DEVELOPMENT OF A FULL-AUTOMATIC MONITORING SYSTEM OF MICROEARTHQUAKES FOR GEOTHERMAL DEVELOPMENT

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The observation of microearthquakes is required for the environmental monitoring in the geothermal development, while it is useful for the detection of the subsurface structure in terms of seismic velocity and fracture distribution. For such a purpose, an accurate recording of earthquake waveform is necessary in a wide range of their magnitude, say, -2 to 4. After WATANABE(1971), the relationship between magnitude (M) and maximum velocity amplitude (A) of ground motion at the epicentral distance (R) is expressed by

$$0.85\ M-2.50 = \log A + 1.73 \log R$$

within a limited R (<200 Km). Using this equation, it is found that at least 102 db of dynamic range of recording is required for the earthquakes between the above magnitudes. Therefore, a very rapid auto-gain-ranging digital amplifier, that is Instantaneous Floating Point (IFP) amplifier, was adopted in the new system. The concept of IFP is very common in the seismic exploration for petroleum but is hardly used in the observation of earthquakes. The IFP amplifier works so as to fill A/D converter bits over 90 % changing its gain which can vary from 0 to 84 db with 6 db step at each digitizing instance. Consequently, the IFP amplifier system achieves a wide dynamic range recording of 120 db or more without any human intervention, where one digital sample is expressed by 4 gain bits and signed 16 bits of A/D converter output.

Fig.1 shows the system configuration.
The data from three seismometers from every station are digitized at every 5 msec and transmitted through telephone communication line to the central computer on real time basis. The computer is always scanning the input data from all the stations so that all the earthquake events are detected, analyzed and filed automatically without missing (Fig.2).
In addition to the aboves, the system has self diagnostic functions such as geophone test, filter test etc., and has auto-adjustment function of transmission skew.

Consequently, the developed new system will provide a full range of automation of the microearthquake observation and will minimize the running cost for its long term operation. Fig.3 and 4 are showing typical outputs from the system.

References

WATANABE, H., 1971, Determination of Earthquake Magnitude at Regional Distance in and near Japan, Journal of the Seismological Society of Japan, Vol. 24, No.3.

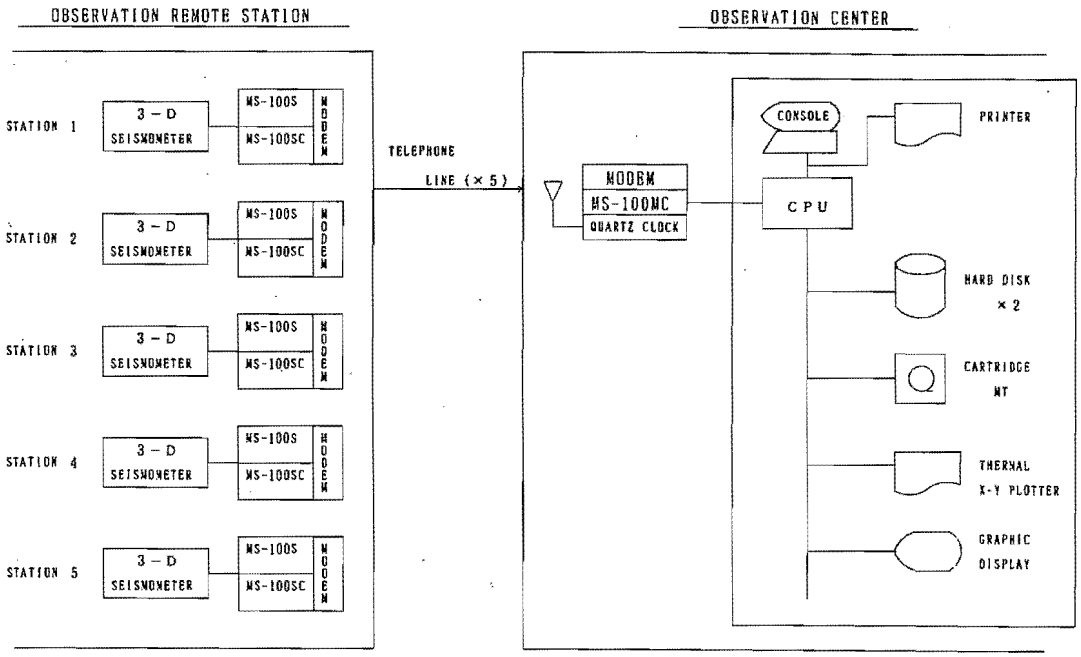


Fig.1 Hardware configuration
of the micro-earthquake observation system

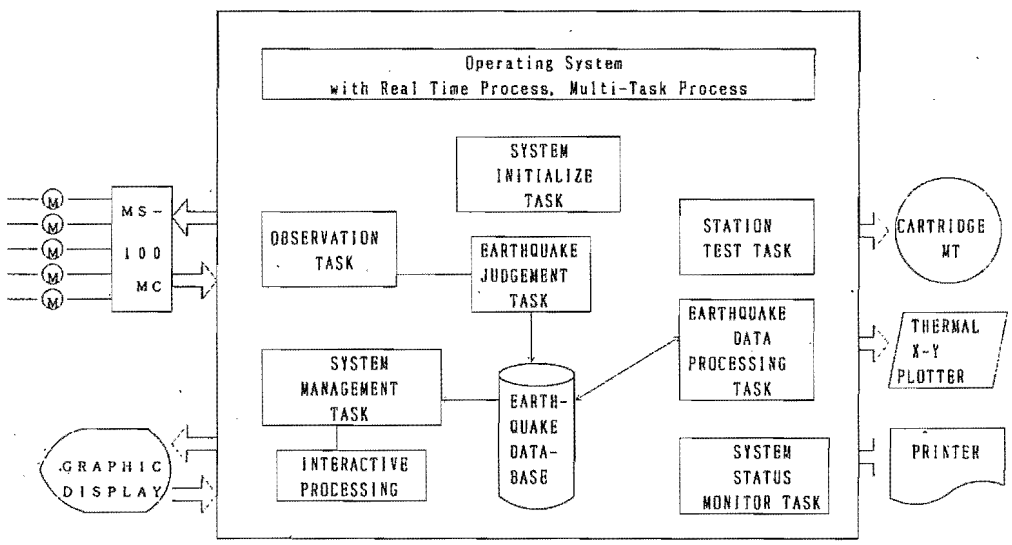


Fig.2 Software configuration
of the mini-computer system in the observation center

EARTHQUAKE ØBSERVATIØN RECØRD

JGII
MS-100
MICRØ EQK
ØBS SYSTEM

EQK Seq. Nø. = 35

DATE = 1987Y 12M 20D

TIME = 5H 34M 9S 480ms

MAGNITUDE = 0.53

HYPØCENTER LØCATIØN

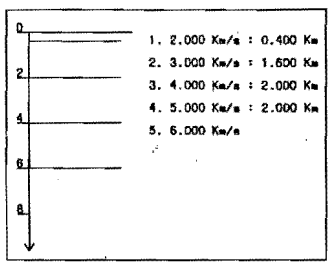
X = E130 39'38.5"

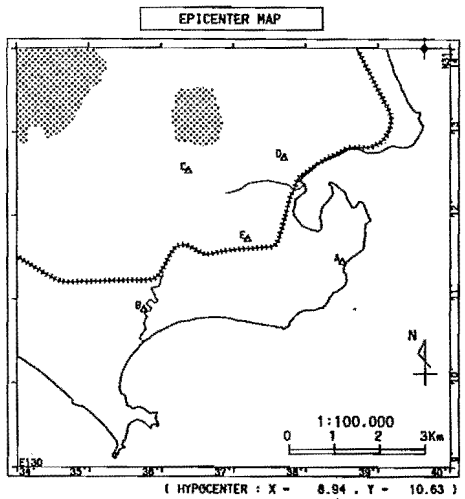
Y = N 31 14'45.2"

Z = -6.46

TO = 7.596

(VELØCITY STRUCTURE)





ØBSERVATIØN STATIØN DATA

ØBS -A- : Fukumoto (N31 11'27.5",E130 38'30.6")
ØBS -B- : Hamachyo (N31 10'53.2",E130 35'45.4")
ØBS -C- : Kokawa (N31 12'32.8",E130 36'22.5")
ØBS -D- : Narikawa (N31 12'42.5",E130 37'42.0")
ØBS -E- : Ohminesan (N31 11'43.8",E130 37'11.9")

at P-wave Arrival

	P-WAVE ARRIVAL		S-P TIME	MAX.AMP. (uKine)			F-P	MAGNITUDE		DISTANCE
	+/-	TIME	(SEC.)	U-D	N-S	E-W	TIME	Ma.	Mjp	(Km)
A	+	9.910	2.617	103	204	180	10.600	0.20	0.56	9.045
B	+	10.395	3.217	72	118	82	6.900	0.22	0.03	11.410
C	-	9.975	2.567	189	258	149	8.700	0.53	0.32	9.251
D	-	9.685	2.215	1398	397	279	7.000	1.44	0.05	8.133
E	+	10.005	2.397	113	186	206	6.400	0.28	-0.06	9.364

PLØTTED on Sun Dec 20 05:48:03 1987

Fig.3 Example of observation record
which is output by the micro-earthquake observation system.
The earthquake took place on Dec.20 1987.
The epicenter is located outside of the map.

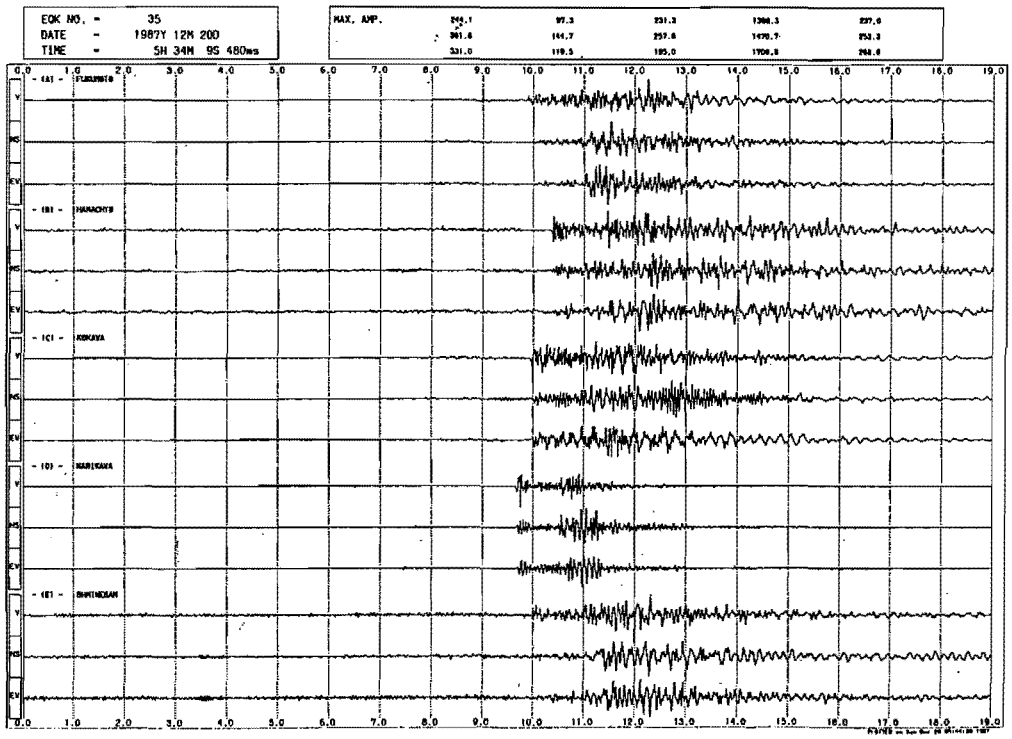


Fig.4 Example of micro-earthquake waveform
which is recorded by the micro-earthquake observation system.
The earthquake data, see fig.3.