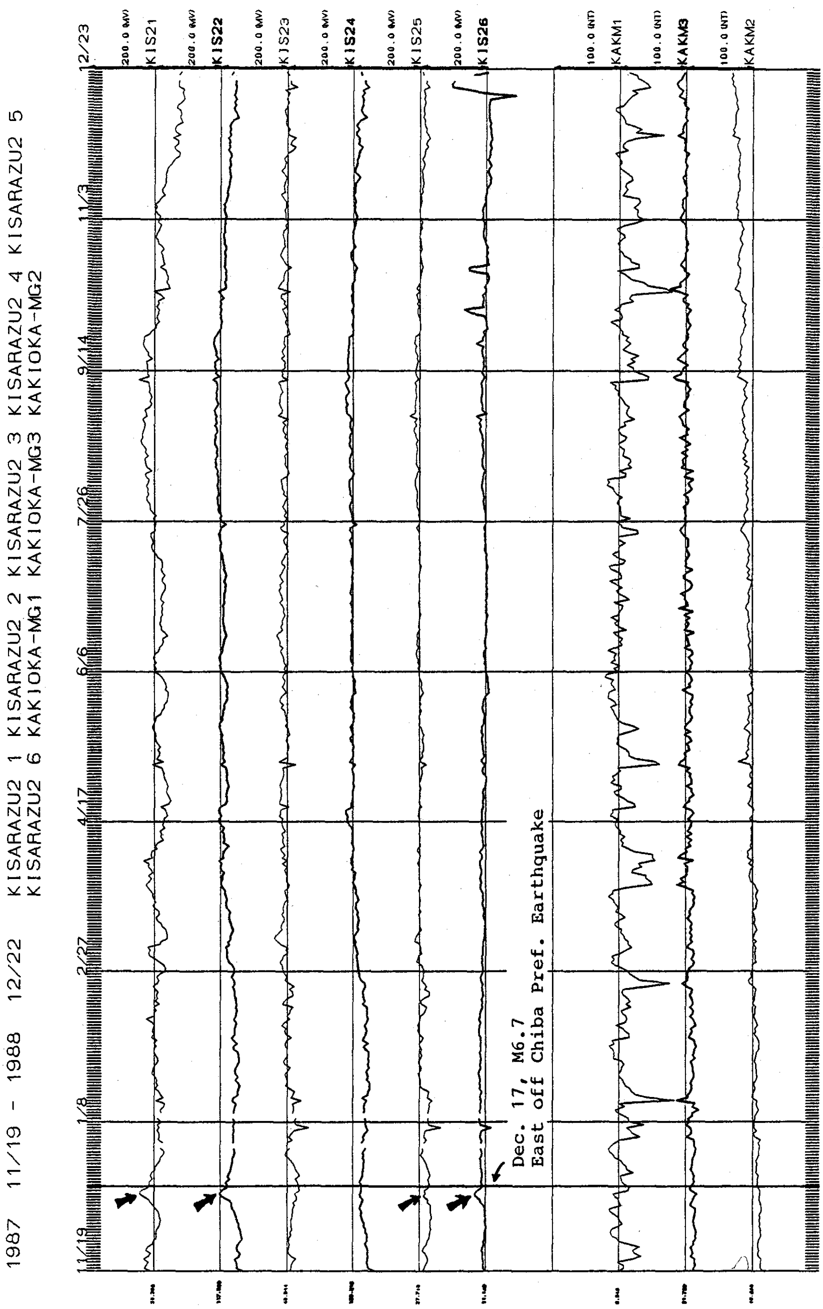


Fig. 24. The long-term record at KIS and the magnetic three components data observed at Kakioka Magnetic Observatory, JMA (KAKM1: H, KAKM3: D, KAKM2: Z) showing the anomalous change on channels 1, 2, 5 and 6 (indicated by thick arrows) before the earthquake east off Chiba Pref., Dec. 17, 1987 (indicated by a thin arrow). These data are averaged over one day.

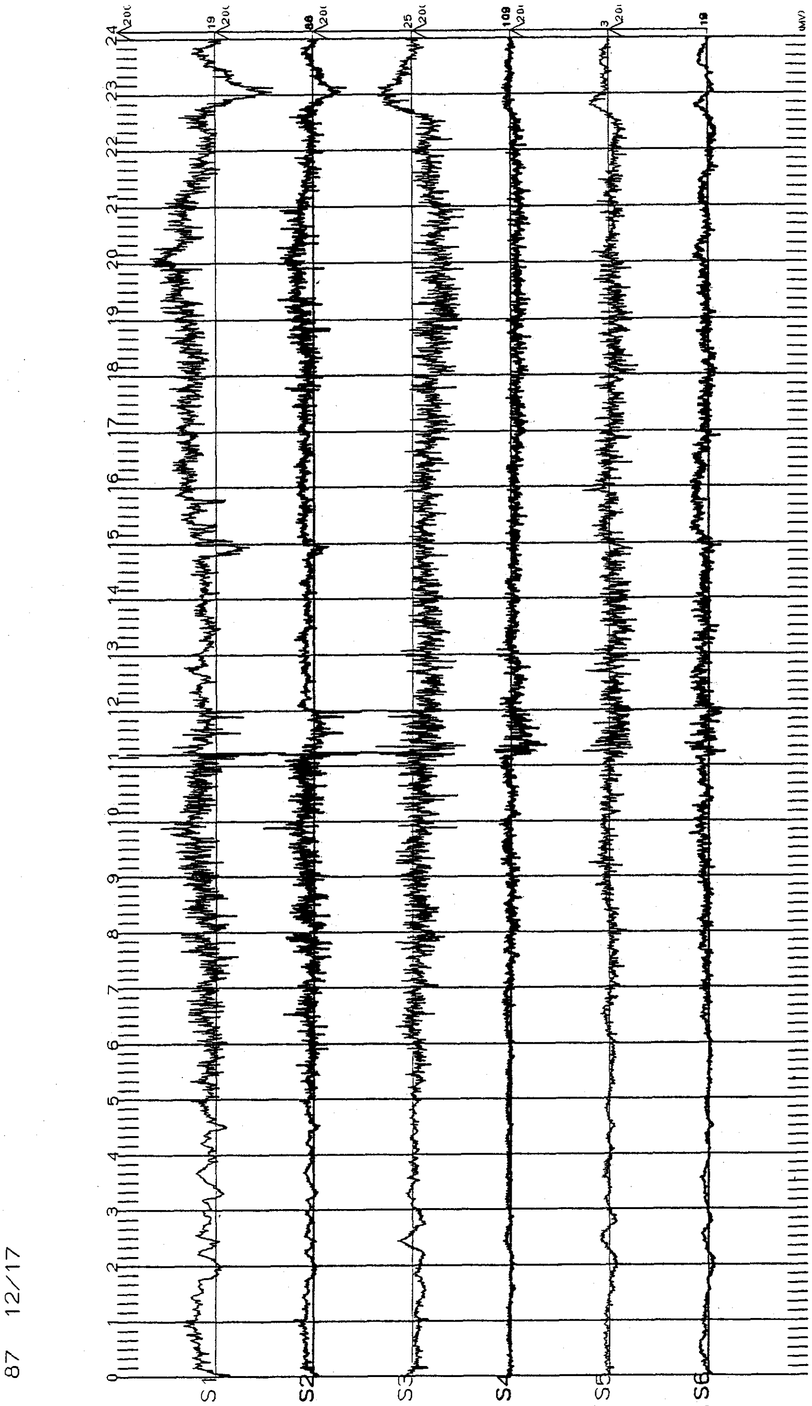


Fig. 25. One-day potential record at KIS on Dec. 17, 1987. Note that noise level changed on all channels after the occurrence of the earthquake east off Chiba Pref. (11: 08).

4-12. OSM (Oshima Is., Tokyo; Fig. 26, Fig. 5c)

This station was installed after the major eruption of Mt. Mihara on Nov. 21, 1986 (ABE and TAKAHASHI, 1987), in order to find precursors of subsequent eruptions, if any, of the volcano. Because we have only four telephone office buildings with available electrodes on the island, only three channels (1, 2, 3) of six are used for the measurement of potential differences. The most distinguishable feature is the noise which appears every 180 seconds, caused by telephone charging pulses appearing every 18

Table 12. Station Data (OSM)

Station name: OSHIMA			OSM	34°44.92′N	139°21.54′E		
Obs. Started on: Nov. 18, 1987							
CH (+)	(−)		Dist(km)	Azm(°)	"GV"	NL(mV)	18s(mV)
1 Motomachi	Okada		13.592	126.3	○	10	150
2 Tsubai	Okata		17.991	95.1	+	10	150
3 Habu	Motomachi		9.621	106.3	○	10	100
4 Futakoyama	(magnetogram)			F			
5 Futakoyama	(=)			D			
6 Nomashi	(=)			F			

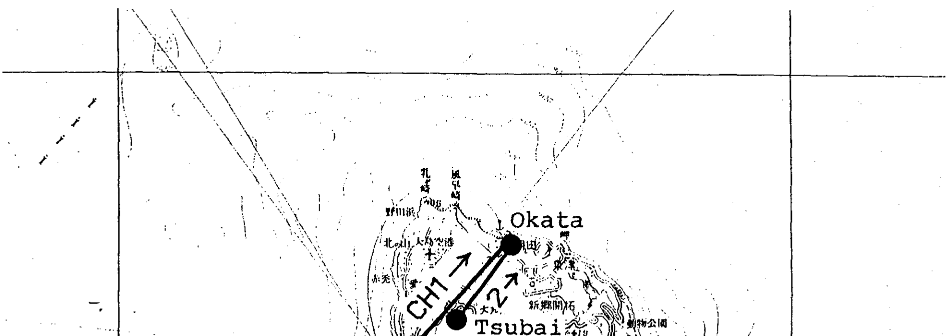


Fig. 26. Distribution of dipoles at station OSM plotted on a topographic map.

seconds, and the transient changes (about a few tens of minutes long) that appear on any of three channels. As seen in Fig. 5(c), the amplitude of 180 sec. noise changes with the period of about half day. This 180 sec. period is explained by the aliasing caused by the difference between the noise period (18 sec.) and the sampling interval (20 sec.), and the half day period occurs because the clock is not synchronized between our data logger and NTT charging system. Before starting the telemetered recording, data were recorded locally on a pen recorder at the Oshima Volcano Observatory of ERI. On Nov. 16, 1987, a remarkable change was observed on channel 3 that measures the potential difference right across the crater of Mt. Mihara (Fig. 26), about an hour before an eruption (IDA *et al.*, 1988) as shown in Fig. 27. This eruption was one of the two eruptions that took place after the major activity in 1987. The second one which took place on Nov. 18, 1987, however, did not show any signal.

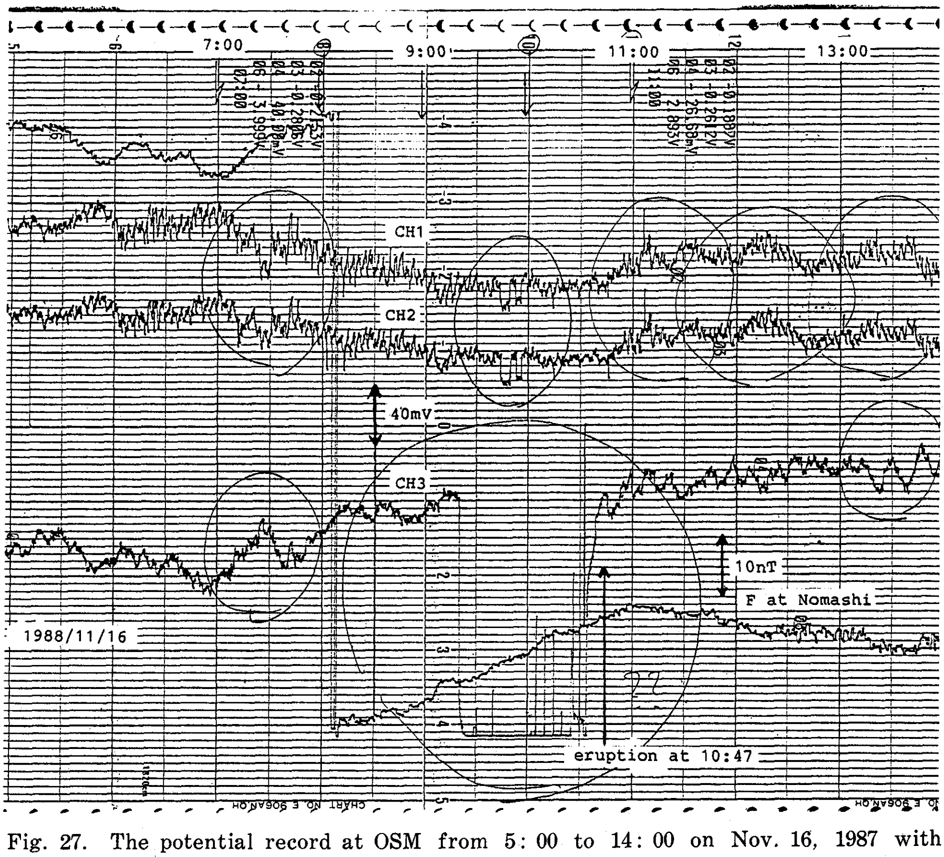


Fig. 27. The potential record at OSM from 5: 00 to 14: 00 on Nov. 16, 1987 with total magnetic force data observed at Nomashi by ERI, showing the anomalous change on ch. 3 before the eruption of Mt. Mihara (10: 49).

4-13. NAG (Nagano, Nagano Pref.; Fig. 28)

This was the station installed for the first time using NTT electrodes. Although the dipoles were as long as those at other stations, electric trains caused very high noise. This station was abandoned on May 12, 1988.

Table 13. Station Data (NAG)

Station name: NAGANO			NAG	36°38.50′N	138°11.39′E		
Obs. Started on: May. 11, 1988			Stopped on: May. 12, 1988				
CH	(+)	(−)	Dist(km)	Azm(°)	"GV"	NL(mV)	18s(mV)
1	Shinko	Kinasa	13.196	335.6		200	0
2	Nakajo	Kinasa	7.839	336.2		150	0
3	Tokiwa	Kinasa	42.635	232.8		200	0
4	Iizuna	Kinasa	11.855	253.3		150	0
5	Tokiwa	Kijimadaira	7.565	158.5		250	0
6	Iiyama	Kijimadaira	5.027	88.5		200	0

Fig. 28. Distribution of dipoles at station NAG plotted on a topographic map.

4-14. KMO (Kamioka, Gifu Pref.; Fig. 29, Fig. 5b)

This network was located across the Atotsugawa Fault, an active fault (The Research Group for Active Faults, 1980). It is generally expected that the amplitude of electrical changes is larger across the fault than along the fault, but since all the available electrodes were located along the same river (Takaharagawa River) flowing across the fault, such a comparison was not possible. Moreover, the data suffered from one type of man-made huge noise, at 'Higashi-mozumi' (ch. 1+, 3+, 4+) near Kamioka Mine, mainly during the daytime and on weekdays. The station was aborted on Oct. 26, 1988.

Table 14. Station Data (KMO)

Station name: KAMIOKA			KMO	36°19.72′N	137°18.00′B		
Obs. Started on: May. 17, 1988			Stopped on: Oct. 26, 1988				
CH	(+)	(−)	Dist(km)	Azm(°)	"GV"	NL(mV)	18s(mV)
1	E-Mozumi	Kamioka	11.273	172.3	++	750	20
2	Kamioka	Kamitakara	7.739	131.4	++	200	0
3	E-mozumi	Kamitakara	17.856	155.8	++	750	20
4	E-mozumi	Okuhida	30.380	134.4	++	750	20
5	Kamioka	Okuhida	22.578	116.5	++	100	0
6	Kamitakara	Okuhida	15.230	109.0	+	150	0

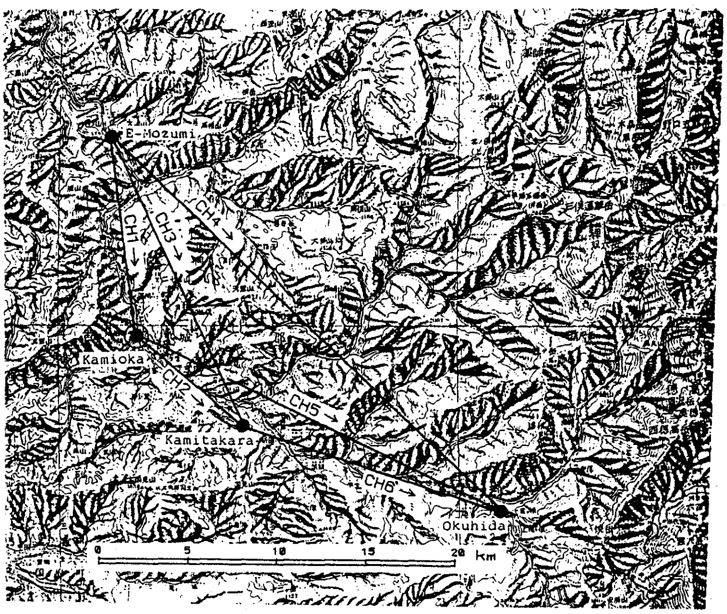


Fig. 29. Distribution of dipoles at station KMO plotted on a topographic map.

4-15. WAK (Wakayama, Wakayama Pref.; Fig. 30, Fig. 5d)

A great number of shallow and small earthquakes occur beneath the area of Wakayama City (MIZOUE *et al.*, 1983), and this station, together with TOK (Tokushima) was aimed at these earthquakes. Furthermore these two stations are located on the Median Tectonic Line. The records at WAK, however, showed extremely high noise level, due mainly to electric trains. The station was abandoned on Oct. 24, 1988.

Table 15. Station Data (WAK)

Station name: WAKAYAMA			WAK	34°13.02′N	135°27.72′E		
Obs. Started on: Sep. 28, 1987			Stopped on: Oct. 24, 1988				
CH	(+)	(−)	Dist(km)	Azm(°)	"GV"	NL(mV)	18s(mV)
1	Momoyama	Tomofuchi	10.530	104.0	+	700	0
2	Okuarakawa	Tomofuchi	6.053	90.9	+	300	0
3	Kitanogami	Kebara	15.241	99.4	++	600	0
4	Kitanogami	Tomofuchi	15.228	74.3	+	1000	3
5	Okuarakawa	Kebara	9.283	136.3	++	800	0
6	Tomofuchi	Kebara	6.622	176.8	++	800	0

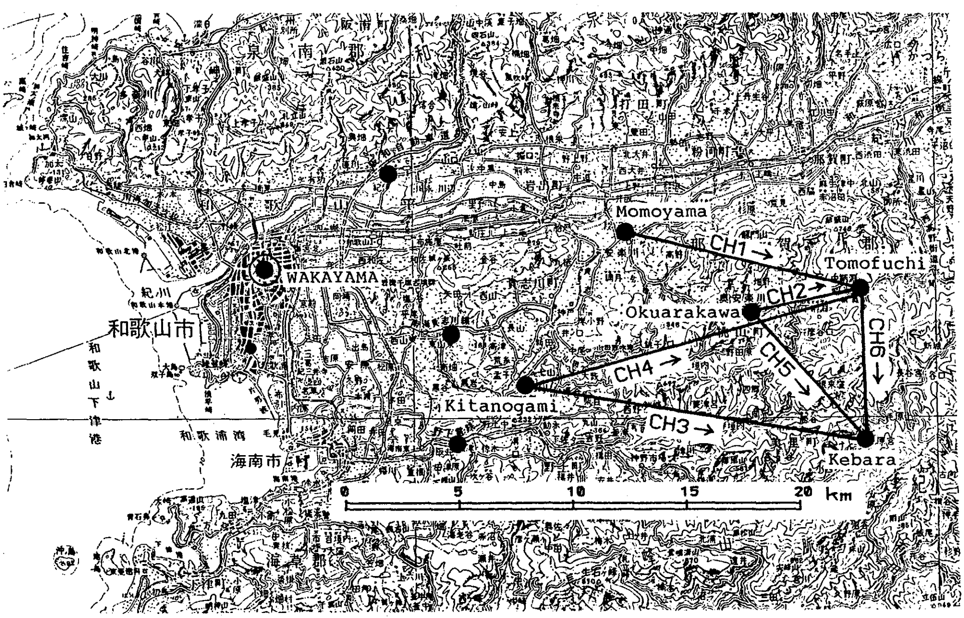


Fig. 30. Distribution of dipoles at station WAK plotted on a topographic map.

4-16. YMS (Yamasaki, Hyogo Pref.; Fig. 31, Fig. 5e)

This network was chosen to measure the potential across the Yamasaki Fault, an active fault (The Research Group for Active Faults, 1980). Ch. 5 and ch. 6 are just on the fault line. Near the central station at Yamasaki, a probable precursor potential change for the earthquake (M=5.5 just below the fault at 20 km depth) was found through a short span measurement (MIYAKOSHI, 1985). In our case, the S/N ratio is rather low and it seems difficult to find such changes. The amplitude of either "geomagnetic variations" or noise is smaller at ch. 6 (along the fault) than others, which may be the effect of the fault. The station was abandoned on Oct. 25, 1988.

Table 16. Station Data (YMS)

Station name: YAMASAKI			YMS	35°00.12′N	134°32.54′E		
Obs. Started on: Feb. 22, 1988			Stopped on: Oct. 25, 1988				
CH	(+)	(−)	Dist(km)	Azm(°)	"GV"	NL(mV)	18s(mV)
1	Anji	Shingu	8.564	211.8	++	300	0
2	Nakamikawa	Tokuhisa	8.146	194.9	++	100	0
3	Ariga	Nakamikawa	16.289	225.9	++	250	0
4	Shikafushi	Ariga	9.838	179.1	++	200	0
5	Nakamikawa	Yamasaki	12.824	122.4	++	150	0
6	Yamasaki	Anji	5.344	112.6	+	100	0

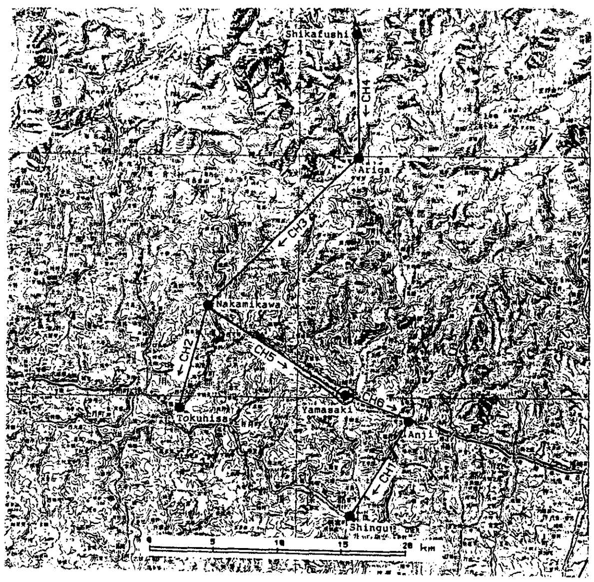


Fig. 31. Distribution of dipoles at station YMS plotted on a topographic map.

4-17. TOK (Tokushima, Tokushima Pref.; Fig. 32, Fig. 5c)

This station, like WAK, is located on the Median Tectonic Line, and is mainly aimed to catch precursors for the earthquakes beneath the Wakayama area. Although ch. 1 and 2 are parallel to the Median Tectonic Line (and parallel to the Yoshinogawa River), their variations are not necessarily smaller than others. As compared with WAK (Wakayama), the daytime noise level is much lower and the S/N ratio is much better.

Table 17. Station Data (TOK)

Station name: TOKUSHIMA			TOK	34°01.11′N	134°24.06′E		
Obs. Started on: Nov. 25, 1987							
CH	(+)	(−)	Dist(km)	Azm(°)	"GV"	NL(mV)	18s(mV)
1	Ichiba	Tokushima	24.043	94.3	○	30	0
2	Donari	Aizumi	12.978	87.4	○	20	0
3	Ichiba	Hirono	12.672	125.7	+	20	0
4	Kamojima	Sanakawachi	12.602	131.6	+	30	0
5	Aizumi	Hirono	14.214	218.4	+	40	0
6	Ishii	Hirono	7.173	215.2	++	30	0

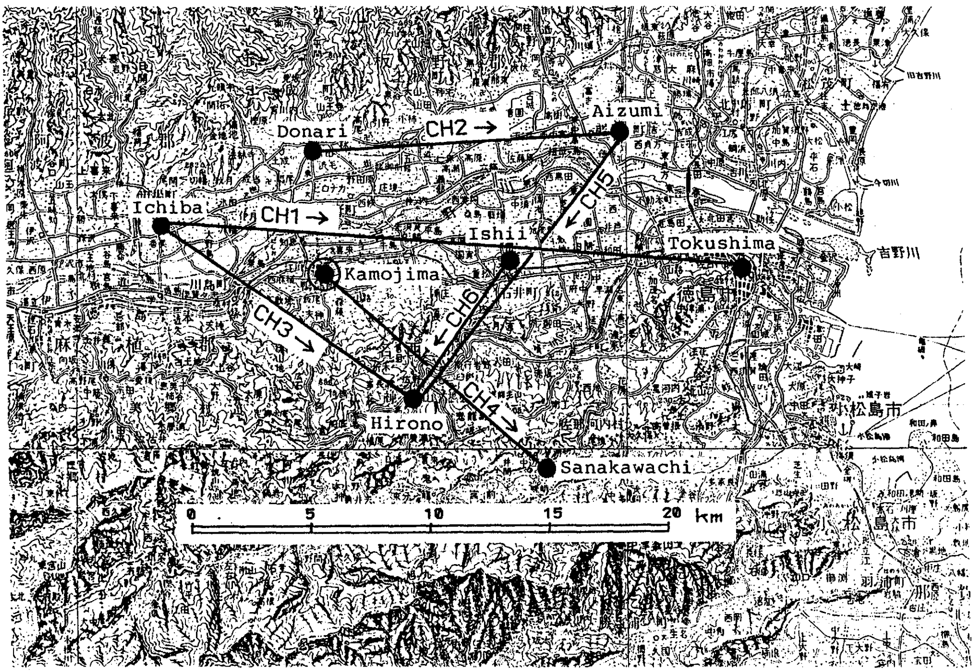


Fig. 32. Distribution ot dipoles at station TOK plotted on a topographic map.

4-18. NKM (Nakamura, Kochi Pref.; Fig. 33, Fig, 5b)

This station was installed aiming at the seismicity along the Nankai Trough, Setouchi area and Bungo Suido. The "geomagnetic variations" do not differ much among dipoles except for ch. 3, which is installed along the coast. So far, clear SES has not been identified at this station, although some suspicious changes have been noted from time to time.

Table 18. Station Data (NKM)

Station name: NAKAMURA			NKM	32°59.44′N	132°56.08′E		
Obs. Started on: Apr. 25, 1988							
CH	(+)	(−)	Dist(km)	Azm(°)	"GV"	NL(mV)	18s(mV)
1	Kawanobori	Mihara	14.109	186.4	+	40	0
2	Tomiyama	Nakamura	12.308	193.9	○	30	0
3	Ohkata	Shimoda	8.885	195.8	○	20	0
4	Kawanobori	Nakamura	8.583	121.7	+	50	10
5	Nakamura	Shimoda	7.054	135.4	+	20	0
6	Tomiyama	Saga	13.056	100.4	+	20	0

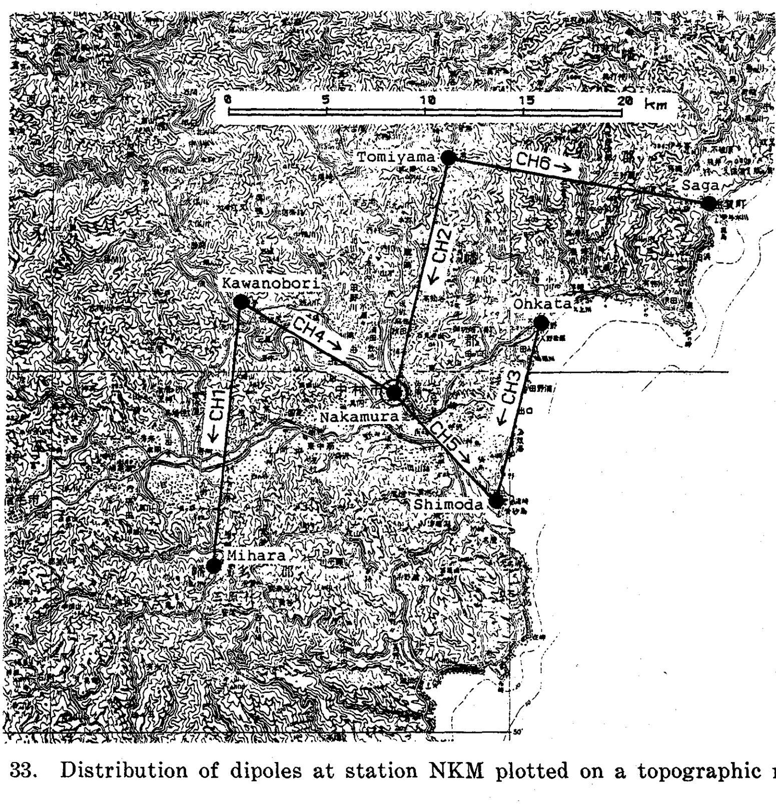


Fig. 33. Distribution of dipoles at station NKM plotted on a topographic map.

4-19. HTA (Hita, Oita Pref. ; Fig. 34, Fig. 5e)

Station Hita is located on the northern side of the Kyushu central graben (The Research Group for Active Faults, 1980). The "geomagnetic variations" are largest on ch. 6, and it seems strange that the polarity of ch. 6 is opposite to that of ch. 1 that is parallel to ch. 6. Ch. 3 ('Yoake') presents very strange huge variations of unknown origin once every few days (Fig. 5e shows a minor event of this type). The station was abandoned on Oct. 26, 1988.

Table 19. Station Data (HTA)

Station name: HITA		HTA	33°19.42′N	130°54.70′E			
Obs. Started on: Feb. 25, 1988		Stopped on: Oct. 26, 1988					
CH	(+)	(−)	Dist(km)	Azm(°)	"GV"	NL(mV)	18s(mV)
1	Ono	Hita	8.405	202.9	○	50	5
2	Hita	Oyama	9.593	144.6	○	50	5
3	Yoake	Hita	3.419	102.2	++	60	10
4	Hita	Amagase	13.069	129.0	○	50	5
5	Oyama	Amagase	4.617	95.1	○	20	0
6	Amagase	Tsue	14.200	200.7	○	50	0

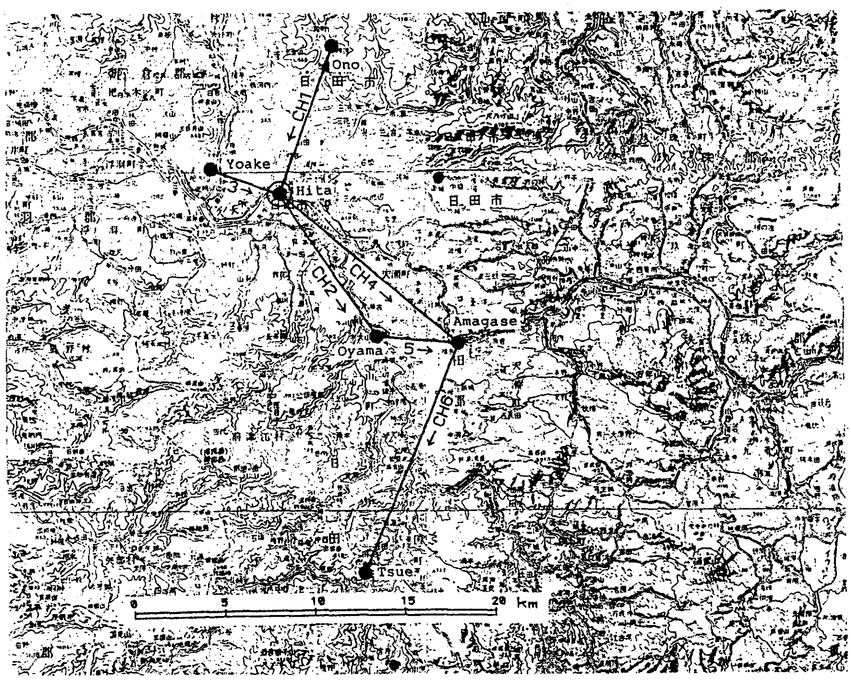


Fig. 34. Distribution of dipoles at station HTA plotted on a topographic map.

4-20. KIK (Kikuchi, Kumamoto Pref.; Fig. 35, Fig. 5c)

This station is very close to station HTA. The S/N ratio is generally low. Like Hita, many water-power stations are in operation nearby. The station was abandoned on Oct. 26, 1988.

Table 20. Station Data (KIK)

Station name: KIKUCHI			KIK	32°58.69′N	130°48.84′E		
Obs. Started on: Oct. 3, 1987			Stopped on: Oct. 26, 1988				
CH (+)	(−)		Dist(km)	Azm(°)	"GV"	NL(mV)	18s(mV)
1 Kikka	Kyokushi		15.614	152.7	○	60	0
2 Kikka	Kikuchi		10.340	162.1	○	40	0
3 Kikka	Shisui		15.774	182.1	○	40	0
4 Yamaga	Kikuchi		12.142	108.3	○	40	0
5 Kamoto	Kikuchi		7.602	106.1	○	30	0
6 Yamaga	Suigen		18.624	90.7	○	60	0

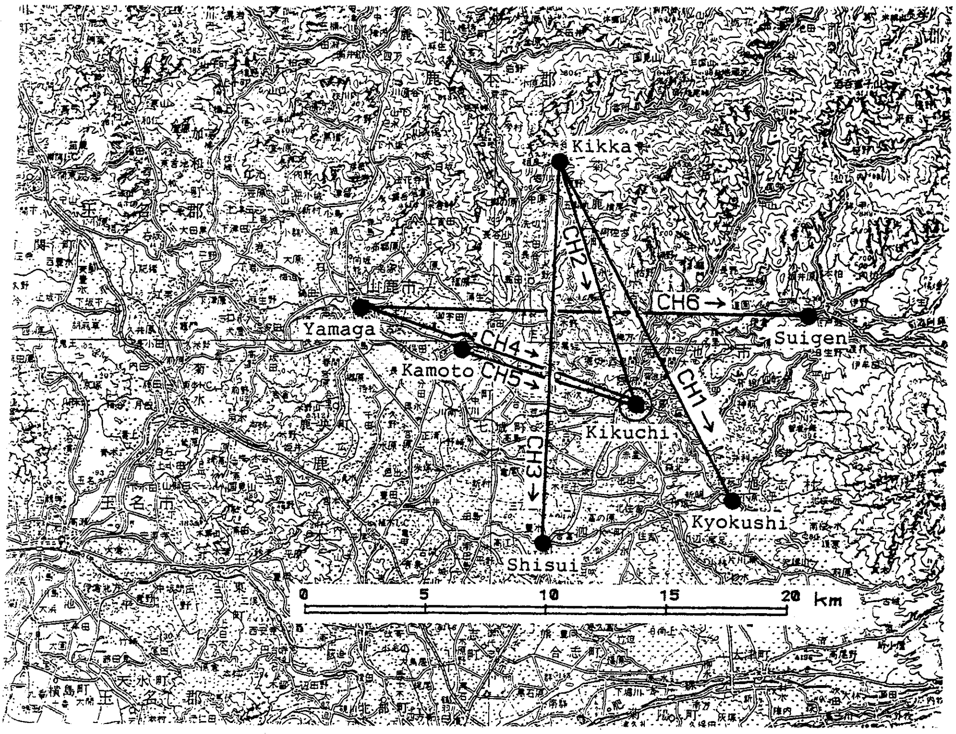


Fig. 35. Distribution of dipoles at station KIK plotted on a topographic map.

4-21. KNY (Kanoya, Kagoshima Pref.; Fig. 36, Fig. 5c)

The target areas of this station are Hyuga-nada and Tanegashima areas, together with the active volcano Mt. Sakurajima. We have a geomagnetic observatory of JMA at Kanoya and can use their magnetic records as reference. All data have low noise even in the daytime, and ch. 3 is quite sensitive to geomagnetic changes. It is strange that ch. 5 and 6 have the opposite polarity to others (especially to ch. 2).

Table 21. Station Data (KNY)

Station name: KANOYA			KNY	31°22.71′N	130°51.31′E		
Obs. Started on: Feb. 8, 1988							
CH	(+)	(−)	Dist(km)	Azm(°)	"GV"	NL(mV)	18s(mV)
1	W-Sakurajima	Tarumizu	15.062	146.6	○	20	0
2	Kurokami	Tarumizu	12.504	183.2	+	30	0
3	Tarumizu	Takayama	28.570	125.2	+	10	0
4	Kanoya	Takayama	9.745	114.1	○	10	0
5	Takakuma	Oaira	17.290	192.2	○	20	0
6	Kanoya	Oaira	5.174	198.4	+	10	0

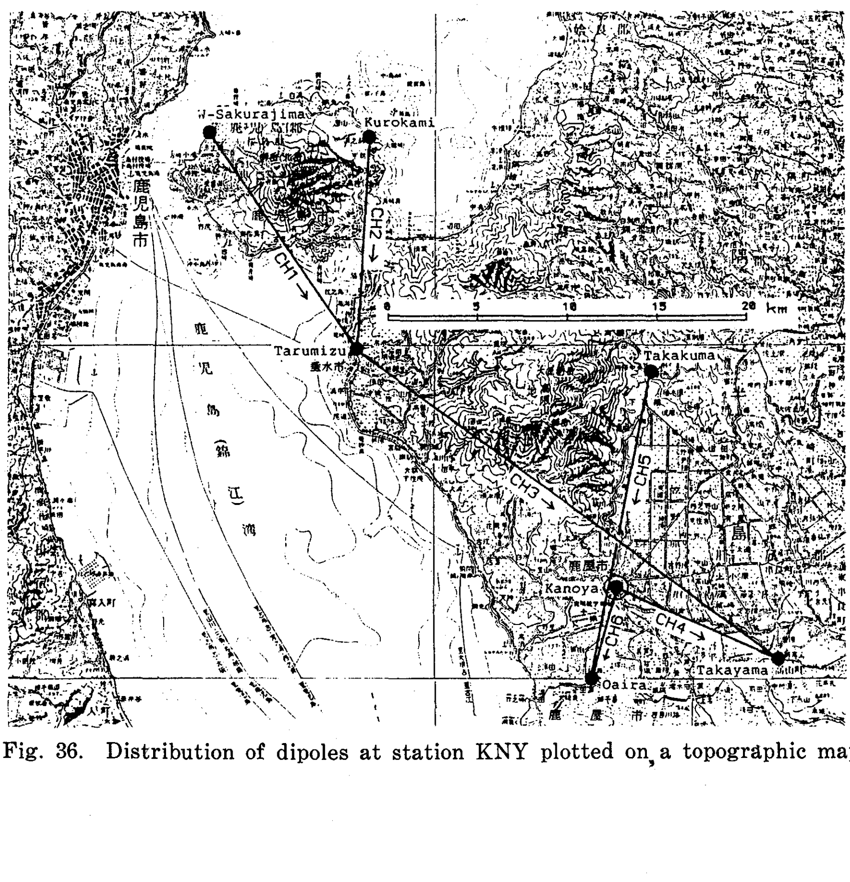


Fig. 36. Distribution of dipoles at station KNY plotted on a topographic map.

4-22. NAH (Naha, Okinawa Pref.; Fig. 37, Fig. 5d)

This station was expected to be free from large artficial noise, because there are no electric trains on the Okinawa Islands. In fact all records are totally free from such noise. Ch. 3 and 4 are more sensitive to geomagnetic changes than ch. 1 and 2, probably due to the coast effect. Some changes at this station also seem to be worth a closer examination for their potential correlation with the seismicity in the surrounding area. A clear coseismic change was observed on Jan. 24, 1988, when an earthquake of magnitude 6.0 took place near the Okinawa Island (26°39.4′N, 128°11.8′E and 75.7 km focal depth according to the JMA Preliminary Earthquake Origin report) as shown in Fig. 38.

Table 22. Station Data (NAH)

Station name: NAHA		NAH	26°11.45′N	127°44.12′E		
Obs. Started on: Sep. 25, 1987						
CH (+)	(−)	Dist(km)	Azm(°)	"GV"	NL(mV)	18s(mV)
1 Oroku	Ojana	10.304	33.5	○	5	0
2 Oroku	Shuri	5.179	41.6	○	10	0
3 Oroku	Tamagusuku	12.737	112.9	○	10	0
4 Haebaru	Tamagushku	8.284	129.6	○	10	0
5 Futenma	Komesu	22.865	201.3	—	10	0
6 Haebaru	Komesu	11.503	201.2	○	10	0

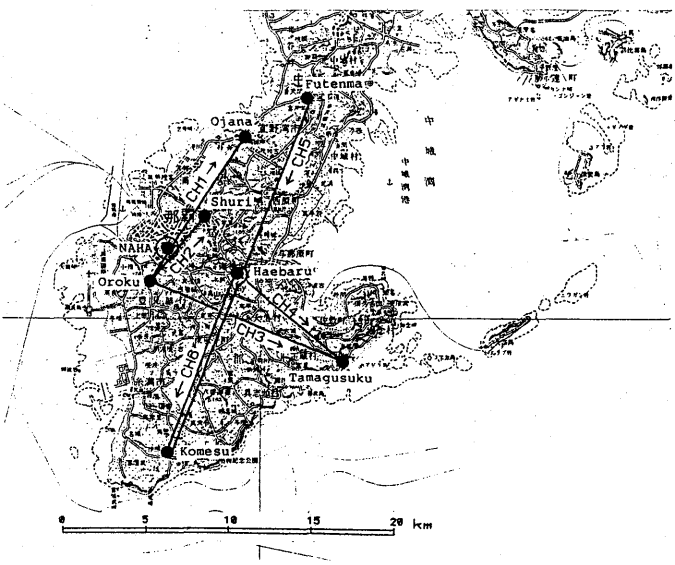


Fig. 37. Distribution of dipoles at station NAH plotted on a topographic map.

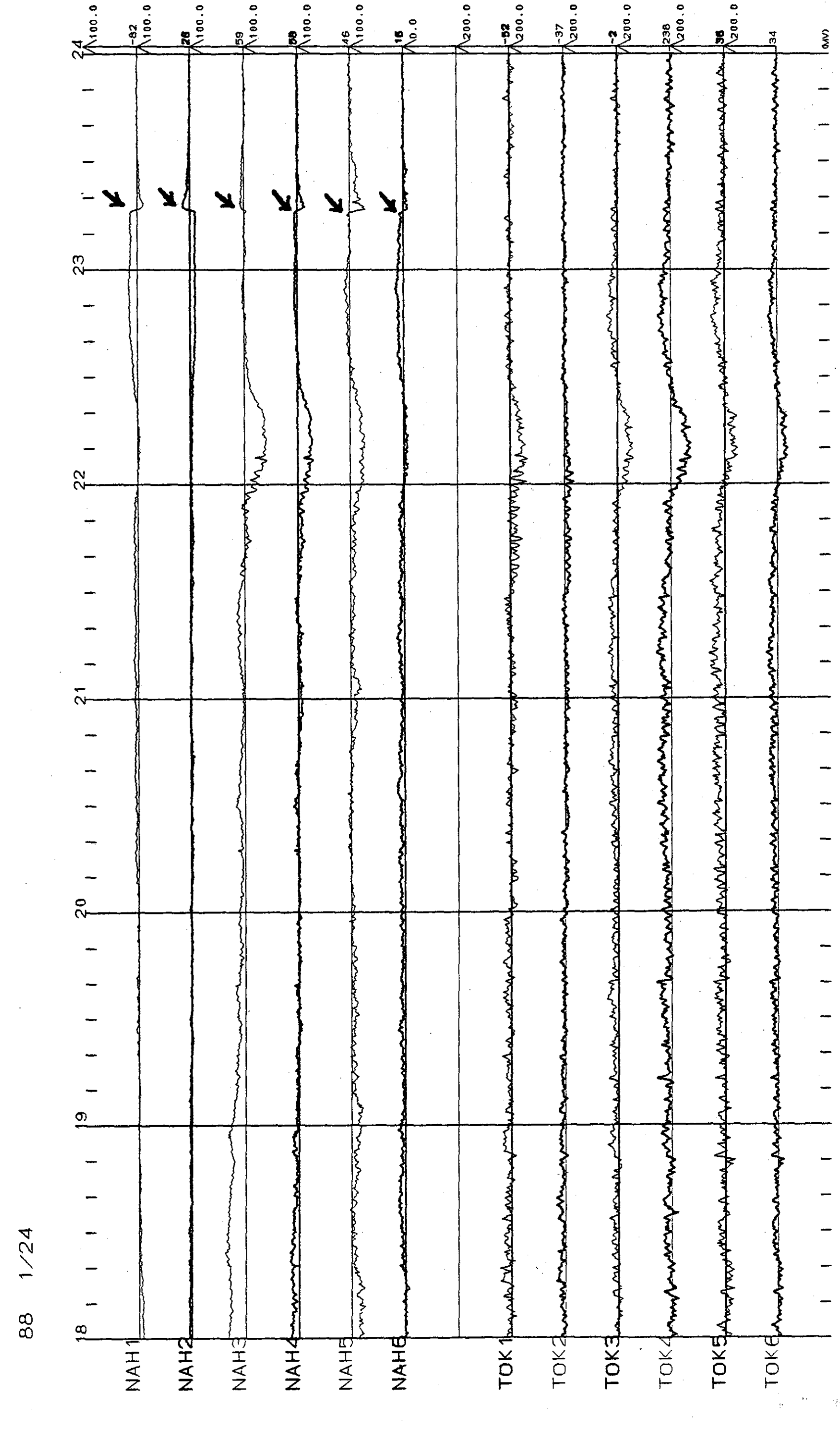


Fig. 38. The potential record at NAH from 18: 00 to 24: 00 on Jan. 24, 1988 with the record at TOK for reference. Note that a clear coseismic disturbance (indicated by arrows) appeared on all channels at the occurrence of earthquake near the Okinawa Island (23: 15).

5. Conclusion

As described above, a telluric potential monitoring system consisting of about 20 stations, each with six dipoles, has been in operation for nearly one year. Several stations were found to be too noisy and had to be abandoned but others are yielding reasonably good records. Preliminary examination of these records suggests that, however, the majority of stations do not show clearly identifiable SES, although a few channels seem to be promising. This is not surprising according to the VAN experience because they also found that channels sensitive to SES were quite rare. It is now planned to seek sensitive stations more thoroughly by testing other sites and by placing short span dipoles at selected sites. Some detailed investigation of the possible SES at a few existing stations will be reported later.

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地電位差同時連続観測による地震予知研究報告 I

—観測網の設置—

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地電位差の局地的ないし地域的な時間的変化の観測による地震予知方法の妥当性を検討している. この方法はギリシアで1980年頃以来非常な成功をおさめていると報告されている VAN 法と呼ばれるものである. 本報告はその第1報として, わが国での観測網の設置及び, それから得られる記録の概況について述べる.

この研究は日本電信電話会社（NTT）との協同研究であり, 各観測点では同社の通信用アースを電極として使用して, 6本の測線（基線長数 km）が設けられた. データは10秒のローパスフィルタをかけた後, 12ビットに A/D 変換され, 20秒サンプリングでメモリに蓄えられる（容量は2日分). 地震研究所からは毎日1回各観測点に電話がかかり, データは同所に転送される（1200 bps, 1観測点あたり約15分を要する). 従って, データは準リアルタイムで見ることができる.

1989年4月現在までに, 全国22ヶ所に観測点が設置されたが, 日光・長野・和歌山など8地点では人工ノイズ（主として直流電車による）が大きすぎるため観測は中止された. その他の14地点では程度の差はあるが, おおむね良好な記録が得られており, 各地の地磁気変動による電位差変化を比較すると, 海岸効果や, 地下電気伝導度分布などについて有用な情報がもたらされている. また弟子屈, 土佐中村, 会津若松などでは, 地震の前兆シグナルかも知れない地電位差変化もみられている. それらについては次報以下で報告する.