AN OBSERVATION NETWORK OF EARTHQUAKE STRONG MOTIONS IN THE SURUGA BAY REGION AND THE IZU PENINSULA

Strong Earthquake Motion Observation Center

Teiji Tanaka (I)
kazuyoshi Kudo (II)
Minoru Sakaue (II)
Etsuzo Shima (III)
Yutaka Osawa (III)
Presenting Author: K. Kudo

SUMMARY

We have installed a strong- motion seismograph array to cover the Suruga Bay and Izu Peninsula area, close to the expected focal region of a future great earthquake. There are a total of 18 stations consisting of a digitally recording accelerograph, a telemetric monitoring device and a high quality time code generator. The accelerometers of 15 stations are set on rock outcrops, while three stations are on sediments to investigate the modifications of seismic waves in different geological conditions.

INTRODUCTION

Observations of strong ground motions close to the earthquake source area are a common need of both seismologists and earthquake engineers to understand the dynamic properties of earthquake faulting, the generation and propagation of seismic waves in the near-field, the inelasticity of the ground due to a high acceleration sequence and so on. To fulfil this need, it is most important where we set up the observation stations and what observational scheme is appropriate. We should chose the obsevation sites close to a highly active seismic region or near the fault of a large earthquake presumed to occur in the near future.

Since 1974, seismicity along the coast of the Izu Peninsula, south central Japan, has been active, that is three moderately large earthquakes of magnitude around 7 and earthquake swarms have occurred during this decade. Also from long-term earthquake prediction research, a more destructive earthquake of magnitude around 8 is considered likely to occur in Suruga Bay. The earthquake prediction research community in Japan suggested that geophysical observation of many kinds should be done in this region, so that the installation of strong-motion seismograph arrays were properly required. The International Workshop on Strong-Motion Earthquake Instrument Arrays (Ref. 1) also recommended the Suruga -Izu region as an area to establish instrument arrays for studying earthquake strong ground motions.

(I) formerly; Associate Prof., Earthq.Res.Inst., Univ. of Tokyo, Japan
presently; Ohsaki Res. Inst., Shimizu Construction Co, Ltd, Japan
(II) Reseach Associate, Earthq.Res.Inst., Univ. of Tokyo, Japan
(III) Professor, Earthq.Res.Inst., Univ. of Tokyo, Japan

We have installed the high quality strong-motion accelerographs with a monitoring system to cover Suruga Bay and the Izu Peninsula with a 20-30 km spacing. The planning started in 1981 and the observation began in January 1983.

STRONG-MOTION ACCELEROGRAPH ARRAY

A series of great interplate earthquakes of magnitude around 8 have occurred along the Nankai trough (off southwest Japan) including the Suruga Bay area. Regarding temporal and spatial regularities of the great-earthquake ocuurrences and recent tectonic evidence, Ishibashi(Ref. 2) suggested that the next great earthquake along the Nankai trough would occur in the Suruga Bay area. A magnitude of 8.3 and a thrust-type fault, length 115 km and width 70 km, are estimated for this future earthquake. Eight observation stations (OMZ, YIZ, SMZ, FJK, NMZ, HDA, MTZ, MIZ) have been established to cover the expected landward extent of the fault, as shown in Fig. 1.

Three moderately large earthquakes of magnitude around 7 have occurred along the south and east coast of the Izu Penisula in 1974, 1978 and 1980. A tendency of the earthquake occurrences to migrate northward is considered plausible, so that strong-motion seismographs have also been installed along the coast of the Izu Peninsula and Oshima Island (YGS, KWZ, YHN, STG, NBK, OSM). Triaxial accelerometers are set on rock outcrops at the stations in order to avoid the effects due to sediments. From the result of preliminary measurements, P- and S-wave velocities of the outcrop at Kawazu station are 3.0 and 1.5 km/sec, respectively.

It is also important for earthquake engineering purposes to understand the characteristics of the seismic waves modified by sedimentary layers. Odawara city, northeast of the Izu Peninsula, is selected as a test sites for the observation of strong-motions in different geological conditions. Seismographs are installed on the rock outcrop (HYK), on the diluvial terrace (JNI) and on the alluvial plain (SKW, TKD). Thus, the newly designed strong-motion observation network consists of 18 stations as shown in Fig. 1. The location and the geological conditions are shown in Table 1.

INSTRUMENTATION

Each observation station has a strong-motion accelerograph, a telemetric monitoring system (except for three stations) and a high quality time code generator. A schematic diagram of the system is shown in Fig. 2.

Accelerograph (SMAD-1)

A triaxial force balance accelerometer with a maximum range of ±2G is used as a sensor. It is connected to the gain ranging amplifier, the input amplitudes are depressed by 1/4 only when they exceed the threshold level (250 or 500gal), and the output signals are converted to digital values of 12-bit words at every 0.01 second. Triaxial signals, station code, event number, coded time, range of amplifier and parity are recorded on a 4-track conventional magnetic tape cassette. A maximum recording time by one tape is 30 minutes. A trigger of an event, both the start and stop of recording, is controlled by both vertical and horizontal signals when they exceed/decrease the preset level, digitally set from 1 to 16 gals. The magnetic tape is not attached to the recording head during the waiting state. Each device has a digital memory for a 10.24 sec time delay, to record the ground motions from the onset of the P-wave. The overall amplitude and phase responses of seismograph are shown in Fig.3. At the stations, NBK, JNI and TKD, a DSA-1 (Kinemetrics) is situated in the basement of a low-rise building.

Telemetric Monitoring system

Each station, except for NBK, JNI and TKD has a monitoring device which dispaches the data, such as maximum accelerations of three components , a triggered time and a duration time of recording, to the monitoring center in the Earthquake Research Institute, using the public telephone line. In addition, it informs us of any unusual conditions at each station, such as a stop/recovery of commercial power supply, a low battery of any of instruments, a magnetic-tape end or an opening/closing of the door. The monitoring system can store a maximum of 32 events and after that old data are replaced by new data. These data can be seen at the monitoring center by giving a command from the center. They also can be stored on the magnetic disk of a mini-computer operating at the center. In adition, it is also capable of calibrating the overall response of the seismograph system (remote-calibration) from the central office. Figure 4 shows an example of the printout obtained at the center.

Self-Adjusting Time Code Generator

Each station has a time code generator controlled by a crystal clock with an accuracy $1/10^{8}$ per second. One coded time-frame consists of 50 pulses during 10 seconds in which month, day, hour, minutes and second are identified. The time code generator is adjusted automatically twice a day by receiving the time signal from a radio broadcast(NHK), so that the exact time is obtained within 5 msec of the Japan standard time. The output signal of the time code generator is connected to the seismograph and a monitoring device.

Playback System and Monitoring Center

A reproducer for recorded magnetic tape cassettes converts serial depositions to parallel ones and to analog signals. The digital output data from a reproducer are stored on the magnetic disk (40MB) of the mini-computer (HITAC E600/3) through a standard digital input/ output interface (DIO). The stored data in the disk are easily transfered to a 9-track computer tape or a double-density floppy-diskette, for users convenience. A potable reproducer, 39x13x19 cm^{3} and weighing 7kg is also provided for playbacks in the field, but only analog output signals are available.

A receiver of the dispached data from the telemetric monitor is always in operation. When data are received at the monitoring center, they are immediately printed out as shown in Fig. 4. When the computer power is turned on, the receiver comes on-line with the computer and giving a command(LIST) from the receiver, the data stored at each station are dispached and stored again in the disk of computer.

EXAMPLE OF DATA

Many small earthquakes (earthquake swarm) occurred along the coast of the Izu Peninsula just after the observations were started. Figure 5 shows the observed maximum accelerations at the stations for an event (M=4.9), which was the largest among the earthquake sequences. The figure is a hard copy of the graphic display (1024x780 dots) belonging to the mini-computer. It takes 30 to 40 minutes to get such a figure, though the elapse time depends on whether a public telephone line is busy or not. A quick report as this is useful for a planning of aftershock observations, a quick accomodation from the view point of admininstration and so on.

Figure 6 shows the wave forms observed at OSM. This is also a hard copy of the graphic display. This earthquake was a small local event as it was felt only Oshima Island (JMA intensity = III). It has the distinctive features of a local earthquake, that is, the accelerations are considerably high but the duration is short, maximum accelaration is recorded on the vertical component, there are significant differences of S-wave arrival time among the three components and so on.

A moderate earthquake of magnitude 6.0 occurred north of the observation network on 8th, August 1983. The seismographs triggered at the closer stations. Figure 7 shows the examples of observed accelerograms. The fault plane solution from P-wave polarization of this earthquake (Ref. 3) shows a vertical strike slip fault. Fig. 7(c) shows the seismograms observed at almost the same distances but different station azimuths. There are significant differences between them. It is interesting to study the differences to see whether they originate from the source radiation pattern or the propagation path. The seismograms of the E-W components (roughly transverse components) are arranged according to the epicentral distances. Roughly speaking, the S-wave velocity is 4.0km/sec.

ACKNOWLEDGMENTS

The authors are indepted to Professors M. Hakuno, K. Kasahara, I. Murai, K. Mogi and K. Tsumura for their valuable comments in the planning of the observation network.

References

1) Iwan, W.D. (Editor), 1978, Strong-Motion Earthquake Instrument Arrays, Proc. International Workshop on Strong-Motion Earthquake Instrument Arrays, (Honolulu, Hawaii).

2) Ishibashi, K., 1981, Specification of a Soon-to-Occur Seismic Faulting in the Tokai District, Central Japan, Based upon Seismotectonics, Earthquake Prediction - An International Review Maurice Ewing Series 4.

3) Okada, Y., S. Imoto, K. Kasahara and M. Ohtake, 1983, On the East Yamanashi Earthquake of 8th August,1983, Abstract; Annual Meeting of Seim. Soc. Japan.

Table 1 Station Data

Station Name	Code	Location		Geology	Topography	Accelero-graph	Full Scale
		Latitude(N)	Longitude(E)				
OMAEZAKI	OMZ	34°36'02"	138°13'46"	Mudstone, Miocene	Terrace	SMAD-1	±2G
YAIZU	YIZ	34°53'33"	138°20'52"	Basalt, Miocene	Hill	SMAD-1	±2G
SHIMIZU	SMZ	35°01'04"	138°26'31"	Sandstone, Pliocene	Gentle Hill	SMAD-1	±2G
FUJIKAWA	FJK	35°08'47"	138°37'14"	Andesite, Miocene	Gentle Hill	SMAD-1	±2G
NUMAZU	NMZ	35°05'38"	138°52'41"	Dacite	Hill	SMAD-1	±2G
HEDA	HDA	34°57'39"	138°48'49"	Andesitic Lavas	Hill	SMAD-1	±2G
MATUZAKI	MTZ	34°45'18"	138°47'33"	Andesitic Lavas	Hill	SMAD-1	±2G
MINAMIIZU	MIZ	34°37'00"	138°52'04"	Andesitic Lavas	Hill	SMAD-1	±2G
YUGASHIMA	YGS	34°54'39"	138°55'35"	Andesite	Mountain District	SMAD-1	±1G
KAWAZU	KWZ	34°44'18"	138°58'47"	Dacite	Hill	SMAD-1	±1G
YAHATANO	YHN	34°51'55"	139°06'19"	Andesitic Lavas	Level Land	SMAD-1	±1G
SHIMOTAGA	STG	35°02'38"	139°04'58"	Basalic Lavas	Gentle Hill	SMAD-1	±1G
HAYAKAWA	HYK	34°14'18"	139°08'47"	Andesite	Gentle Hill	SMAD-1	±1G
SAKAWA	SKW	35°15'59"	139°11'49"	Sand, Alluvium	Level Land	SMAD-1	±1G
NEBUKAWA	NBK	35°12 00"	139°08'27"	Lavas	Hill	DSA-1	±1G
JONAI	JNI	35°14'47"	139°09'36"	Sand, Diluvium	Level Land	DSA-1	±1G
TAKADA	TKD	35°17'05"	139°11'41"	Sand, Alluvium	Level Land	DSA-1	±1G
IZUOSHIMA	OSM	34°44'46"	139°21'52"	Basaltic Lavas	Gentle Hill	SMAD-1	±1G

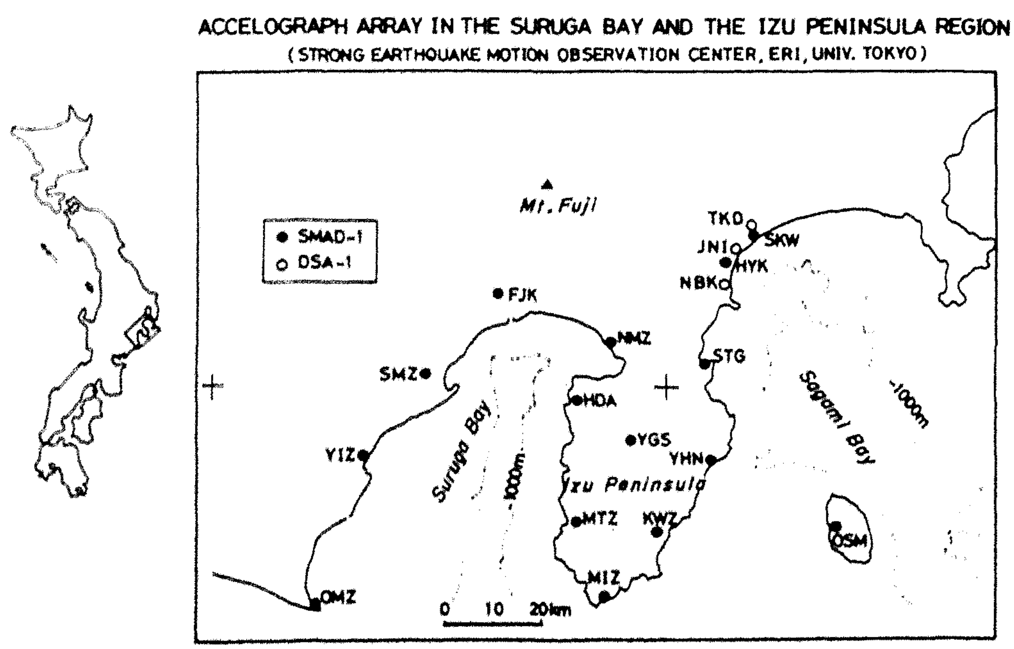

Fig. 1 Strong-motion accelerograph array in the Suruga Bay and Izu Peninsula region.

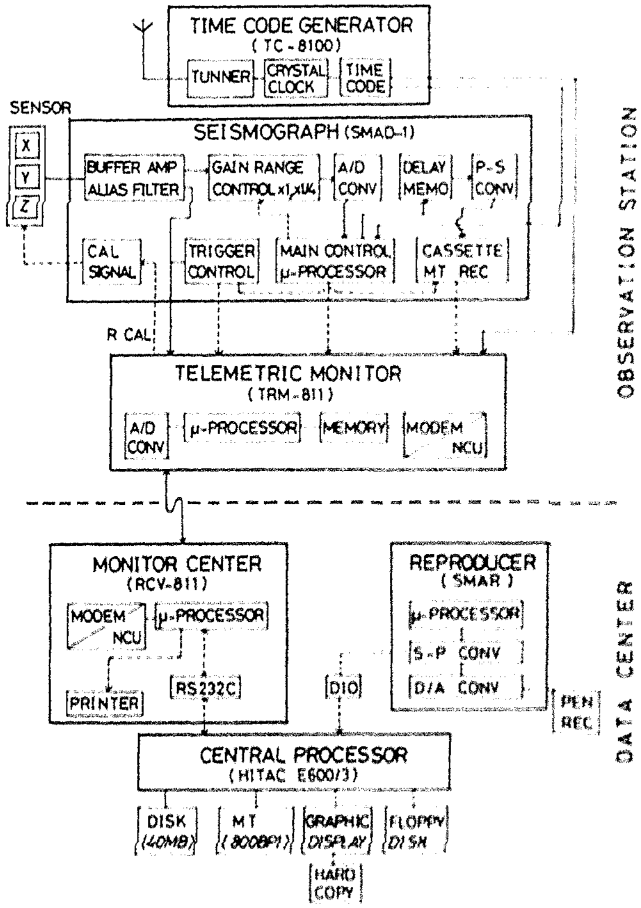

Fig. 2 A schematic diagram of the observational and processing system.

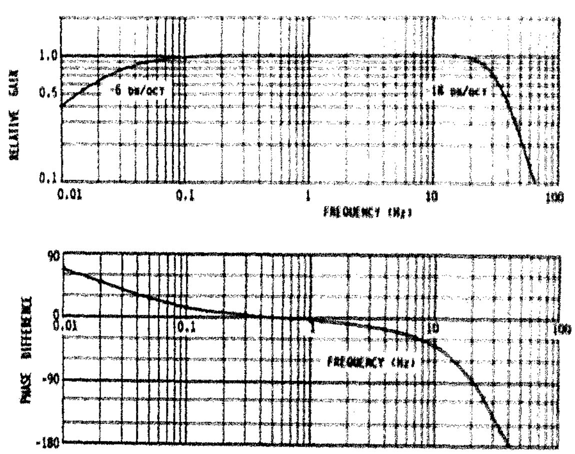

Fig. 3 Frequency characteristics of an accelerograph(SMAD-1).

DATA	NAME	DATE M D	TIME H M S	MAX ACC (GAL) CH1	CH2	CH3	AGC	TAPE M S	RUN M S	ALARM D T 1 2 3 P
EARTHQ	OBM	02/27	17:12:36	2	2	2	00	00:20	08:29	
EARTHQ	HYK	02/27	17:33:44	1	1	1	00	00:22	07:42	
~~EARTHQ~~	~~OBM~~	~~02/27~~	~~18:05:31~~	~~2~~	~~2~~	~~2~~	~~00~~	~~00:19~~	~~08:48~~	
EARTHQ	HYK	02/27	21:14:56	11	5	10	00	00:27	08:09	
EARTHQ	FJK	02/27	21:15:06	5	5	5	00	00:43	10:29	
~~EARTHQ~~	~~OBM~~	~~02/27~~	~~21:14:45~~	~~23~~	~~12~~	~~19~~	~~00~~	~~00:50~~	~~09:38~~	
EARTHQ	STB	02/27	21:14:52	8	6	10	00	00:35	03:19	
TEST	STB	01/10	14:05:23	0	0	0	00	00:21	00:21	
CAL	STB	01/10	14:52:31	221	216	221	00	00:21	05:46	
R CAL	KMZ	01/18	14:53:43	210	210	209	00	00:17	01:20	
LIST	OBM	01/14	17:31:15	2	2	2	00	00:09	00:09	
LIST	OBM	01/15	21:16:19	2	2	2	00	00:10	00:19	
LIST	OBM	01/15	23:36:35	2	2	2	00	00:09	00:28	
LIST	OBM	01/16	16:21:19	27	10	15	00	00:19	00:47	
LIST	OBM	01/16	17:12:58	8	9	7	00	00:14	01:01	
LIST	OBM	01/16	17:53:12	14	9	7	00	00:16	01:17	
ALARM	HYK	01/10	10:59:01			(DOOR OPENED)				1 0 0 0 0 0
ALARM	HYK	01/10	10:59:37			(DOOR CLOSED)				0 0 0 0 0 0
ALARM	HYK	01/10	11:00:46			(TAPE ENDED)				0 1 0 0 0 0
ALARM	HYK	01/10	11:34:27			(LOW BATT. SEIS.)				0 0 1 0 0 0
ALARM	HYK	01/10	11:34:51			(LOW BATT. T.C.G.)				0 0 0 1 0 0
ALARM	HYK	01/10	11:36:17			(LOW BATT. TEL.M.)				0 0 0 0 1 0
ALARM	HYK	01/10	11:36:20			(POWER OFF)				0 0 0 0 0 1

Fig. 4 An example of printout obtained by a telemetric monitering system.

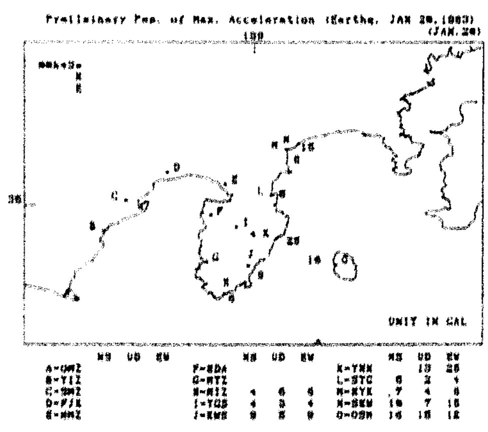

Fig. 5 A mapping of the maximu. accelerations using telemetered data.

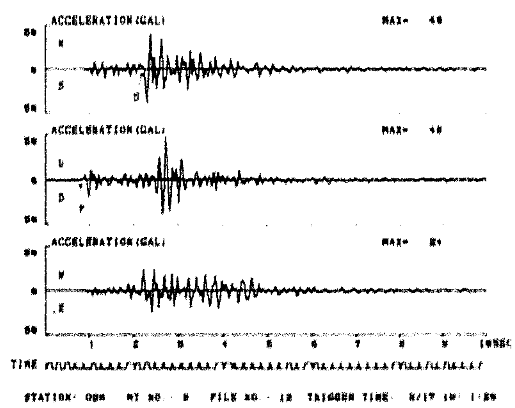

Fig. 6 A sample of observed accelerograms from a small local earthquake.

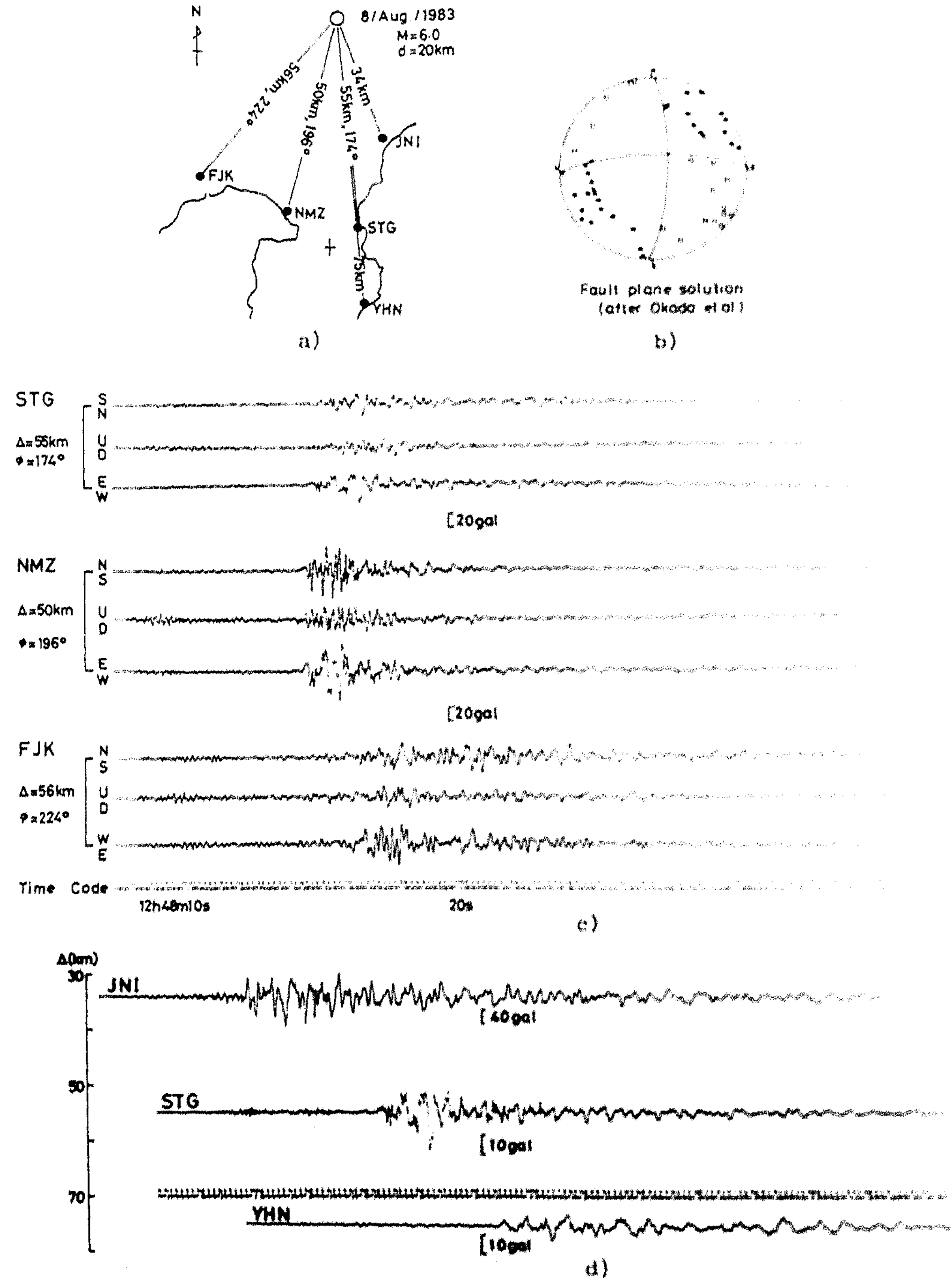

Fig. 7 a) Locations of the epicenter and the observation stations.
b) A fault plane solution (after Okada et al, Ref.3).
c) Accelerograms at different station azimuths.
d) Accelerograms at different epicentral distances.