Jour. Kor. Inst. Mining Geol.
v. 13, no. 1 (1980), pp. 1-19

Study on Earthquakes of Korea based on the Local Data of 1926～1943*

Sang Jo Kim**

Abstract : The local earthquake data, observed by Wiechert seismograph in Korea during Feb. 1926–May 1943, was provided and investigated. Using S–P monogram of JMA, mainly Tsuboi's formula and additional intensity data, the earthquake parameters are obtained as much as possible within a reasonable discrepancy. The seismic characteristics as to the epicenter distribution was discussed under the viewpoint of its relation to the adjacent geologic structure. Some statistical results are analyzed comparing with Kyushu region which provide a reasonable interpretation on the seismicity of Korea. By superposing the available information of the individual events, the general trend of stress field was found to be east–west compression, which mostly agree with that of the southwestern Japan.

1. Introduction

Up to a few years ago, the study on earthquake of Korea has not been active enough to present a basic knowledge to civil engineering, geophyscs and other geosiences, and to the practical application. This was caused by not only the lack of interest in seismology due to the absence of any destructive earthquake in contemporary records, but also the lack of reliable instrumental data from many stations compiled during proper period.

However the Hongseong earthquake on Oct. 7, 1978 was enough to refresh the public interest, even if its magnitude was found not more than 5.

In this situation, the publication of original data for 17 years (Feb. 1926 - May 1943) is thought to be meaningful, which is one of the major purpose of this paper.

This homogenous data of local stations was observed by Japanese at that time and, up to now, has been kept in JMA (Japan Meteoro logical Agency) in the form of Seismological Monthly Original Register in which the interpreted results of seismogram and additional intensity information were recorded.

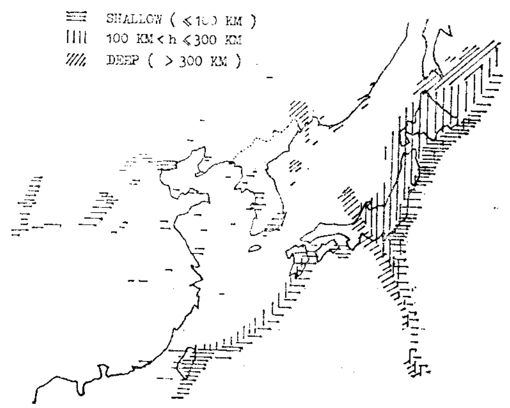

Fig. 1 Schematic seismicity map of Korea and vicinity sketched from mainly Ichikawa (1) and Hattori (2).

Thanks to Dr. M. Ichikawa, Seismological Division of JMA, this complete data could be investigated and published.

Korea is located between the most active seismic zone in the Circum-pacific belt and the continental platform which has experienced significant destructive earthquakes, as shown in figure 1.

The deep earthquake zone at northeast of Korean peninsula being interpreted with relation to the descending Pacific plate is out of discussion in this paper. On the other hand, the

---

* This paper is submitted to IISEE as the Indivisual Study Report for the course of seimology in 1978-1979.

** Korean Central Meteorogical Office, Seoul.

southwestern Japan is to be discussed owing to its geographical location and expected relation in earthquake generating stress.

The seismicity of the Korean peninsula, according to Kim, et al. (3), was considerably active in the 13th centry through the 17th century, and even the earthquake of magnitude 7 could be expected by calculating the maximum intensity estimated from description of the historical literature for nearly 2,000 years. So this study may corresponds to only one fraction of the relatively calm stage.

As the most important mechanical factor in earthquake genesis, it can be noted that "a feature of the Quaternary tectonic history of Korea is the tilting of the peninsula which has resulted in uplift in the east and downwarping in west" (4).

2. Characteristics of data

Before discussing the meaning of earthquake parameters, it is necessary to mention on the nature of data which used in this study. Without the certain criteria for the reliability and accuracy of data, approaching to a definite conclusion is thought to be unreasonable.

This data-observed by Wiechert seismograph which has the mechanical magnification of 70~80 for horizontal components (pendulum mass of 200kg) and of 50 for vertical component (80 kg)-contains the information on date and time, intensity in JMA scale, maximum amplitude of ground motion (μ), total duration of oscillation, time difference of initial P and S waves, the properties of initial P-wave and some additional intensity report from 6 stations in Korea during 17 years.

All the time used in this paper is KST (Korea Standard Time) equivalent to the zone time of longitude 135°E (GMT+9 hrs), same as Japan standard time.

The total number of data sets (recorded events) is 90 which shows the characteristics in table 2.

It was found that there are some discrepancy in several cases, even though checking the original seismogram was not possible owing to no existance of it. For example, the events at about 30Km west of Gunsan were recorded at 6 stations with 5 data of S-P time. Among them the P-arrival of Busan is 30.5 seconds earler than that of Daegu, while S-P time of Busan is 12.2 seconds larger than Daegu from epicenter.

When considering the technology in timekeeping at that time, it is reasonable to believe only the time interval instead of absolute time of second unit.

As mentioned before, this data was extracted from the Original Register compiled all the data of events which was recorded at the whole stations including those in Korea and Taiwan. It is quite natural that this data is the most reliable owing to its originality.

Tab. 1 Name of station which appeared in the Original Register only for Korean events.

6 in Korea	Seoul, Incheon, Daegu, Busan, Chupungryeong, Pyeongyang
6 in Japan	Izuhara, Fukuoka, Fukue, Kumamoto, Nagasaki, Mizazaki

Tab. 2 Properties of data-numbers of each article

Total	Seismic data	Intensity only	Number of data sets contains;								Max. amplitude	Initial P-wave
			1	2	3	4	5	6	7	8		
90	87	3	50	16	4	5	6	3	1	2	37	14

Tab. 3 Comparison of earthquakes' data within the region bounded by lat. 34°N～42°N, long. 124°E～130°E (Feb. 1926-May 1943).

Provider	Number of events	Differences of earthquake parameters for 5 events only which can be considered same one				
		Near Mt. Geumgang	Near Andong	Near Mt. Jiri	Near Geumchon	Near Sariwon
Rustanovich, et al.	18 4≤M≤8−9	*16Jan1933 M=4	*7Dec1935 M=6−7	*3Jul1936 M=8−9	*24Jan1937 M=6−7	*15Mar1937 M=6−7
present author	28 3.7≤M≤5.3	16Jan1933 20:27hr. M=3.8	7Dec1935 20:11hr. M=4.3	4Jul1936 06:02hr. M=5.3	25Jan1937 04:00hr. M=3.7	16Mar1937 02:45hr. M=4.0

* M values may indicate the maximum intensity instead of magnitude and the dates seem not to be local standard (KST) but GMT.

In order to prevent some possible confusion, the earthquake parameters-listed as supplementary table in the paper of Rustanovich et al. (5)-are to be discussed only for the same period. It is because that the paper is thought to play an important role in the study of Korean earthquakes and the related problems. They presented 49 earthquake parameters (M≥4) in table 4, titled "Epicenters of Korean Earthquakes from Instrument Records".

Among them, only 18 events are corresponding to those within the region bounded by lat. of 34°N-42°N and long. of 124°E-130°E which completely covers the Korean peninsula.

As exhibited on the above table, only 5 events counsidered as the same one even though 3 of them have one day advanced dating. Those dates were comfirmed not true by rechecking the Original Register, as long as the person who concerned had not made a mistake in data writing. It was found that miswriting date was nearly impossible because those data had been recorded sucessively only in time order without any regional division of station.

The most significant discrepancy is lying on magnitude scale listed in the column which was indicated by "M". However, considering the statement described on page 942 (in English translation) as "-earthquake of scale intensity 8～9 on 3 July 1936 in the south of the country.", there might have been some confusion between magnitude and maximum intensity, or have made a simple mistake in making the table.

Table 4 proposes that those 13 events, listed as Korean earthquakes only in their table, may be the same one which had occurred far from Korea. It is because that the relatively large events on and around those indicated dates-only which contain stations in Korea-were recorded as the righthand side description on this table. The above detailed discussion was made for the purpose of providing some basics to the earthquake study of Korea in immature stage, as expecting further advanced investigation.

It would be preferable for the detailed charteristics to be examined in the raw data listed on the appendix, in which all the data including intensity information is arranged chronogically with the earthquake parameters mentioned in the following section.

3. Determination of earthquake parameters

As shown on the characteristics of the data above, determination of earthquake parameters is one of major portion of this study. It is quite routine, as far as the data is sufficient, to compute those parameters by electronic computer programming, but which could give only 17 answers among 87 events for this data with large deviation of location. To make

Tab. 4 Comparison of expected same events

Rustanovich et al.					Data recorded on the Original Register for the same date event in which Koreau stations inserted		
			Epicentral coordinates				
Yr.	Mo.	Day	°N	°E	h. m.	Approx. epicenter	K/A*
1926	Mar.	14	38.0	128.0	17:55	Naze island, South of Kyuhsu	1/9
1927	Feb.	3	35.0	125.0	12:50	150Km NW of Shanghai, China	2/58
1932	Dec.	12	34.8	128.8		not confirmed	
1934	Dec.	12	37.0	124	19:09	Some place 450Km from Seoul	2/2
1935	Aug.	27	39.6	128.4	01:32	Ishigakiſima I., East of Taiwan	5/17
1935	Aug.	27	39.6	128.4	14:22	Ishigakijima I., East of Taiwan	4/14
1935	Oct.	15	37.5	127.0	23:31	Lat. 37.7°N, Long. 135.4°E	3/96
1936	Oct.	19	37.5	129.5		not confirmed	
1936	Oct.	26	34.5	128.5		not confirmed	
1937	Feb.	26	35.0	125	13:15	SE off Etorofu I., south of Kurile Is.	2/38
1937	Mar.	30	38.5	125.7	20:38	Central Taiwan	1/13
1938	Jul.	19	36.8	128.6		not confirmed	
1938	Jul.	20	35.4	127.9		not confirmed	

K/A*: Number of recorded station in Korea/Total recorded number

data as useful as possible, the following methods and procedures were used.

(1) **Epicenter and Depth**: The time difference of P-and S-wave's arrival (Ts-p) were mainly used instead of the arrival time's differences for P-wave, which is applied for the hyperbola method and circle method[6], because the absolute time keeping is expected unreliable in those days. Using the S–P monogram of JMA, which shows the relationship between epicenter distance, Ts-p and depth for local events in and near Japan, the locations were drawn graphically[7].

But the locations could not easily obtained owing to (a) improper relative direction of stations to epicenter, (b) reasonable numbers of mis-reading in S-wave arrival and (c) possible discrepancy between the theoretical in Japan and actual travel time in Korea. So all the information i.e., intensity distribution, the direction of P-wave motion, and polarization of maximum amplitue were combined to obtain the most resonable location, which implies the existence of author's subjectiveness. But it is believed that most epicenters of major events have its error within 10Km.

Through the above procedure, epicenters of 47 events were determined (see Fig. 3).

Depth estimation was made by trial and error method for the best fit of location, even though most of the data were not correct enough to determine the depth. This showed that all the earthquakes did not occur in deep depth more than 40Km. Also from the general viewpoint of tectonic earthquakes in well-known Japan area, there is no reason for these events within Korean peninsula not to be shallow.

(2) **Magnitude**: In order to obtain magnitude of local earthquakes, the characteristic of ground condition and instrument, which has caused the existance of different formulas for local use, should be considered.

However, at present stage, it was found that the most appropriate method is to use Tsuboi's formula:

$$M=1.73\log\Delta+\log A-0.83 \qquad (3\text{-}1)$$

where A is the maximum displacement amplitude of the ground due to that earthquake (measured in micron) observed at an epicentral distance Δ (measured in Km) and log is the common logarithm, which is equivalent to the Gutenberg-Richter's magnitude and has been used in JMA for local events with limitation of focal depth less than 60Km and of period of five seconds and below[(8)].

In addion, Tsumura's formula was used, which was driven from total duration of oscillation on record. This empirical formula:

$$M' = -2.53 + 2.85\log(F-P) + 0.0014\Delta \quad (3\text{-}2)$$

where $F-P$ is total duration in second and Δ is epicentral distance in Km, is equivalent to the magnitude by Tsuboi's formula with accuracy of $\pm 0.2 \sim 0.3$ (standard error) within 1,000Km[(9)].

In this study, 30 events of 87 seismological data sets only provided magnitude determination by Tsuboi's formula instead of Tsumura's method was applicable for all events, even though there are considerable discrepancy in both magnitude determinations. For these data, it is clear that the magnitude by Tsumura (M') is less reliable because of remarkable difference on $F-P$ of each station for same event.

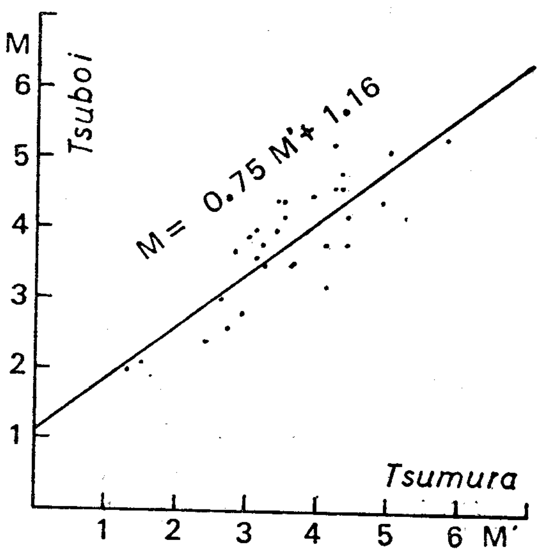

Fig. 2 The relationship between the magnitudes by Tsuboi (M) and by Tsumura (M′)

In order to provide a unified criterion in magnitude scale, that is, to covert M′ into M, the following equation was obtained by the least square method from the 30 events which gave both M and M′:

$$M = (0.75 \pm 0.09)M' + (1.16 \pm 0.34) \quad (3\text{-}3)$$

which is applicable only to data of this study (see Fig. 2).

(3) **Origin Time**: As far as time keeping is unreliable, it was considered meaningless to calcuate origin time up to second-unit.

All the parameters obtained by above procedures was listed together with original seismological data on appendix.

4. Local distribution of epicenters

In general, one can state that geographical distribution of earthquakes is not random, i. e., it shows a property of local concentration as far as a certain change of geological structure and stress system does not exist in a region and time concerned, being based on the generating mechanism of tectonic earthquake. Therefore, the local distribution of a relative short period can represent the general tendency of regional variation in seismicity.

Figure 3 shows the local distrbution of 47 epicenters, obitained from the data treated in this paper, in terms of magnitude intervals 1.0.

The most distinguishable phenomenon is that there are no earthquakes occured above latitude of 39.5°N, around which the eastern coastline of the peninsula changes remarkably from NE to NW trend together with the major mountain range. Most of the region, above this line, is possessed by mountainous region called Gaema plateau. It is a little doubtful whether the absence of events is true or not, owing to even the seismological station, Pyeongyang, of the highest latitude is below that line. However,

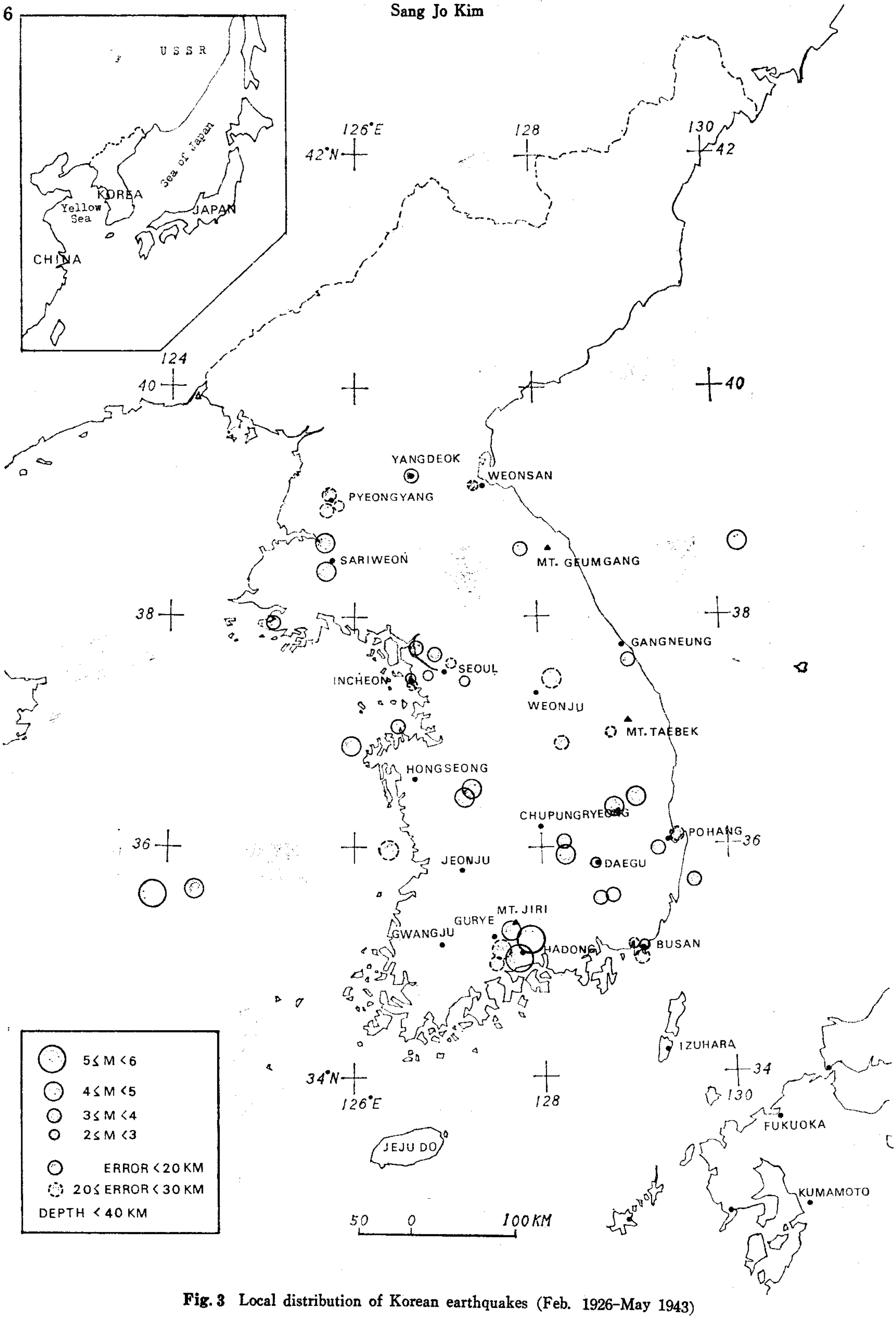

Fig. 3 Local distribution of Korean earthquakes (Feb. 1926–May 1943)

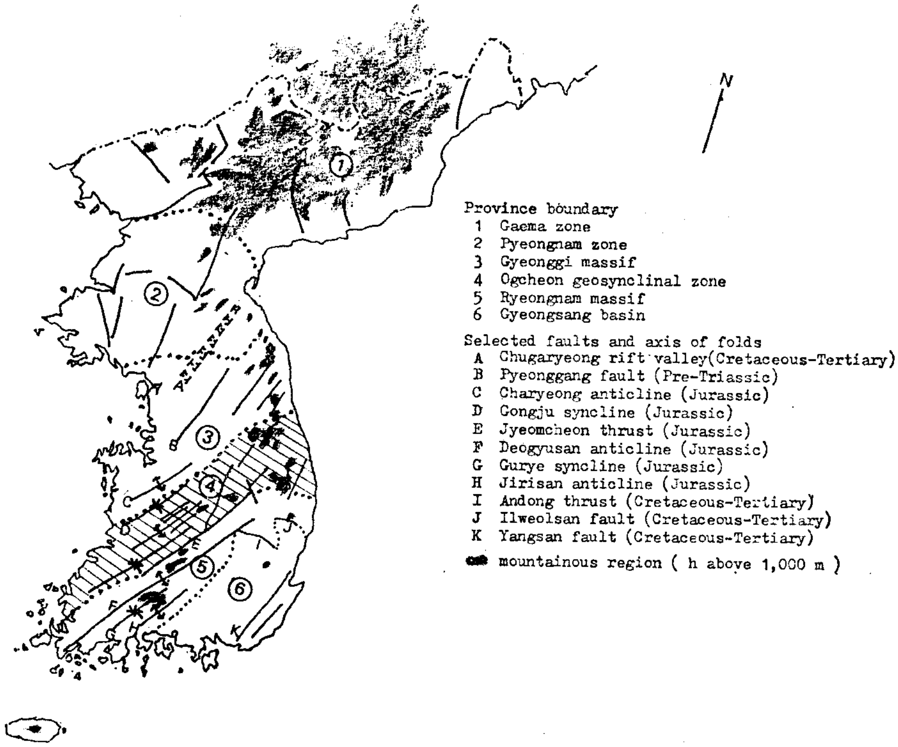

Fig. 4 Schematic geologic structure map of Korea-simplified from Kim(10) and the northern part referred to Rustanovich(5)

it is so safe to state that no events of magnitude 4.5 and over occurred there except deep earthquakes around the northeastern end of Korean border.

Another significant characterstic of local distribution can be indicated by the sequence of major events around the border of Gyeongsang region, located at utmost southeast of peninsula, which corresponds to the Gyeongsang basin for the name of geological province (see Fig. 4).

Among thsoe events, 5 concentrated earthquakes at south of Mt. Jiri should be noted. This area, which is closely related with 3 structural unit-named Gurye syncline, Jirisan anticline and the border line between Gyeongsang basin and Ryeongnam massif-had released remarkable strain energy through 2 major earthquakes, i. e., M 5.3 on July 4, 1936 (so called Sanggy-sa earthquake) and M 5.2 on Aug. 22, 1938 (can be called Hadong earthquake). This Gyeongsang region was found to have 5 more events (approx. M:3) at least. The released energy is to be treated in following section.

It is found interesting that very rare event was located in Ogcheon geosynclinal zone (Ogcheon fold belt) while it shows many complicated faults and axis of folding. According to Kim, O. J. (10), all the lines of faults and folding axes in this zone are associated with Jurassic deformation (Daebo Orogeny) except several folds with Triassic deformation (Songrim distrubance). It needs also to be poined out that Jeonju city in this zone generally had reported relativly higher intensity than the other station nearer to epicenter. But it is very doubtful whether the observation of intensity was correct or not.

Another possible trend is the location of epicenters along the northern border of Ogcheon zone. Among them, two events ($4 \leqslant M < 5$) about 50Km ESE of Hongseong are located with relation to Charyeong anticlne and Gongju syncline geographically.

One group of events ($M \leqslant 4$) at mid-west of Gyeonggi massif, around Seoul, Incheon and north of Hongseong, is geographically located southern end of Chugaryeong rift valley and Pyeongyang fault. This area had actually experienced at least 7 more events (approx. M:3), taking account of those earthquakes which give very rough information-such as within 50Km from Seoul and Incheon.

A notable arrangement of epicenter in Pyeongnam zone seems to be northsouth line connecting Pyeongyang and Sariwon, along which several faults run as shown in Fig. 3. Rustanovich (5) described these faults as "the most important fault zone and faults along which movement took place in the Mesozoic (sometimes inherited)" and for some of them "as the same, but rejuvenated in the Cenozoic".

In Korean peninsula, the existance of late Quaternary faulting is not reported, which is particularly emphasized to be "a far more valuable tool in estimating seismicity…" by Allen(11)

The local distribution was discussed with geographic relation to geologic structure which might have associated with earthquakes, but the result obtained from incomplete data is pointed out not to be adequate to introduce any certain conclusion.

5, Magnitude-frequency distribution

The characteristic of earthquakes in a certain seismic region can be specified by comparing the constants in a simple empirical equation:

$$\log N(M) = A - bM \qquad (5\text{-}1)$$

where $N(M)$ is the number of events of magnitude M or greater per unit time, which is called Gutenberg-Richter's formula.

Especially coefficient b has been interpreted in many viewpoints and has obtained in different methods which can give considerable differences. The magnitudes obtained from original data was classified in magnitude interval of 0.2, instead of 0.1 as shown on table 5, because maximum error in magnitude determination is expected to be about ± 0.5.

In order to calculate coefficient b, nearly treated as a regional constant, Utsu's method, showing the following equation, was adopted (12):

$$b = \frac{s \log e}{Mi - s\,Ms}\eta \qquad (5\text{-}2)$$

where M_i is the sum of the magnitudes of all s earthquakes with magnitude Ms and larger,

Tab. 5 Magnitude-frequency distribution of Korean earthquakes (1926~1943)

*M	$n(M)$	$N(M)$
5.4	2	2
5.2	1	3
5.0	0	3
4.8	1	4
4.6	5	9
4.4	4	13
4.2	2	15
4.0	5	20
3.8	8	28
3.6	12	40
3.4	9	49
3.2	6	55
3.0	7	62
2.8	4	66
2.6	6	72
2.4	3	75
2.2	5	80
2.0	2	82

*M means $M-0.1 \leqslant M < M+0.1$
$n(M)$: frequency of each in interval.
$N(M)$: accumulated number of events

and η is fator for correcting the effect of length of magnitude interval.

The estimate of b by above equation, of which the notation was revised and the correction factor was added to original one, was shown as same as the maximum likelihood estimate (MLE) by Aki[13].

In Fig. 5, two magnitude frequency distribution were plotted, that is, lower one is for Korean events treated in this paper and the other is for the events of Kyushu and vicinity (30°N−35°N, 129°E−133°E) which were observed and analyzed by JMA for the same period (1926∼1943). The data of Kyushu region was selected with limitation of focal depth within 100km and magnitde over 2.5, but actually most of them showed shallow depth (less than 40km) and magnitude over 3.5 which implies that the comparison of two statistical results is reasonable.

The b value of Korean events was found to be 0.75 while 0.96 for kyushu region.

The correction factor was applied only to the Korean events which was classified in 0.2 interval (ΔM=0.2) because of negligeble correction for ΔM of 0.1, according to Utsu's correction table (table 6).

These b values can be supported by Fig. 6 showing the relation of b value and M_s which is the smallest limit of classified magnitudes in each data set for calculation of b value.

The relatively steady incrent of b value in small magnitude portion up to 3.5 for Korean events and up to 4.85 for Kyushu region, is corresponding to the upward convex portion of magnitude-frequency distribution in small magnitude range (see Fig. 5), which is a general tendency in actual statistics. And the b values become stable up to certain stage at which b was calculated from remarkably small number of data and/or from considerably fluctuating frequencies. The b value obtained at Ms, from which the relatively stable tendency starts, was found to be quite expressive for the slope of

Tab. 6 Correction η as a function of $b\Delta M$ (after Utsu)

$b\Delta M$	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8
η	1.000	1.004	1.017	1.039	1.070	1.108	1.154	1.208	1.268

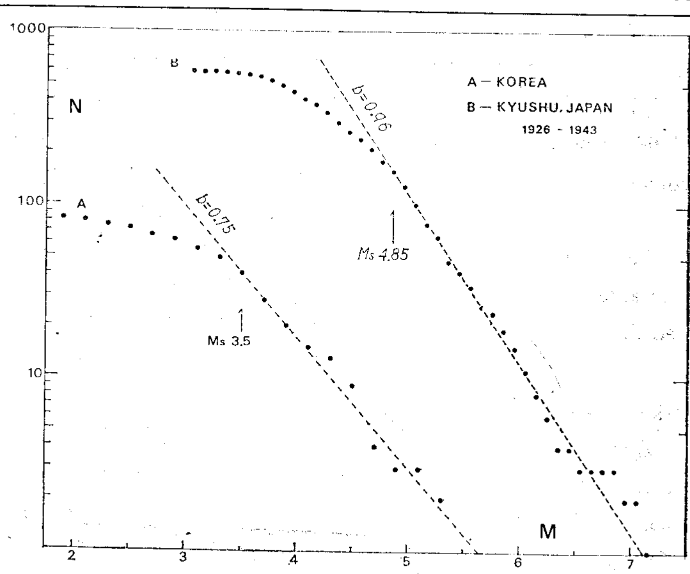

Fig. 5 Magnitude-accumulated frequency distribution

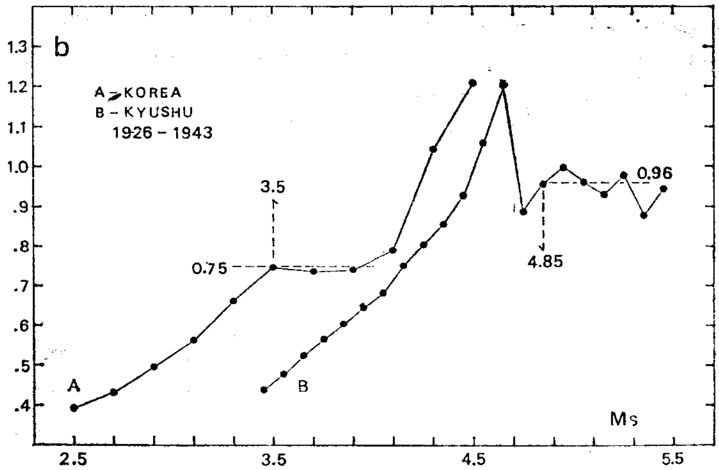

Fig. 6 b value variation as to Ms change

linear portion which satisfy the Gutenberg-Richter's law (Eq. 5-1) as shown in Fig. 5.

As recalculating *b* value worldwidely, which obtained by least square method (LSE) and reported by many investigators, Utsu proposed such a criticism that the regional and temporal comparison of *b* values should be carried out very carefully with a certain criterion since many factors such as methods of determination (LSE or MLE), magnitude scales (local, body or surface wave), and sources of data can affect *b* values considerably(14). For example, he showed different *b* values 0.96, 0.94 and 0.96 for 3 seismotectonic region using same data (1931~1950, M 6), while original Tsuboi's results are 1.06, 0.72 and 0.66 respectively, which might have caused geotectonical interpretation of *b* values.

However, as far as no absolute criterion exist, difference of *b* values due to applied methods can be analyzed through another viewpoint.

If M_s in Fig. 6 is taken as any magnitude equally within 4.3, *b* value for Korean events are always larger than those for Kyushu region. But considering the linear portion which presents most reasonable fitting to Gutenberg-Richter's law, 0.75 and 0.96 for each region seem to be natural, taking the lowest limit (M_s) differently.

The exact value of Korean events without correction is 0.74238 at M_s of 3.5 while for the same range *b* of ordinary least square estimate is 0.74245±0.04. This fact implies tiat *b* value does not vary by use of different method for the limited linear portion.

Above mentioned discussion was also made by Ichikawa, explained the upward convex phenomenon in magnitude-frequency distribution by contamination due errors in the magnitude determination, saying "There is no definite criterion for determining the lowest magnitude to obtain the most probable *b* value in Utsu's method, because the position of large solid circle (which indicates the position of the *b* value assumed in the simulation) differs from case to case..." in his paper studied by computer simulation methed(15) Even though *b* itself has caused a certain critical discussion, it is still meaningful to interpret *b* value as an indication of geotectonical characteristics as far as those old one obtained by LSE method are sufficient to represent the property of linear portion in which the G-R law holds in general.

The obtained *b*, 0.75 for Korean peninsula and 0.96 for Kyushu region, are found to be corresponding to the moderate (1.0~0.7) *b* value zone which is possessed of the Circum-Pacific and Alpide orogenic zones includlng island arcs of big islands and peninsulas-according to Miyamura's study(16) in which the sequence of *b* value changes (high to low) appears to correspond to the development of geotectonic structure, from an infant stage to an old quiet end, i.e., from oceanic regions (1.0~1.8), orogenic zones (0.7~1.0), continental rift zones and platform block zones, to old shield zones (0.6~0.4).

Through the above discussion the phenomenon of the smaller *b* (0.75) for Korean peninsula than 0.96 for Kyushu region can be believed to show an obvious agreement to the fact that geological condition of Korea is older than that of SW part of Japanese islands.

In this connection, one proposal may be provided that the *b* value might be determined only for the magnitude-frequency range which shows the most probable agreement to Gutenberg-Richter's law (Eq. 5-1)-with the variable lowest limit (Ms in Eq. 5-2) for each case-and then in addition to *b* value, the lowest limit of magnitude also might be interpreted as an indication of seismicity like coefficient A in Eq. 5-1.

Moreover in Fig. 5, it is notable that the M_s for Kyushu region can not be lower than that of Korean events, even if the detectivility of earthquake ($4<M<5$) in Kyushu region is considered to be higher than in Korea.

6. Energy release pattern

In order to study the temporal variation of seismicity, the pattern of accumulated energy release, in general, is to be examined. However, the data of 17 years is too short to find a certain tendency or temporal variation of seismicity. So, only the comparative analysis was treated.

The following statistical formula introduced by Gutenberg-Richter was use:

$$\log E = 11.8 + 1.5M \qquad (6\text{-}1)$$

where E is energy in ergs and M corresponds to magnitude dermined from surface waves. As considering only the relative problem, this formula could be applied without any criterion.

In Fig. 7, 3 patterns of cumulative released energy-A for all the events in Korean peninsula, B for Gyeongsang region that is the southeastern portion of the peninsula (see Fig. 4) and C for Kyushu region of Japan (30°N~35°N, 129°E~133°E)-was shown with different scales, that is, left ($\times 10^{18}$erg) for A and B and right ($\times 10^{21}$erg) for C.

Major earthquakes in Korea during this period are M5.4 on Mar. 14, 1932 M5.3 on Jul. 4, 1936 and M5.2 on Aug. 22, 1938, while in Kyushu region M6.9 on May 22, 1929, M7.1 on Nov. 2. 1931 and M7.2 on Nov. 19, 1941. All the major events have depth range of less than 40km. Among them the event of magnitude 5.4 occured at 240km far off southwestern coast of peninsula (35°35′N, 123°51′E) which is nearly equivalent distance to the width of peninsula, while epicenters of the others (M5.3 and M5.2) are very closely (approx. 20Km) located at south of Mt. Jiri whch is the southwestern border of Gyeongsang region.

The total relased energy is 2.22×10^{20} ergs, equivlent to an earthquake of magnitude 5.7, while the energy of 1.07×10^{23} ergs (≒M7.5) was released in Kyushu region. It is noteworthy that only in Gyeongsang region, energy of 1.14×10^{20} ergs (≒M5.5) was released which possess 50% of the total events in Korea and about 80% of in-land events, eliminating offshore events of M5.4 (marked T in Fig. 1.43 $\times 10^{20}$ ergs), while the area is about 17% of whole land area of epicenter's distribution.

In the period studied here, the total released energy of Kyushu region is 5×10^{2} times of

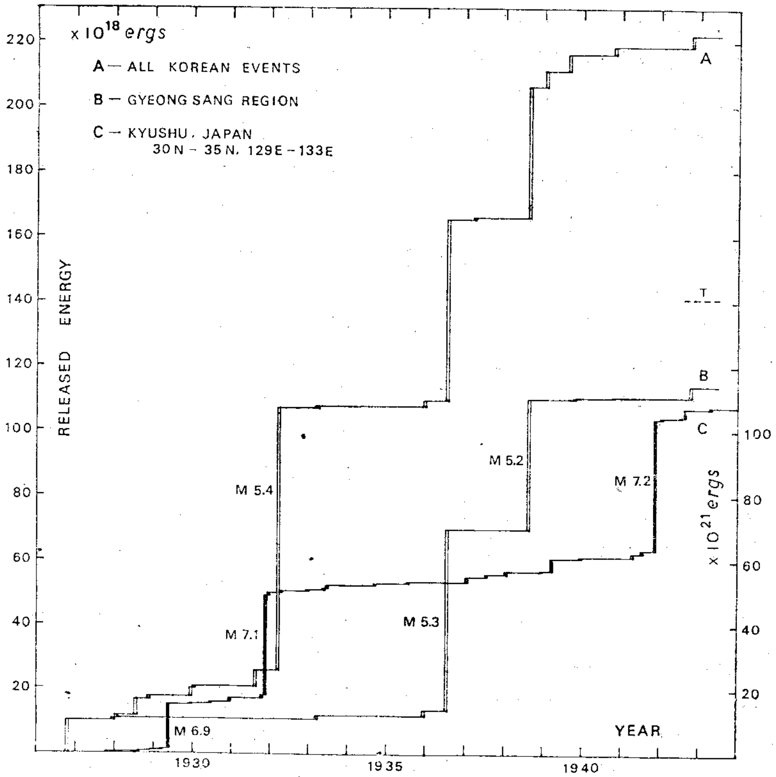

Fig. 7 Cumulative released energy (only C in righthand scale)

that in Korea, which proves relatively lower seismicity of Korea. It is also considerable that energy ratio of threshold magnitudes M_t(=Ms in previous section), energy of M 4.85 per that of M 3.5, shows 10^2 which has the same order of above mentioned 5×10^2.

Finally, one fact that the two major events of Gyeongsang region occurred around middle of the relatively calm stage (10 years between M7.1 and M7.2) of Kyushu region, also can not be passed over.

7. Earthquake Mechanism

As mentioned about characteristics of data, it is nearly impossible to obtain a proper solution of focal mechanism of an indivisual earthquake from those data which have only several information on initial P-wave motion. However, assuming a region is under the generally same stress field, the trend of earthquake mechanism be estimated

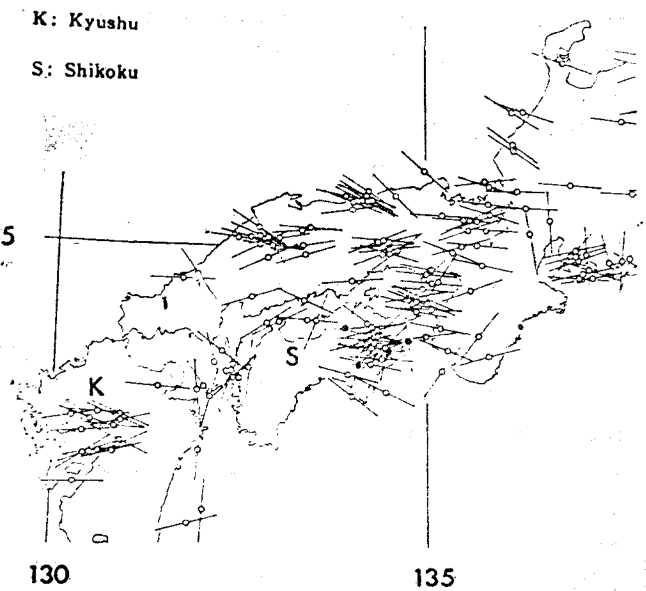

Fig. 8 Distribution of pressures for the very shallow earthquakes in southwestern Japan (after Ichikawa)

by superposition of each different data.

When most of earthquakes in Korean peninsula can be treated as the very shallow events in earth crust, even though any definite evidence has not been studied for the individual event, the earthquake mechanism of Japanese islands (espeially very shallow events in southwestern Japan) can give a fundamental knowledge.

As shown in Fig. 8, the general trend of pressure axis in southwestern Japan is east-west direction, except for those in a region of northeastern Kyushu and some in eastern Shikoku which changed abruptly in time, according to Ichikawa's study on earthquake mechanism(1).

Being based on the above, the direction of pressure in Korean peninsula is expected east-west direction, in general, at least in southeastern region.

All the initial P-wave motion (up and down) for 11 individual events were superposed in Fig. 9 with 3 horizontal P-motion for eathquakes around Mt. Jiri. Those are not sufficient to allow one to draw exact nodal line. The pattern, however, exhibits quadrantal seperation of push (up) and pull (down) implies nodal lines of which directions are NE-SW and NW-SE approximately. This trend is also coincident with the 3 arrows of horizontal motion. The discrepancy in southeastern portion of diagram was found due to the data of an earthquakes at utmost southwest of Pyeongnam zone.

From this superposition method, the general trend of compressional stress in Korean peninsula, more reasonably in southern half, can be stated to be east-west direction as same as that of southwestern Japan in crustal layer.

An additional viewpoint is to be examined through the intensity distribution patterns of specific earthquakes which presented relatively detailed information on intensity as shown in

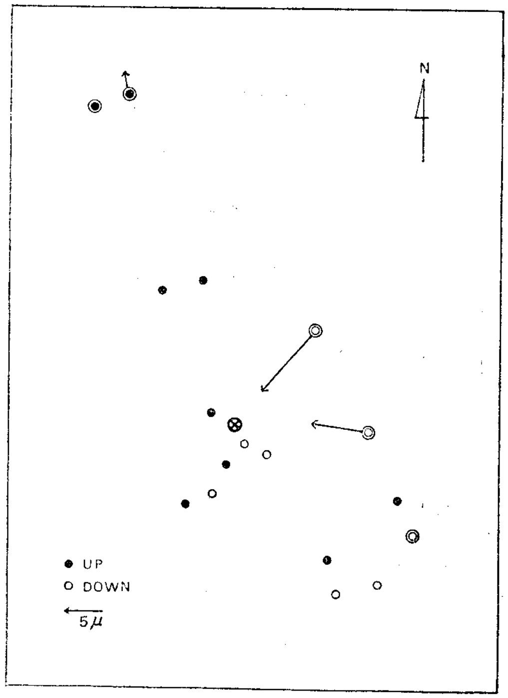

Fig. 9 Superposed initial motion of P-wave-arrows and double cicles are for Mt. Jiri events.

Fig. 10. For local earthquakes, the intensity (damage on construction and sensation) can be considered to be governed mainly by transversal wave(S) instead of P-wave. The isoseismal pattern has introduced many kinds of interpretation related with ground condition and geological structure. In addition to these factors, the correspondence with earthquake mechanism has some meaning to be examined.

Among the Fig. 10, A and B are for the nearly same region. In the pattern of isoseismal, orthogonal elongation, of which major one is NW-SE direction, can be compared with S-wave amplitude pattern of the double couple force system in earthquake mechanism, assuming the ground condition is homogeneous. The geologic structral factor, such as fault, can be treated together with mechanism.

Especially the pattern of case B(Sariwoen earthquake) shows very close agreement with the quadrant pattern obtained by superposition of initial motion of P-wave (Fig. 9). This can

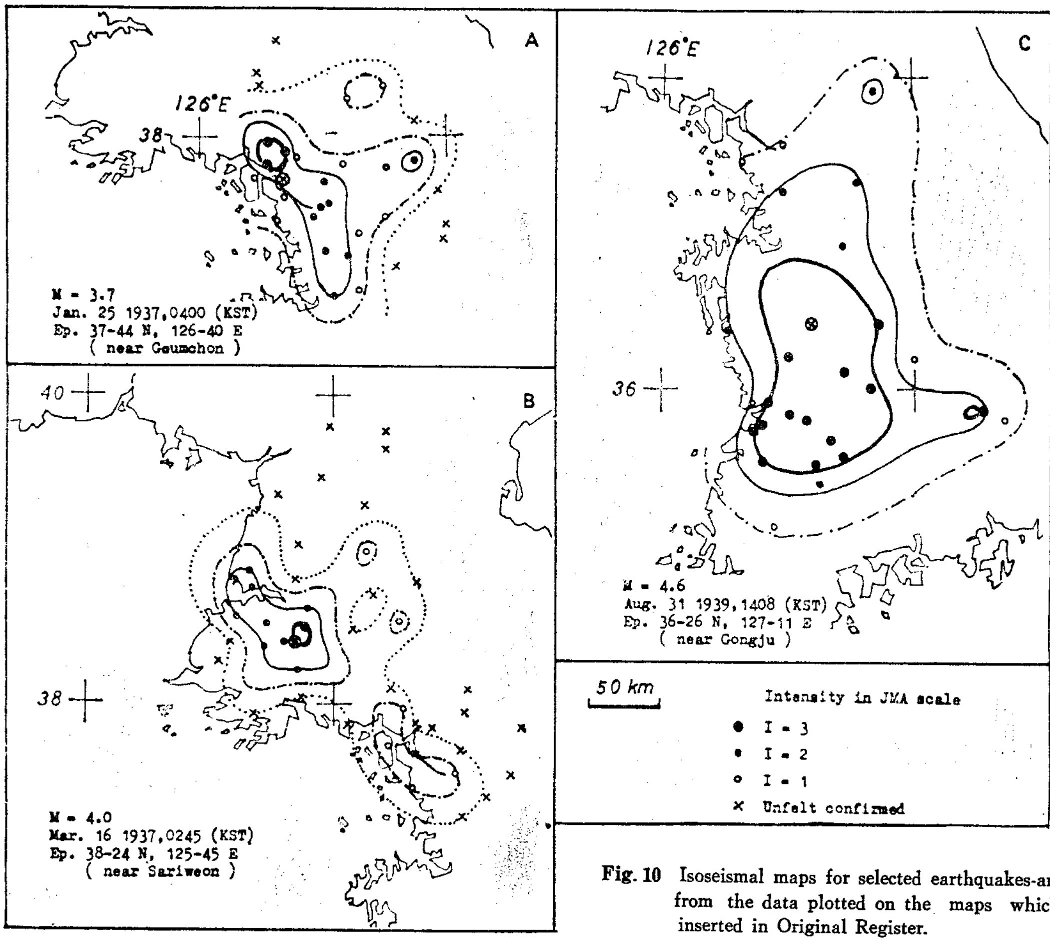

Fig. 10 Isoseismal maps for selected earthquakes-analyzed from the data plotted on the maps which were inserted in Original Register.

be thought that the case B is strike-slip faulting in NW-SE direction by the compression of E-W direction with very shallow depth.

On the contrary, the case C shows a different pattern of which the axis of maximum intensity runs about NE-SW direction. Even though the elongation is not so sharp, it is enough to be compared with the case A and B.

As mentioned before (see Fig. 3 and 4), Sariweon earthquake and Gongju (case C) event are positioned relating to the faults running along the Pyeongyang-Sariweon line and Charyeong anticline and/or Gongju syncline (both in Jurassic) respectively.

These feature may be indicated as an approximate coincidence of the maximum elongation of isoseismal and the direction of geologic structure. Through the above discussion, it is proposed that the general trend of compression in eastwest direction can be applied to the recent tectonic aspect of Korean peninsula.

8. Acknowledgments

I am deeply indebted to Dr. M. Ichikawa of Japan Meteorological Agency for his providing the original data, on which had not been studied as a whole, and for his valuable guidance. And also my sincere thanks should be expressed to the director Dr. M. Otsuka and the other staff members of International Institute of Seismology and Earthquake Engineering (IISEE), remembering their memorable lectures and free discussions. I am under an obligation to Mr. Park, G. P. during preparation of this paper. Finally, I appreciate the various assistance of Japan International Co-operation Agency (JICA) and JMA.

References

1. Ichikawa, M., 1971, Renalyses of mechanism of earthquakes which occurred in and near Japan, and statistical studies on the nodal plane solution obtained, 1926~1968: Geophys. Mag., 35, 207-273.
2. Hattori, S., 1978, Seismic risk maps in the world (maximum acceleration and maximum particle velocity) (I)-China and its vicity: Bull. IISEE, 16, 119-150.
3. Kim, S. G. & Hyun, B. K., 1978, Seismicity of the Korean peninsula and its relation with plate tectonics: Jour. Korean Inst. Mining Geol., 11, 69-80.
4. Reedman, A. J. & Um, S. H., 1975, Geology of Korea: Geol. and Mineral Inst. Korea, pp. 129.
5. Rustanovich, D. N., Masailis, V. L. & Cheon, H. S., 1961, The seismicity of Korea and aspect of its seismotctonics and seismic zoning: Bull. (Izv.) Acad. Sci. USSR, Geophys. Ser., 939~954, (English translation).
6. Bath, M., 1973, Introduction to seismology, Chapter 4.
7. Ichikawa, M. & Mochizuki, E., 1971, Travel time tables for local earthquakes in and near Japan: Papers in Meteo. and Geophys., 22, 229-290.
8. Tsuboi, C., 1954, Determination of Gutenberg-Richter's magnitude of earthquakes occurring in and near Japan, Zisin (II), 7, 185-193.
9. Tsumura, K., 1967, Determination of earthquake magnitude from total duration of oscillation: Bull. Earthq. Res. Inrt., 45, 7-18.
10. Kim, O. J., 1975, Granites and tectonics of South Korea: Jour. Korean Inst. Mining Geol., 11, 69-80.
11. Allen, C. R., 1975, Geological Criteria for evaluating seismicity: Bull. Geol. Soc. Amer., 86, 1041-1057.
12. Utsu, T., 1965, A method for determining the value of b in a formula $\log n = a - bM$ showing the magnitude-frequency relation for earthquakes: Geophys. Bull. Hokkaido Univ., 13, 99-103.
13. Aki, K., 1965, Maximum likelyhood estimate of b in the formula log $N = a - bM$ and its confidence limits: Bull. Earthq. Res. Inst., 43, 237-239.
14. Utsu, T., 1971, Aftershocks and earthquake statistics (III): J. Fac. Sci. Hokkaido Univ., Ser. VII (Geophys.), 3, 379-441.
15. Ichikawa, M., 1978, Some problems on earthquake magnitude-frequency distribution: Geophys. Mag. (JMA), 38, 33-43.
16. Miyamura, S., 1962, Magnitude-frequency relation of earthquakes and its bearing on geotectonics: Proc. Jap. Acad., 38, 27-30.

1926~1943年의 局地資料에 의한 한국 地震의 硏究

金 尙 照

요 약 : 本論文에서 1926년 2월부터 1943년 5월까지 國內에서 Wiechert 地震計로 觀測된 局地資料가 提示·硏究되었다.

日本 氣象廳(JMA) 現用 S-P monogram(travel time table)을 基礎로 하고 주로 Tsuboi의 地震 規模(magnitude) 계산式과 震度資料의 補助 利用으로 적절한 限界內에서 가능한 限 많은 地震要素(parameter)를 産出하였다.

또한 震央分布와 관련한 地震 特性이 隣接地質構造와 連關·論議되었으며 몇몇의 統計結果가 日本 九州地域과 비교 분석됨으로서 한국의 地震 活動에 관한 合理的인 解析이 내려졌다.

地震 mechanism을 規明하기에는 充分하지 않지만, 단편적인 資料들을 superposition method에 의하여 綜合한 結果, 日本 南西部(九州) 地域의 그것과 대체로 一致하는 東一西 壓縮의 stress field가 作用하는 일반적 傾向性을 發見할 수 있었다.

APPENDIX

```
1926 FEB.  5 22  /  LUNG= 126.7  LAI= 39.5  H=SFC  M=3.4  ACR=B
                    #####AROUND YANGDEOK          #####
ST.       I     P TIME          MAN MAE MAZ PAN PAE PAZ  S-P F-P
              D  H  M   S
INCHEO   0    5 22  7 52.0                                S   S
            I=3 YANGDEOK-GUN                           22.0  76
-----------------------------------------------------------------

1926 MAY
ST.       1     P TIME                                 M - 3.3
              D  H  M   S       MAN MAE MAZ PAN PAE PAZ  S-P F-P
INCHEO   0    2 22 27 31.0                                S   S
-----------------------------------------------------  25.0  70
-----------------------------------------------------------------

1926 JUNE
ST.       I     P TIME                                 M - 3.3
              D  H  M   S       MAN MAE MAZ PAN PAE PAZ  S-P F-P
INCHEO   0   10 18 23  1.0                                S   S
-----------------------------------------------------  26.0  70
-----------------------------------------------------------------

1926 OCT.  5  8 43  LUNG= 128.3  LAI= 35.9  H=SFC  M=4.8  ACR=A
                    #####50KM WNW OF DAEGU        #####
ST.       I     P TIME          MAN MAE MAZ PAN PAE PAZ  S-P F-P
              D  H  M   S
INCHEO   0    5  8 43 37.                                 S   S
BUSAN    0    5  8 43 23.           33                 27.0 215
            I=3 JEONJU  DAEGU                          15.0
            REMARKS (EARTHQUAKE SOUND AT UPPER STREAM OF NAGDUNG-GANG)
-----------------------------------------------------------------

1927 MAR.
ST.       I     P TIME                                 M - 2.9
              D  H  M   S       MAN MAE MAZ PAN PAE PAZ  S-P F-P
INCHEO   0   31  9 56 25.                                 S   S
-----------------------------------------------------   5.0  47
-----------------------------------------------------------------

1927 DEC.  5  6 10  LONG= 128.2  LAI= 37.5  H=SFC  M=4.0  ACR=C
                    #####AROUND WEONJU            #####
ST.       I     P TIME          MAN MAE MAZ PAN PAE PAZ  S-P F-P
              D  H  M   S
INCHEO   0    5  6 10 31.      11  23                     S   S
            I=2 SOUTHWESTERN  GANGWEON-DO              17.0  50
-----------------------------------------------------------------

1928 JAN. 12  0 47  LONG= 127.6  LAI= 35.1  H=SFC  M=4.2  ACR=C
                    #####50KM SW OF MT.JIRI       #####
ST.       I     P TIME          MAN MAE MAZ PAN PAE PAZ  S-P F-P
              D  H  M   S
INCHEO   0   12  0 47                                     S   S
            I=3 JEONJU          4 - 5   3 + 3 - 1 + 1  34.0 115
            I=2 WIDE AREA FROM JEUNJU TO TUNGYEONG
            REMARKS (EARTHQUAKE SOUND)
-----------------------------------------------------------------

1928 MAY
ST.       I     P TIME                                 M - 3.6
              D  H  M   S       MAN MAE MAZ PAN PAE PAZ  S-P F-P
SEOUL    0    8  5 11 58.0      1   2                     S   S
INCHEO   0    8  5 12  1.       1   1      + 0 - 0     37.0  63
-----------------------------------------------------  30.4
-----------------------------------------------------------------

1928 JUNE 30  4 26  LONG= 127.5  LAI= 35.0  H=SFC  M=5.0  ACR=C
                    ######45KM SW OF MT.JIRI      #####
ST.       I     P TIME          MAN MAE MAZ PAN PAE PAZ  S-P F-P
              D  H  M   S
INCHEO   0   30  4 26 48.       1   1                     S   S
            I=1 GURYE                                  34.6  80
-----------------------------------------------------------------

1928 JULY
ST.       I     P TIME                                 M - 4.6
              D  H  M   S       MAN MAE MAZ PAN PAE PAZ  S-P F-P
SEOUL    0    3  1 26 13.4      3  13                     S   S
INCHEO   0    3  1 26 10.      27  23                  27.0 108
-----------------------------------------------------------------

1928 SEPT
ST.       I     P TIME                                 M - 2.0
              D  H  M   S       MAN MAE MAZ PAN PAE PAZ  S-P F-P
INCHEO   0   17 16 18 21.7      1   4                     S   S
-----------------------------------------------------   3.0  19
-----------------------------------------------------------------

1928 NOV. 19 11 45  LUNG= 130.2  LAI= 38.6  H= 20  M=4.1  ACR=B
                    #####150KM NE OF GANGREUNG    #####
ST.       I     P TIME          MAN MAE MAZ PAN PAE PAZ  S-P F-P
              D  H  M   S
SEOUL    0   19 11 45                                     S   S
INCHEO   0   19 11 45  6.8      2   1                  35.0 355
BUSAN    0   19 11 45 13.           2                  38.7 122
-----------------------------------------------------------------

1928 DEC.
ST.       I     P TIME                                 M - 3.3
              D  H  M   S       MAN MAE MAZ PAN PAE PAZ  S-P F-P
SEOUL    0    1  3  0 37.5      1   1                     S   S
            I=2 JEONJU                                 28.5  53
-----------------------------------------------------------------
```

```
1929 JAN.
ST.       I     P TIME                                 M - 3.5
              D  H  M   S       MAN MAE MAZ PAN PAE PAZ  S-P F-P
INCHEO   0   15  7 58 31.5     11  13                     S   S
SEOUL    0   15  7 58 37.6      1   0                   8.4
-----------------------------------------------------   3.0  88
-----------------------------------------------------------------

1929 DEC. 27  3 14  LONG= 125.7  LAI= 38.7  H=SFC  M=4.4  ACR=B
                    #####10KM N OF SARIWEON       #####
ST.       I     P TIME          MAN MAE MAZ PAN PAE PAZ  S-P F-P
              D  H  M   S
INCHEO   0   27  3 15 47.1      6   3                     S   S
SEOUL    0   27  3 15 49.1     10  12   + 3 - 3 - 6    26.6  84
PYONGY   2   27  3 14 50.               + 1 - 2        20.0 144
-----------------------------------------------------------------

1930 JAN.
ST.       I     P TIME                                 M - 3.0
              D  H  M   S       MAN MAE MAZ PAN PAE PAZ  S-P F-P
INCHEO   0    3 21 55 26.1          1                     S   S
-----------------------------------------------------  27.8  52
-----------------------------------------------------------------

1930 JAN.
ST.       I     P TIME                                 M - 4.0
              D  H  M   S       MAN MAE MAZ PAN PAE PAZ  S-P F-P
INCHEO   0   12 21 56 30.       0   3                     S   S
-----------------------------------------------------  37.0  85
-----------------------------------------------------------------

1930 MAR.
ST.       I     P TIME                            UNDETERMINED
              D  H  M   S       MAN MAE MAZ PAN PAE PAZ  S-P F-P
SEOUL    0    7 12 56 13.5      4   6                     S   S
-----------------------------------------------------  60.0 154
-----------------------------------------------------------------

1930 JULY 13  7 46  LUNG= 125.2  LAT= 38.0  H=SFC  M=3.8  ACR=B
                    #####SW OF HWANGHAE-DO        #####
ST.       I.    P TIME          MAN MAE MAZ PAN PAE PAZ  S-P F-P
              D  H  M   S
INCHEO   0   13  7 46  3.3      5   6   -  +  + 1         S   S
SEOUL    0   13  7 46  8.7      5   6   -  + 1         18.0  82
-----------------------------------------------------  21.0  74
-----------------------------------------------------------------

1930 JULY
ST.       I     P TIME                                 M - 3.2
              D  H  M   S       MAN MAE MAZ PAN PAE PAZ  S-P F-P
SEOUL    0   15  8 17           2   2                     S   S
-----------------------------------------------------        60
-----------------------------------------------------------------

1930 NOV.
ST.       I     P TIME                                 M - 3.4
              D  H  M   S       MAN MAE MAZ PAN PAE PAZ  S-P F-P
INCHEO   0    3  5 19                                     S   S
-----------------------------------------------------  39.0  81
-----------------------------------------------------------------

1931 MAY
ST.       I     P TIME                                 M - 3.8
              D  H  M   S       MAN MAE MAZ PAN PAE PAZ  S-P F-P
INCHEO   0    9 23  4 19.5      1   2                     S   S
-----------------------------------------------------  33.0 180
-----------------------------------------------------------------

1931 MAY
ST.       I     P TIME                                 M - 3.5
              D  H  M   S       MAN MAE MAZ PAN PAE PAZ  S-P F-P
INCHEO   0   30 21  7 44.4      2   1                     S   S
-----------------------------------------------------  25.0 120
-----------------------------------------------------------------

1931 JULY
ST.       I     P TIME                                 M - 3.3
              D  H  M   S       MAN MAE MAZ PAN PAE PAZ  S-P F-P
TAEGU    0    1  7 13  3.5                                S   S
-----------------------------------------------------        68
-----------------------------------------------------------------

1931 AUG. 12 15 44  LUNG= 126.0  LAT= 36.9  H=SFC  M=4.6  ACR=A
                    #####OFF NW COAST OF SEOSAN   #####
ST.       I     P TIME          MAN MAE MAZ PAN PAE PAZ  S-P F-P
              D  H  M   S
SEOUL    1   12 15 44 10.8                                S   S
PYONGY   0   12 15 44 23.8                             14.2  60
TAEGU    0   12 15 44 30.8      8   6                  28.8 456
BUSAN    0   12 15 45 29.3     34  16                  31.0 269
-----------------------------------------------------        41
-----------------------------------------------------------------

1931 SEPT
ST.       I     P TIME                                 M - 2.4
              D  H  M   S       MAN MAE MAZ PAN PAE PAZ  S-P F-P
TAEGU    0   17  6 53 36.2                                S   S
-----------------------------------------------------        26
-----------------------------------------------------------------

1931 SEPT 17  7  0  LONG= 128.6  LAT= 35.9  H=SFC  M=2.1  ACR=A
                    #####DAEGU                    #####
ST.       I     P TIME          MAN MAE MAZ PAN PAE PAZ  S-P F-P
              D  H  M   S
TAEGU    1   17  7  0 38.8     23  20                     S   S
-----------------------------------------------------   0.9  23
-----------------------------------------------------------------
```

```
1932 MAR. 14 22 53  LONG= 123.9  LAT= 35.6  H= 10  M=5.4  ACR=A
                    *****FAR OFF SW COAST          *****
ST.       I     P TIME            MAN MAE MAZ PAN PAE PAZ  S-P F-P
              D  H  M    S
INCHEO    0   14 22 53 16,6                                 S   S
SEOUL     0   14 22 53 20,0                               35,6 200
PYONGY    0   14 22 53          20                        39,6 480
BUSAN     0   14 22 53                                    53,0 079
TAEGU     0   14 22 53                                    45,0 275
FUKUE     0   14 22 53                                    47,1 179
FUKUOK    0   14 22 53           9                        57,2 281
KUMAMO    0   14  0  0          29  24                    78,3 260
IZUHAR    0   14 22 53                                         296
          I=3 JEONJU                                      63,3
          I=2 IRI
```

```
1932 MAR. 14 23  2  LONG= 124.3  LAT= 35.6  H= 10  M=4.3  ACR=A
                    *****FAR OFF SW COAST          *****
ST.       I     P TIME            MAN MAE MAZ PAN PAE PAZ  S-P F-P
              D  H  M    S
INCHEO    0   14 23  2 51,4                                 S   S
SEOUL     0   14 23  2                                    32,0 180
BUSAN     0   14 23  2                                    36,0 300
TAEGU     0   14 23  2                                    46,5 211
FUKUOK    0   14 23  2                                    43,1 107
                                                          71,9 200
```

```
1932 APR. 19 20 13  LONG= 128.6  LAT= 35.5  H=SFC  M=3.0  ACR=A
                    *****45KM SE OF DAEGU          *****
ST.       I     P TIME            MAN MAE MAZ PAN PAE PAZ  S-P F-P
              D  H  M    S
TAEGU     0   19 20 13 57,7                                 S   S
BUSAN     0   19 20 14  2,7                                4,8  37
          I=1 HYEONPUNG-MYEON                              9,0  61
```

```
1932 JUNE
ST.       I     P TIME                                M = 3.6
              D  H  M    S        MAN MAE MAZ PAN PAE PAZ  S-P F-P
BUSAN     0   14 13 53                                      S   S
                                                               100
```

```
1932 JULY  7 19 58  LONG= 125.7  LAT= 38.9  H=SFC  M=3.4  ACR=C
                    *****AROUND PYEONGYANG         *****
ST.       I     P TIME            MAN MAE MAZ PAN PAE PAZ  S-P F-P
              D  H  M    S
PYONGY    2    7 19 58 59,          30                      S   S
                                                          2,3  78
```

```
1932 AUG. 17 14  6  LONG= 127.3  LAT= 39.2  H=SFC  M=2.2  ACR=C
                    *****AROUND WEONSAN            *****
ST.       I     P TIME            MAN MAE MAZ PAN PAE PAZ  S-P F-P
              D  H  M    S
INCHEO    0   17 14  6 13,0                                 S   S
          I=1 WEONSAN                                           20
```

```
1932 NOV.
ST.       I     P TIME                                M = 3.5
              D  H  M    S        MAN MAE MAZ PAN PAE PAZ  S-P F-P
BUSAN     0   18  8 34 38,9                                 S   S
                                                                90
```

```
1932 NOV.
ST.       I     P TIME                                M = 3.6
              D  H  M    S        MAN MAE MAZ PAN PAE PAZ  S-P F-P
BUSAN     0   19  7 18 44,5                                 S   S
                                                               104
```

```
1932 NOV.
ST.       I     P TIME                                M = 3.7
              D  H  M    S        MAN MAE MAZ PAN PAE PAZ  S-P F-P
BUSAN     0   19  7 51  4,4                                 S   S
                                                               115
```

```
1932 NOV.
ST.       I     P TIME                                M = 3.2
              D  H  M    S        MAN MAE MAZ PAN PAE PAZ  S-P F-P
BUSAN     0   19  8 18 47,4                                 S   S
                                                                63
```

```
1932 NOV.
ST.       I     P TIME                                M = 3.2
              D  H  M    S        MAN MAE MAZ PAN PAE PAZ  S-P F-P
BUSAN     0   19  8 22 45,4                                 S   S
                                                                67
```

```
1933 JAN. 16 20 27  LONG= 127.8  LAT= 38.6  H= 20  M=3.8  ACR=A
                    *****26KM WEST OF MT.GEUMGANG*****
ST.       I     P TIME            MAN MAE MAZ PAN PAE PAZ  S-P F-P
              D  H  M    S
INCHEO    0   16 20 27 13,7                                 S   S
BUSAN     0   16 20 28 40,0                               19,7 120
SEOUL     0   16 20 27  9,8
PYONGY    0   16 20 27                                    16,6 120
WONSAN    2   16 20 27                                    20,7  60
          I=2 WEONSAN
          I=X ANBYEON  TONGCHEON  JINYANG  ONJEONGRI
          I=X GIMHWA  INJAE  GAPYEONG
```

```
1933 MAR.  3 16 19  LONG= 127.7  LAT= 35.3  H=SFC  M=4.0  ACR=A
                    *****NEAR MT.JIRI              *****
ST.       I     P TIME            MAN MAE MAZ PAN PAE PAZ  S-P F-P
              D  H  M    S
BUSAN     0    3 16 19  3,5                                 S   S
TAEGU     0    3 16 19  8,3                               15,0 234
IZUHAR    0    3 16 19 14,5                               13,0 124
FUKUOK    0    3 16 19 25,7                               20,2 104
NAGASA    0    3 16 19 49,8                               33,1 117
KUMAMO    0    3 16 19 52,5                               26,2 147
SEOUL     0    3 16 20 23,0                               40,1  40
```

```
1933 JULY 13  1 18  LONG= 126.9  LAT= 37.7  H=SFC  M=3.0  ACR=A
                    *****18KM NW OF SEOUL          *****
ST.       I     P TIME            MAN MAE MAZ PAN PAE PAZ  S-P F-P
              D  H  M    S
SEOUL     1   13  1 18 32,9     33          * 1 - 3         S   S
INCHEO    0   13  1 18 37,1                                2,2  90
                                                           9,9  55
```

```
1933 OCT.                                          UNDETERMINED
ST.       I     P TIME            MAN MAE MAZ PAN PAE PAZ  S-P F-P
              D  H  M    S
PYONGY    0   14 16  0                                      S   S
                                                          26,4 281
```

```
1933 NOV. 20 23 18  LONG= 125.8  LAT= 39.0  H=SFC  M=2.9  ACR=C
                    *****AROUND PYEONGYANG         *****
ST.       I     P TIME            MAN MAE MAZ PAN PAE PAZ  S-P F-P
              D  H  M    S
PYONGY    1   20 23 18 21,8       7         * 3 - 4         S   S
                                                          1,5  44
```

```
1933 DEC.                                          UNDETERMINED
ST.       I     P TIME            MAN MAE MAZ PAN PAE PAZ  S-P F-P
              D  H  M    S
TAEGU     0   16  5 59 14,4                                 S   S
          I=3 JEONJU
```

```
1933 DEC.                                          UNDETERMINED
ST.       I     P TIME            MAN MAE MAZ PAN PAE PAZ  S-P F-P
              D  H  M    S
TAEGU     0   20 22 53 34,3                                 S   S
          I=3 JEONJU
```

```
1935 JAN.
ST.       I     P TIME                                M = 3.9
              D  H  M    S        MAN MAE MAZ PAN PAE PAZ  S-P F-P
INCHEO    0   22  9 36 25,6                                 S   S
                                                          15,9 130
```

```
1935 JULY
ST.       I     P TIME                                M = 2.5
              D  H  M    S        MAN MAE MAZ PAN PAE PAZ  S-P F-P
TAEGU     0   28 23 44  7,5                                 S   S
BUSAN     0   28 23 44 29,2                                     21
                                                          17,1  40
```

```
1935 NOV. 11 22 49  LONG= 128.8  LAT= 37.0  H=SFC  M=2.1  ACR=C
                    *****SW OF MT.TAEBAEG          *****
ST.       I     P TIME            MAN MAE MAZ PAN PAE PAZ  S-P F-P
              D  H  M    S
TAEGU     0   11 22 49  6,1                                 S   S
INCHEO    0   11 22 49 30,0                                     20
          I=1 PUJYEO-RI  IN  GYEONGSANGBUK-DO                   18
```

```
1935 DEC.  7 20 11  LONG= 129.0  LAT= 36.4  H=SFC  M=6.3  ACR=A
                    *****30KM SE OF ANDONG         *****
ST.       I     P TIME            MAN MAE MAZ PAN PAE PAZ  S-P F-P
              D  H  M    S
TAEGU     1    7 20 11 30,6     33  55      - 6 - 6         S   S
BUSAN     0    7 20 11 40,5                                9,8
INCHEO    0    7 20 11                                    18,4 370
          I=X SEOUL  CHUPUNGRYEONG                             117
```

```
1935 DEC.
ST.       I     P TIME                                M = 3.3
              D  H  M    S        MAN MAE MAZ PAN PAE PAZ  S-P F-P
TAEGU     0    7 20 13 30,0                                 S   S
SEOUL     0    7 20 14  8,2                                     62
                                                               120
```

```
1936 JAN.                                          UNDETERMINED
ST.       I     P TIME            MAN MAE MAZ PAN PAE PAZ  S-P F-P
              D  H  M    S
TAEGU     0   26  2 50  9,0                                 S   S
                                                           9,0
          I=1 HYEUNPUNG-MYEON  DALSEONG-GUN  GYEONGSANGBUK-DO
```

```
1936 JAN.
ST.       I     P TIME                                M = 3.7
              D  H  M    S        MAN MAE MAZ PAN PAE PAZ  S-P F-P
INCHEO    0   26  7 20 49,5                                 S   S
SEOUL     0   26  7 20 53,2                               17,0  63
TAEGU     0   26  7 26  5,2                               22,0 180
                                                                90
```

```
1936 MAR.  7 14 26  LONG= 129.0  LAT= 35.1  H=SFC  M=3.1  ACR=C
                    #####AROUND BUSAN                #####
ST.      I      P TIME          MAN MAE MAZ PAN PAE PAZ  S-P F-P
             D  H  M   S                                  S   S
BUSAN    0   7 14 26 30,6                                3.5  53
-----------------------------------------------------------------
```

```
1936 APR. 29  3 46  LONG= 128.2  LAT= 36.9  H=SFC  M=3.5  ACR=C
                    #####AROUND DANYANG              #####
ST.      I      P TIME          MAN MAE MAZ PAN PAE PAZ  S-P F-P
             D  H  M   S                                  S   S
SEOUL    0  29  3 46 37,6                               17.0  73
INCHEO   0  29  3 46 41,8                               19.4  68
         I=1 PYEONGCHANG  GANGREUNG  GIMCHEON
-----------------------------------------------------------------
```

```
1936 JULY  4  6  2  LONG= 127.9  LAT= 35.2  H=SFC  M=5.5  ACR=A
                    #####NEAR SSANGGYE-SA,MT,JIRI#####
ST.      I      P TIME          MAN MAE MAZ PAN PAE PAZ  S-P F-P
             D  H  M   S                                  S   S
TAEGU    2   4  6  2 35,9     76 123      - 8 - 7       13.1 946
BUSAN    2   4  6  2 37,5    119  97      + 1 - 8       14.2 837
SEOUL    0   4  6  2 58,8     66  52                    30.6 620
INCHEO   0   4  6  2 59,4     20  34      +   -   +     33.8 630
-----------------------------------------------------------------
```

```
1936 JULY  4 16 42      I=1 HADONG
-----------------------------------------------------------------
```

```
1936 JULY  4 20 40      I=1 HADONG
-----------------------------------------------------------------
```

```
1936 JULY  5 13 55      I=2 HADONG
1936 JULY  5 13 55      I=1 HANYANG
-----------------------------------------------------------------
```

```
1937 JAN. 25  4  0  LONG= 126.7  LAT= 37.7  H=SFC  M=3.7  ACR=A
                    #####NEAR GEUMCHON               #####
ST.      I      P TIME          MAN MAE MAZ PAN PAE PAZ  S-P F-P
             D  H  M   S                                  S   S
SEOUL    2  25  4  0 21,5                 +10 -18        5.3  90
INCHEO   1  25  4  0 22,9     13  27      +   -   +      4.5 107
PYONGY   0  25  4  0 42,8                               21.6 360
BUSAN    0  25  4  0                                    42.5 150
         I=3 JANGDAN  GAESEONG  PUNGDEOK
         I=2 UIJEONGBU  SEOUL  CHUNCHEON
         I=1 POCHEON  MUNSAN  GANGHWA  ANSEONG  YANGPYEONG
         I=1 INCHON  GIMPO  GAPYEONG  CHEOLWON  GIMHWA  EUNJANG
         REMARKS (EARTHQUAKE SOUND IN WIDE AREA)
-----------------------------------------------------------------
```

```
1937 MAR. 16  2 45  LONG= 125.8  LAT= 38.4  H=SFC  M=4.0  ACR=A
                    #####NEAR SARIWEON               #####
ST.      I      P TIME          MAN MAE MAZ PAN PAE PAZ  S-P F-P
             D  H  M   S                                  S   S
INCHEO   1  16  2 45 40,1     11  11      -   +   +     16.6  55
SEOUL    1  16  2 45 42,7      7   6                    17.6  69
BUSAN    0  16  2 46 30,7
TAEGU    0  16  2 46  8,0                               29.6 177
         I=3 SARIWEON
         I=2 HWANGJU  SINWEON  JAERYEONG  SINJU  EUNYUL  ANAG
         I=1 JINNAMPO  GWANGYANGMAN  YONGGANG  SINGYE
         I=1 SAMDEUNG  GANGHWA  GAESEONG
-----------------------------------------------------------------
```

```
1937 SEPT  8 22 59  LONG= 126.8  LAT= 37.5  H=SFC  M=2.7  ACR=A
                    #####BETWEEN INCHEON,SEOUL   #####
ST.      I      P TIME          MAN MAE MAZ PAN PAE PAZ  S-P F-P
             D  H  M   S                                  S   S
INCHEO   1   8 22 59 47,3                                2.8  38
SEOUL    0   8 22 59 47,5     10  10                     2.3  57
-----------------------------------------------------------------
```

```
1937 SEPT                                            M = 2.6
ST.      I      P TIME          MAN MAE MAZ PAN PAE PAZ  S-P F-P
             D  H  M   S                                  S   S
INCHEO   0   8 22 40 56,5                                3.0  28
SEOUL    0   8 22 40 57,9                                1.5  46
-----------------------------------------------------------------
```

```
1938 JAN. 28 14 20  LONG= 127.2  LAT= 37.5  H=SFC  M=2.7  ACR=B
                    #####22KM SE OF SEOUL            #####
ST.      I      P TIME          MAN MAE MAZ PAN PAE PAZ  S-P F-P
             D  H  M   S                                  S   S
SEOUL    0  28 14 20 57,9      3   5      + 1 - 1        2.6  60
-----------------------------------------------------------------
```

```
1938 FEB.                                            M = 3.0
ST.      I      P TIME          MAN MAE MAZ PAN PAE PAZ  S-P F-P
             D  H  M   S                                  S   S
INCHEO   0  18 14 27 32,6                               13.8  55
SEOUL    0  18 14 27 33,2                               11.5  60
-----------------------------------------------------------------
```

```
1938 AUG. 22  9 46  LONG= 127.8  LAT= 35.0  H=SFC  M=5.2  ACR=A
                    #####NEAR HADONG                 #####
ST.      I      P TIME          MAN MAE MAZ PAN PAE PAZ  S-P F-P
             D  H  M   S                                  S   S
TAEGU    1  22  9 46 44,3                               13.2 259
CHUPUN   1  22  9 46 45,6     69 121                    13.1 135
BUSAN    0  22  9 46 46,9                               14.5 150
IZUHAR   2  22  9 46 57,4                     -12       21.5 270
SEOUL    0  22  9 47  6,2     32  45                    34.9 175
INCHEO   0  22  9 47 11,4                               32.0 145
NAGASA   0  22  9 47 23,9                               36.1 240
KUMAMO   0  22  9 47 31,6                               42.0 226
-----------------------------------------------------------------
```

```
1939 JAN. 10 10  4  LONG= 127.3  LAT= 36.5  H=SFC  M=4.6  ACR=A
                    #####NEAR GONGJU                 #####
ST.      I      P TIME          MAN MAE MAZ PAN PAE PAZ  S-P F-P
             D  H  M   S                                  S   S
INCHEO   1  10 10  4 20,6     14  18      + 4 - 2 + 4   14.6
SEOUL    2  10 10  4 20,9     30  36      +   -         15.0 325
TAEGU    0  10 10  4 26,0                               17.3 694
CHUPUN   0  10 10  4         120  60                    10.2 218
BUSAN    0  10 10  4                                    26.2 120
IZUHAR   0  10 10  4                                    35.9
         I=3 PYEONGTAEG  YANGPYEONG  JANGHOWEON  SUWEON
         I=2 INCHON  YEONGBUK  GWANGJU  IN  GYEONGGI-DO
         I=2 SUWEON  GEUMWANGSEONG
         I=1 ANSEONG  EUIJEONGBU
-----------------------------------------------------------------
```

```
1939 JAN. 23  9 55  LONG= 126.5  LAT= 37.1  H=SFC  M=3.7  ACR=A
                    #####SW OF NAMYANG-MAN(BAY)  #####
ST.      I      P TIME          MAN MAE MAZ PAN PAE PAZ  S-P F-P
             D  H  M   S                                  S   S
INCHEO   1  23  9 55 32,9     13  27                     6.0  90
SEOUL    0  23  9 55 34,9      1   1                     9.3 120
CHUPUN   0  23  9 55 50,4                               18.8 240
BUSAN    0  23  9 56 32,5                                     40
TAEGU    0  23  9 56 29,1                                    151
-----------------------------------------------------------------
```

```
1939 JUNE 26 15 43  LONG= 125.8  LAT= 39.1  H=SFC  M=3.2  ACR=C
                    #####AROUND PYEONGYANG           #####
ST.      I      P TIME          MAN MAE MAZ PAN PAE PAZ  S-P F-P
             D  H  M   S                                  S   S
PYONGY   1  26 15 43          10                         4.8  90
-----------------------------------------------------------------
```

```
1939 JULY  4 15  1  LONG= 126.6  LAT= 37.4  H=SFC  M=2.5  ACR=B
                    #####AROUND INCHEON              #####
ST.      I      P TIME          MAN MAE MAZ PAN PAE PAZ  S-P F-P
             D  H  M   S                                  S   S
INCHEO   0   4 15  1 48,3                                2.4  30
-----------------------------------------------------------------
```

```
1939 AUG.  2 19 47  LONG= 129.6  LAT= 35.7  H= 10  M=3.8  ACR=A
                    #####30KM NE OF ULSAN            #####
ST.      I      P TIME          MAN MAE MAZ PAN PAE PAZ  S-P F-P
             D  H  M   S                                  S   S
BUSAN    0   2 19 47  5,4                               10.1 100
TAEGU    1   2 19 47  9,6                               11.8  86
CHUPUN   0   2 19 47 19,7                               17.9 100
SEOUL    0   2 19 48 11,9                                     60
INCHEO   0   2 19 48 23,2                                9.6 180
IZUHAR   0   2 19 47 27,7                               19.2 170
         I=3 POHANG
         I=2 GYEONGJU
         I=1 ULSAN
-----------------------------------------------------------------
```

```
1939 AUG. 31 14  8  LONG= 127.2  LAT= 36.4  H=SFC  M=4.6  ACR=A
                    #####NEAR GONGJU                 #####
ST.      I      P TIME          MAN MAE MAZ PAN PAE PAZ  S-P F-P
             D  H  M   S                                  S   S
INCHEO   1  31 14  8 15,0                               15.8  80
SEOUL    1  31 14  8 16,3     38  46                    16.4 215
TAEGU    1  31 14  8 16,7                               15.5 175
BUSAN    0  31 14  8 29,3                               26.2 130
CHUPUN   1  31 14  8  8,0    180  65                    10.6 377
         I=3 JEONJU
-----------------------------------------------------------------
```

```
1939 SEPT 22 19 34  LONG= 128.6  LAT= 35.9  H=SFC  M=3.6  ACR=B
                    #####AROUND DAEGU                #####
ST.      I      P TIME          MAN MAE MAZ PAN PAE PAZ  S-P F-P
             D  H  M   S                                  S   S
TAEGU    1  22 19 34 25,8                                    112
-----------------------------------------------------------------
```

```
1939 SEPT 22 21  8  LONG= 129.0  LAT= 35.1  H=SFC  M=2.6  ACR=B
                    #####AROUND BUSAN                #####
ST.      I      P TIME          MAN MAE MAZ PAN PAE PAZ  S-P F-P
             D  H  M   S                                  S   S
BUSAN    1  22 21  8 27,2                                1.8  34
-----------------------------------------------------------------
```

```
1939 SEPT 24 11 35  LONG= 129.0  LAT= 35.1  H=SFC  M=2.4  ACR=B
                    #####AROUND BUSAN                #####
ST.      I      P TIME          MAN MAE MAZ PAN PAE PAZ  S-P F-P
             D  H  M   S                                  S   S
BUSAN    0  24 11 35 38,1                                2.3  27
-----------------------------------------------------------------
```

```
1939 UCT. 22 20  4  LONG= 129.3  LAT= 36.0  H= 10  M=3.5  ACR=A
                    #####10KM SW OF POHANG          #####
ST.        I    P TIME          MAN MAE MAZ PAN PAE PAZ  S-P F-P
              D  H  M    S
TAEGU      1  22 20  4 36,0                                S    S
BUSAN      0  22 20  4 41,0                              8.8   57
SEOUL      0  22 20  5 47,6                              8,5   66
IZUHAR     0  22 20  5 57,6                                   120
CHUPUN     0  22 20  5 36,7                             23,7
                                                              120
-----------------------------------------------------------------
```

```
1940 MAR, 31 15 56  LONG= 129,0  LAT= 37.6  H= 10  M=3,5  ACR=A
                    #####15KM S OF GANGNEUNG        #####
ST.        I    P TIME          MAN MAE MAZ PAN PAE PAZ  S-P F-P
              D  H  M    S
SEOUL      0  31 15 56 12,8                                S    S
TAEGU      0  31 15 56                                  21.1  118
INCHEO     0  31 15 56                                  23,6   72
           I=3 CHUNCHEON                                24,4   80
           I=2 GANGREUNG
-----------------------------------------------------------------
```

```
1940 MAY  15 15 28  LONG= 127,1  LAT= 37.6  H=SFC  M=2,2  ACR=C
                    ####AROUND SEOUL                #####
ST.        I    P TIME          MAN MAE MAZ PAN PAE PAZ  S-P F-P
              D  H  M    S                               S    S
SEOUL      0  15 15 28 20,8       2   2                 4,8   13
-----------------------------------------------------------------
```

```
1940 UCT,  8 19 46  LONG= 126,4  LAT= 36.0  H=SFC  M=6,4  ACR=B
                    #####50KM OFF COAST OF GUNSAN#####
ST.        I    P TIME          MAN MAE MAZ PAN PAE PAZ  S-P F-P
              D  H  M    S
INCHEO     0   8 19 46 22,9                                S    S
BUSAN      0   8 19 46 36,4                             20.5  360
TAEGU      0   8 19 47  6,9                             32.6  280
NAGASA     0   8 19 47 45,7                             20.8  100
KUMAMO     0   8 19 48  1,7                             18.6  120
MIYAZA     0   8 19 48  9,6                                   298
                                                        29.5  170
-----------------------------------------------------------------
```

```
1940 OCT. 22 23 18  LONG= 128.2  LAT= 36.1  H=SFC  M=3.4  ACR=A
                    #####38KM NW OF DAEGU           #####
ST.        I    P TIME          MAN MAE MAZ PAN PAE PAZ  S-P F-P
              D  H  M    S
CHUPUN     0  22 23 18 45,3                                S    S
TAEGU      0  22 23 18 45,1                              3,9   91
                                                         4,8   68
-----------------------------------------------------------------
```

```
1940 OCT.                                               M = 2.3
ST.        I    P TIME          MAN MAE MAZ PAN PAE PAZ  S-P F-P
              D  H  M    S
SEOUL      0  23 16 35 38,0                                S    S
                                                         9,4   20
-----------------------------------------------------------------
```

```
1940 NOV,                                               M = 3.6
ST.        I    P TIME          MAN MAE MAZ PAN PAE PAZ  S-P F-P
              D  H  M    S
TAEGU      0   5 15  8 59,7                                S    S
                                                         4,4   98
-----------------------------------------------------------------
```

```
1941 APR, 13  4 51  LONG= 128,8  LAT= 35,6  H=SFC  M=3,1  ACR=A
                    #####35KM SSE OF DAEGU          #####
ST.        I    P TIME          MAN MAE MAZ PAN PAE PAZ  S-P F-P
              D  H  M    S
TAEGU      1  13  4 51  1,1     11   4                     S    S
BUSAN      0  13  4 51  4,5                              4,4   73
                                                         7,5   68
-----------------------------------------------------------------
```

```
1941 APR.                                               M = 2.8
ST.        I    P TIME          MAN MAE MAZ PAN PAE PAZ  S-P F-P
              D  H  M    S                                 S    S
CHUPUN     0  13  5 26 24,2                             16.4   42
-----------------------------------------------------------------
```

```
1942 AUG.                                               M = 2.7
ST.        I    P TIME          MAN MAE MAZ PAN PAE PAZ  S-P F-P
              D  H  M    S                                 S    S
TAEGU      0  27  4 21 15,7                                    39
-----------------------------------------------------------------
```

```
1942 OCT.  7  9  4  LONG= 128,8  LAT= 36.3  H=SFC  M=4,5  ACR=A
                    #####25KM S OF ANDONG           #####
ST.        I    P TIME          MAN MAE MAZ PAN PAE PAZ  S-P F-P
              D  H  M    S                                 S    S
CHUPUN     0   7  9  4 30,9     88                       9,4   30
TAEGU      3   7  9  4 55,6          8      +12 +18      8,3  168
SEOUL      0   7  9  5  8,8     18  13                  25,3  120
INCHEO     0   7  9  5 16,7                             28,3  180
IZUHAN     0   7  9  5 14,0                             29,8  139
-----------------------------------------------------------------
```

```
1942 NOV.                                               M = 2.5
ST.        I    P TIME          MAN MAE MAZ PAN PAE PAZ  S-P F-P
              D  H  M    S                                 S    S
INCHEO     1  24 20 11 21,8     11  12  11               2,5   22
-----------------------------------------------------------------
```

```
1942 NOV, 24 20 23  LONG= 126.6  LAT= 37,5  H=SFC  M=2,3  ACR=A
                    #####NEAR INCHEON               #####
ST.        I    P TIME          MAN MAE MAZ PAN PAE PAZ  S-P F-P
              D  H  M    S                                 S    S
INCHEO     0  24 20 23 37,4     19  35  21               1,6   18
-----------------------------------------------------------------
```

```
1943 JAN.  4  6 40  LONG= 129,5  LAT= 36.1  H=SFC  M=3.0  ACR=B
                    #####AROUND POHANG              #####
ST.        I    P TIME          MAN MAE MAZ PAN PAE PAZ  S-P F-P
              D  H  M    S
TAEGU      0   4  6 40                                     S    S
CHUPUN     0   4  6 40                                  11.0   48
           I=2 POHANG                                          64
-----------------------------------------------------------------
```

```
1943 MAY                                                M = 2.1
ST.        I    P TIME          MAN MAE MAZ PAN PAE PAZ  S-P F-P
              D  H  M    S                                 S    S
INCHEO     0  16 18  4  1,7                              7,5   20
-----------------------------------------------------------------
```

```
1943 MAY                                                M = 2.0
ST.        I    P TIME          MAN MAE MAZ PAN PAE PAZ  S-P F-P
              D  H  M    S                                 S    S
INCHEO     0  16 18 40 13,0                                    17
-----------------------------------------------------------------
```

* Time : KST (GMT+9hrs)   LONG : E, LAT : N

H : Depth in Km   SFC : very shallow (h<40)

Max. Amplitude in micron   Initial P motion

MAN : N–S component   PAN : N(+) S(−)

MAE : E–W component   PAE : E(+) W(−)

MAZ : Z component   PAZ : U(+) D(−)

S–P : Arrival Time difference between S–& P–wave in sec.

F–P : Total duration of oscillation in sec.

ACR : Error range of epicenter locating.

A = Error less than 10Km

B = 10≤Error<20Km

C = 20≤Error<30Km