DIGITALIZATION OF GROUND SURVEY DATA AND MICROZONING

Sadaiku Hattori[+] and Yoshiaki Kashimura[++]
Presenting Author: S.Hattori

SUMMARY

There are a large quantity of ground survey data(geological data, N-values etc.(1)) for Tsukuba Science City ,Japan, which were made by surveys carried out before constructions of institutes, universities,experimental facilities and so forth , and give informations connected with soil conditions in depth of less than 100m. First of all, these ground survey data were digitalized and the underground structure of S wave velocity and density were estimated, when the relationships between S wave velocity or density and soil condition and/or N-value were used. Secondly, the amplification charact-erristics of ground at many grid points were calculated and the regional distributions of the predominant periods and amplification ratios were gotten for the first, the second and the third peaks on amplification curves.

1. SIGNIFICANCE OF MICROZONING AND SOME EXAMPLES

In order to mitigate earthquake disasters, the following must be done. (1) evaluation of seismic risk, (2) estimation of earthquake disasters and (3) countermeasure against the earthquake disasters. The evaluation of seismic risk means to estimate seismic inputs on the base rock by taking account of seismicity, active faults and so forth, and to investigate behaviours of ground due to such seismic inputs. The estimation of seismic disasters is to study regional characteristics of various sorts in the area concerned and to infer the degree of damage on each of buildings,facilities and also total earthquake disasters at the occurrence of a great earthquake. The countermeasure should be considered to mitigate the earthquake disaster and, if possible, to make it zero. The microzoning on amplification characteristics and liquifaction characters of ground is one of important research subjects for seismic risk evaluation and/or estimation of earthquake disasters.

Masaki et al.(2) calculated the amplification curve for each one km mesh in Nagoya area and obtained regional distributions of maximum amplification ratio and amplification ratio of the first peak. They showed that the results were compatible with damage ratios of wooden houses at Nobi earthquake, Tonankai earthquake and Mikawa earthquake. Iida et al.(3,4) also obtained regional distributions of predominant periods and maximum

[+]Head of Applied Seismology Section, International Institute of Seismology and Earthquake Engineering(IISEE).
[++]Staff of IISEE

amplitudes in Nagoya area on the basis of amplification curves. For Kanto areas, especially , for the central part of Tokyo, Sugimura et al (5) drew up regional distributions of predominant period of the first peak on amplification curves. There are also examples of microzoning at Sendai and Osaka areas(6,7). This kind of microzoning shoud be carried out for areas which are densely populated and for which the countermeasures against earthquake disaster are necessary.

2. GEOLOGICAL ASPECTS OF TSUKUBA AREA AND RESULTS OF SEISMIC PROSPECTING

The geological structures of Tsukuba area are summarized in the following.

(1) Base rock: The base rock consists of granite and metamorphic rock which form Tsukuba mountain area. Depths of the base rock which have been confirmed by boring surveys are 487m and 482m at the northern part and 813m at the southeastern part of Tsukuba area.

(2) Kazusa layer: The depth of Kazusa layer is around 250m. This layer is divided into two parts ,of which the upper part consists of gravels and the lower one is composed of alternate layers of sand and mud.

(3) Shimofusa layer: This layer is classified to two parts and moreover the lower part is divided into two subparts. The lower subpart is found at the northern Tsukuba area and consists of alternate layers of fine sand with silt and clay with silt. The upper subpart which abounds in gravel and sand is found at whole part of Tsukuba area. The upper part (Narita layer), which includes shells and of which the thickness is 20-35m, consists of silt and clay.

(4) Ryugasaki layer: Ryugasaki layer which connects with Narita layer discordantly, consists of fine layers of sand, organic matters ,humus and silt.

(5) Jhoso clay layer: Jhoso clay layer of which the thickness is 2-3m, is composed of volcanic ash with organic matters and connects with Ryugasaki layer.

(6) Alluvium: Alluvium distributes at low land areas along rivers and consists of silt, clay, sand and sand with gravel. The width of alluvium are 4-5km along Sakura river and 0.4-0.5km along other small rivers.

Though many ground surveys have been carried out in Tsukuba areas, there are only five cases of seismic prospecting. It is said that Alluvium, Ryugasaki layer and Narita layer, especially the sand part of them are in danger of liquefaction(1).

3. DIGITALIZATION OF GROUND SURVEY DATA AND ESTIMATION OF GROUND STRUCTURE.

The total number of ground survey sites at Tsukuba area is 2600 , among which the results of 1500 sites have been published(1). These data were digitalized for estimation of underground structures, which are necessary for calculation of amplification curves. Digitalization were carried out as in the following. The kinds of soil were classified to four classes such as (a) clay, (b) silt, (c) sand and (d) gravel and the actual soils were expressed by means of combining them. Digital values which were obtained as the results are (1) depth of geological boundaries, (2) N-value, (3) depth where N-values were measured, (4) class of soil, (5) coordinate of survey site and (6) height of survey site.

It is desirable to introduce formulas peculiar to the area concerned by which S wave velocity and density can be estimated on the basis of geological conditions, N-value and so forth. As there are few data of S wave velocity and density in Tsukuba area, however, the following formulas due to Iida et al. were used.

$$Vs=100\ N^{0.15}H^{0.10} \cdot \begin{bmatrix} 1.00 & \text{alluvium} \\ 1.33 & \text{diluvium} \\ 1.73 & \text{tertiary} \end{bmatrix} \cdot \begin{bmatrix} 1.00 & \text{clay} \\ 0.87 & \text{silt} \\ 0.86 & \text{sand} \\ 0.99 & \text{sand-gravel} \end{bmatrix} \quad (1)$$

$$\rho=1.66\ N^{0.03}H^{-0.01} \cdot \begin{bmatrix} 1.00 & \text{alluvium} \\ 1.01 & \text{diluviun} \\ 1.01 & \text{tertiary} \end{bmatrix} \cdot \begin{bmatrix} 1.00 & \text{clay} \\ 1.01 & \text{silt} \\ 1.04 & \text{sand} \\ 1.06 & \text{sand-gravel} \end{bmatrix} \quad (2)$$

The underground structure at any place was estimated as in the following. (1) For every survey point within a 50m radius around the site X of which the underground structure is necessary, S wave velocities and densities were calculated every 0.5m in depth by eqs. (1) and (2). (2) S wave velocities and densities every 0.5m in depth at the site X were obtained by averaging values of the same depth at all points. (3) The same processes were repeated till the depth of underground structure had reached to the Tertiary formation by making the radius around the site X increase at intervals of 50m. Moreover, S wave velocity distribution at the site X was simplified by V_s=FLOAT(IFIX(V_s/A+0.5))*A, when the value of A was decided so that the number of layers is less than 50. Density of each layer was also estimated by the same process as mentioned above.

4. CALCULATION OF AMPLIFICATION CURVE.

Haskell method (8) was used for calculation of amplification curves. Assuming the amplitude of S wave incident upon the base rock to be V=Vi exp ($i\omega t$)(Vi:constant), the amplification characteristics on the ground surface was calculated by the equation

$$V_0 = \frac{i\, h_n\, \mu_n}{A_{21}+i h_n\, \mu_n\, A_{11}} \cdot 2 \cdot V_1 = \frac{2\omega\ \rho_n\ V_{sn}\ \exp(i\phi)}{\{(\omega\ \rho_n\ V_{sn}\ A_{11})^2+(A_{21})^2\}^{1/2}} \cdot V_1$$

where ρ : density, $\phi=\tan^{-1}(A_{21}/\omega\,\rho_n\ V_{sn}\ A_{11})$, ω: angular frequency, $h_m=\omega/V_{sm}$, μ_m; rigidity of mth layer, V_{sm} ; S wave velocity of mth layer, $A=a_{n-1}\cdot a_{n-2}\cdots a_1$ and a_n ; layer matrix.

Calculations were carried out for the cases of $\varepsilon=\mu'/\mu$=0.000, 0.001 0.002 by assuming the media to be Voigt type visco-elastic one($\mu_m=\mu_m+i\omega$; μ_m ; coefficient of viscosity)

In Fig.1(a), the left is the geological section, and the right is the underground structure of S wave velocity,density and N-value. Fig.1 (b) compares amplification curves for the cases of =0.000 and 0.001 ,where dotted and real lines correspond to cases of A=5.0 and 30.0, respectively.

5.MICROZONING OF GROUND AMPLIFICATION AT THUKUBA AREA.

In this report, analyses were made for the area in and around Tsukuba

Science City of which the area range are 140° 1′ 45″ E-140° 11′ 45″ E (about 15km) and 35° 58′ 45″ N-36° 10′ 10″ N (about 21km). The area was divided into many rectangles of 15′ meshes in the longitude and the latitude, of which sizes are equivalent to 0.38km in the longitude and 0.46km in the latitude.

The reason of having made the above meshes are as follows: (1) Dividing on the basis of longitude and latitude is very common and (2) It is fairly easy to compare the above meshes with ones which have been used by other organizations such as Land Use Agency and Agency of Statistics.

The ground surveys had been carried out prior to construction of research institutes, educational facilities and so forth, and therefore, survey points are located a little partially. The underground structure at each mesh was obtained by the method mentioned before. For some meshes, the underground structure could not be determined because of partial locationg of ground survey points. The calculation results on amplification curves and the underground structure for every point have been memorized in magnetic tapes, by which the following microzoning were made.

The frequency range which is important from the viewpoints of earthquake damages of ordinary buildings is 1.0-10.0 Hz. It is found that the amplification curves have a few peakes in the above frequency range. The amplification ratio and the predominant frequency of three peaks were investigated, where the first , the second and the third peaks mean ones at low,middle and high frequency in the range 1.0-10.0Hz. This is because if only the first peak is treated as usual, we can not understand the whole of amplification characteristics(Fig.2). Fig.3 shows distributions of predominant periods of three peaks, where upper, middle and lower parts in each mesh indicate predominant periods of the first, the second and the third peaks, respectively and the classification are as follows: (1) $0.0<T\leq0.2$, (2) $0.2< T \leq0.35$, (3) $0.35<T\leq0.55$, (4) $0.55<T\leq0.75$, (5) $0.75<T\leq1.00$, (6) $1.00<T$. Empty meshes mean that there are no peaks .Fig.4. shows distrubutions of amplification ratio of the first, the second and the third peaks, where the classification are as follows: (1)-3, (2)-4, (3)-5, (4)-6, (5)-7, (6)-8, (7)8-.

By combining Figs.3 and 4 , it is possible to know details of amplification characteristics at any points. The amplification characteristics of Tsukuba Science City area are as follows. (1) The predominant period of the first peak (T_1) is $0.35sec<T_1$ for almost whole area except a few sites where $0.55sec<T_1$ or $0.75sec<T_1$. The amplification ratios (A_1) of the first peak are high ($4.0<A_1$) at sites (N10, E10), (N27, E37), and (N40, E20), especially, the ratio is $8.0<A_1$ around the site (N40, E25) where the depth of base rock is very shallow. At other areas, A_1 is less than 4.0. (2) The predominant period of the second peak (T_2) are $0.35sec<T_2\leq0.75sec$ for the area (N29-N39, E9-E16), $0.35sec<T_2\leq0.55sec$ in and around the site (E31, N19), and $0.20sec<T_2\leq0.35sec$ for the area (N20-N30,E15-E40). For other areas, T_2 is less than 0.20sec. The amplification ratio of the second peak are $8.0<A_2$ for the site (N40, E25), and $0.40<A_2\leq5.0$, $5.0<A_2\leq6.0$ and $6.0<A_2\leq7.0$ for other areas. (3) The predominant period of the third peak (T_3) is $0.35sec<T_3\leq0.55sec$ around the site(N30,E13). For other areas, T_3 is less than 0.20sec. The amplification ratio of the third peak are $7.0<A_3\leq8.0$ around the site (N40, E25),and are very complicated in other areas.

CONCLUSION

Microzoning of amplification characteristics for Tsukuba Science City area were carried out by utilizing ground survey data. These data were located a little partially because surveys were made prior to constructions of research institutes ,educational facilities and so forth. For some points without data, therefore, the underground structure had to be determined by using the data of neighbouring points. In the future, we can make the data in the present area more complete by means of (1) adding new data obtained by surveys at points without data,and (2) improving the data on the basis of ground surveys carried out newly for point with old data. At many regions in Japan, ground surveys have been executed for any purposes and the data have been accumulated. If these data are digitalized and stored in a common way, it is possible to carry out microzoning for any regions and to raise the accuracy in company with accumulation of the data.

The following must be done for microzoning with the intention of mitigating earthquake disasters: (1) Opening to the public ground survey data as much as possible, (2) Making data base by digitalizing ground survey data in a definite format, (3) Carrying out microzoning in an uniform accuracy , for as many regions as possible, on the basis on the above data and (4) Putting into practice microzoning not only for amplification characteristics of the ground but also for other ones such as liquefaction, land slides and so forth.

REFERENCES

(1) Ministry of construction;Ground survey data of Tsukuba science city (in japanese),1980.

(2) Masaki, K., T.Tsuboi, H.Taniguchi and K.Iida; S wave amplification characteristics of Nagoya area (in Japanese), Bull. Aichi Institute of Technology, No.1413, 227-233, 1977.

(3) Iida, K., K.Masaki and T.Tsuboi; Seismic response of Nagoya area due to reflection theory of S wave(in Japanese),Bull. Aichi Institute of Technology,No.1313, 181-190, 1978.

(4) Iida,K. ,K.Masaki and H.Taniguchi; On the vibration characteristics of Nagoya area due to microtremors and earthquake disasters(in Japanese) Bull. Aichi Institute of Technology, No.1213, 127-134, 1977.

(5) Sugimura, Y., K.Ito, T.Kubo, Y.Sugita, M.Niki and H.Ohoka; Investigation on evaluation method of dynamic ground characteristics in urban area (in Japanese),Journal BRI, 373-378,1980.

(6) Earthquake disaster survey mission of Building Research Institute; Report of disaster survey on Miyagikenoki earthquake 1978(in Japanese), Report of The Building Research Institute, No.80, 1-596, 1979.

(7) Yoshikawa ,S.,Y.T.Iwasaki and M.Tani;Microzoning of Osaka Region, Proceeding of The Second International Conference on Microzonation, Vol.1, 445-456, 1978.

(8) Haskell,N.A.; Crustal reflection of plane SH waves, J. Geophs. Res., 65, 4147-4150, 1960.

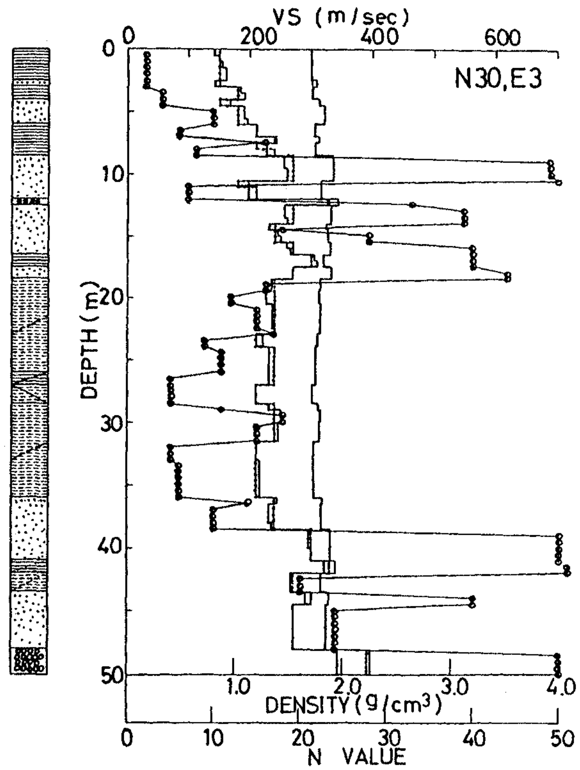

Fig.1(a)

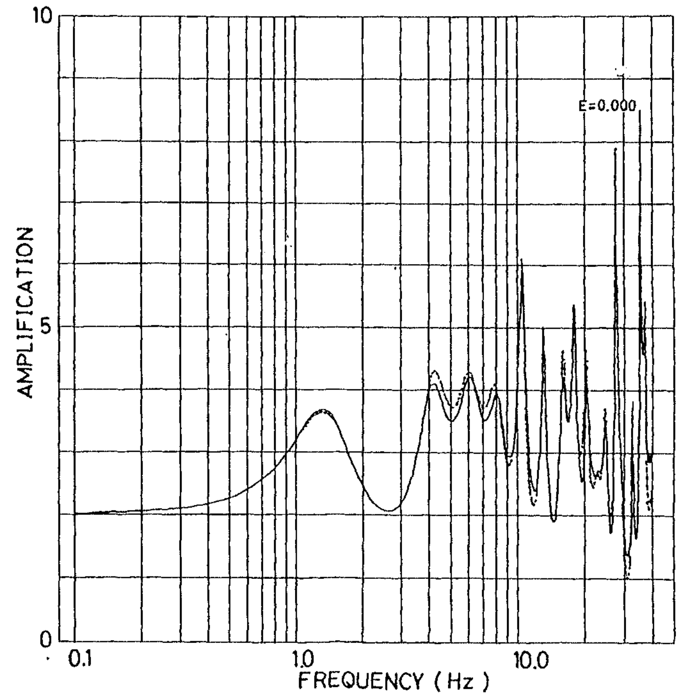

Fig.1(b-1)

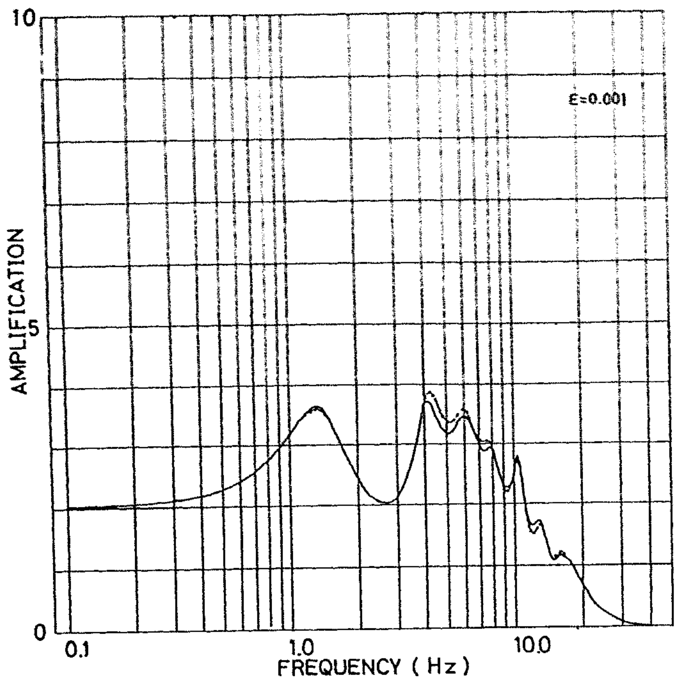
10
5
0
AMPLIFICATION
ε=0.001
0.1
1.0
10.0
FREQUENCY (Hz)

Fig.1(b-2)

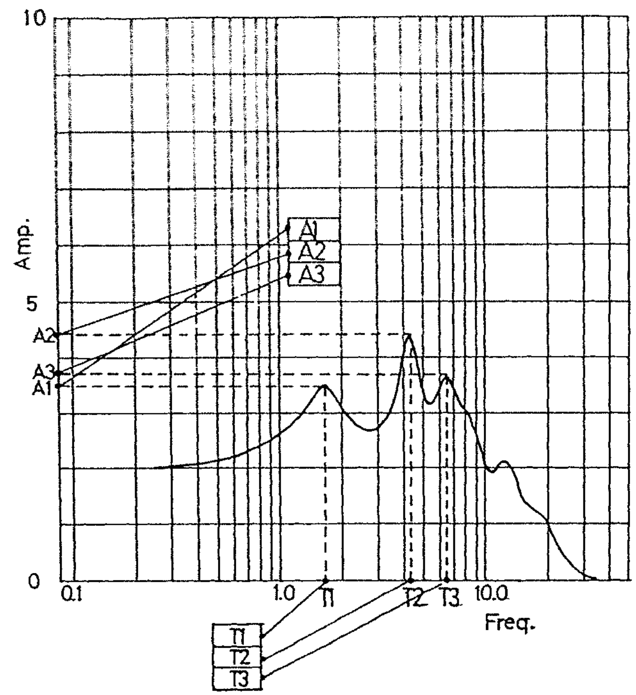
10
5
0
Amp.
A1
A2
A3
0.1
1.0
10.0
T1
T2
T3
Freq.

Fig.2

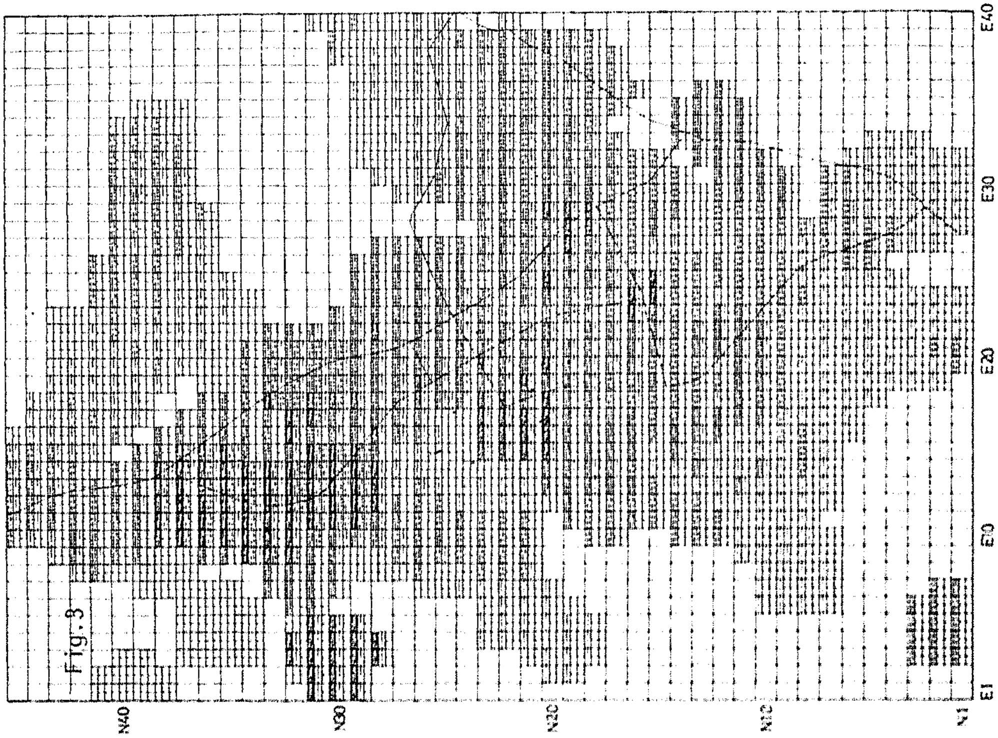
Fig.3
N40
N30
N20
N10
N1
E1
E10
E20
E30
E40
□<0.20≤ ▤ <0.35≤ ▦ <0.55≤ ▩ <0.75≤ ■ <1.00≤ ■
E=0.000 PEAK:1,2,3

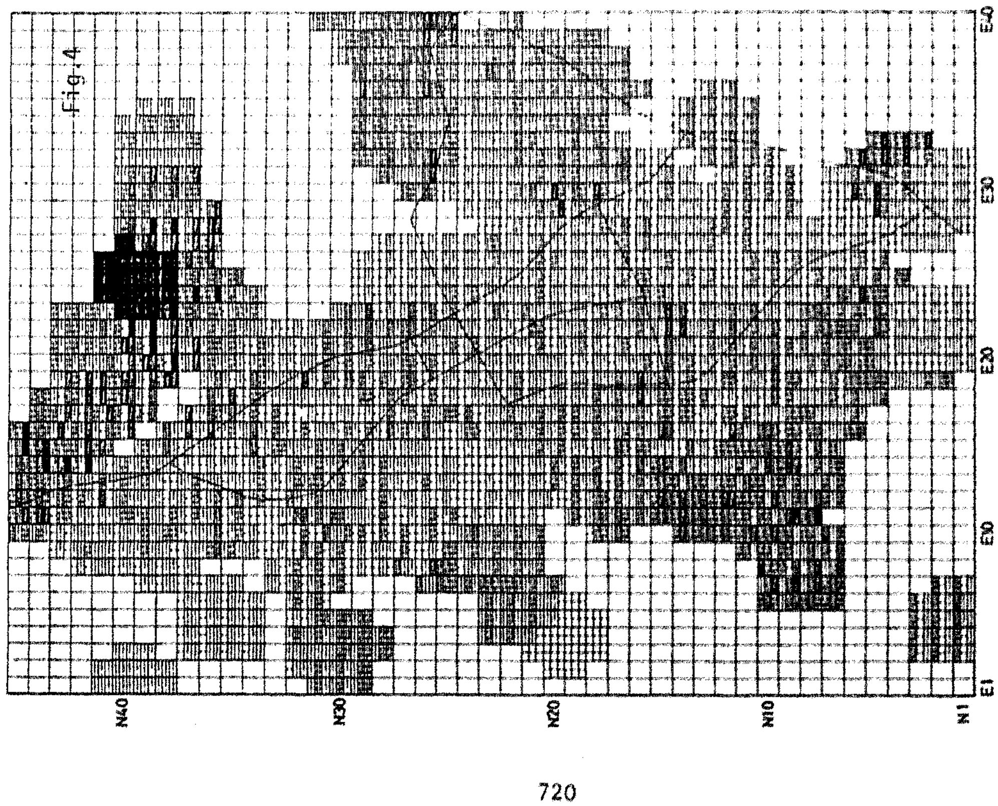
Fig.4
N40
N30
N20
N10
N1
E1
E10
E20
E30
E40
□<3.0≤ ▤ <4.0≤ ▦ <5.0≤ ▩ <6.0≤ ■ <7.0≤ ■ <8.0≤ ■
E=0.000 PEAK:1,2,3