Jour. Kor. Inst. Mining Geol.
vol., 11, No. 2, 1978 pp. 69—80

Seismicity of the Korean peninsula and its Relation with plate tectonics

So Gu Kim* · Byung Koo Hyun**

Abstract

The seismicity of the Korean peninsula (2A. D.-1977) is investigated temporally and spatially to estimate seismic hazard zones in the Korean peninsula, based on macroseismic data from description of the historical literature and reported data by JMA, ERI, World Data Center-A, and ISC.

The contemporary seismicity of the Korean Peninsula is found to be low as compared to the past, and also surrounding Japan and China. Korean seismicity was considerably active the 13th century through the 17th century even though it is relatively calm in the temporal seismic gap. The Korean peninsula is also a region of less stress accumulation due to the tension axis from sea-floor spreading in and near the peninsula and release of seismic energy not only at the hinge of subduction in the Japanese Island Arc, but also at the block edge of the Pacific Marginal Tectonic Domain in the Chinese continent.

I. Introduction

The fundamental objective of seismology is to study the temporal and spatial seismicity and their characteristics. Moreover the investigation of seismicity will yield not only basic knowledge of plate tectonic process, but also all the geophysical phenomena associated with it.

One usually says that Korean peninsula belongs to the quiet seismicity, but it is not true. For we can find the fact that throughout the history many distructive earthquakes destroyed human lives and properties. It is, however, true that the contemporary seismicity of the Korean peninsula is found to be low as compared to the past, and to the surrounding Japan and mainland China.

The study of seismicity in the Korean peninsula well be related to the basic and applied research in the earthquake resistant-design for hi-rise buildings, ports, bridges, submerged tunnels, and neuclear power plants. In addition to understanding plate tectonics in the Far East, the investigation of seismicity will assist to track migration, accumulation, and distribution of mineral sources dependent upon the system of plate tectonics.

II. Data and Analysis.

The seismological data in Korea can be classified as two groups-historical earthqu-

---

* ** Korea Research Institute of Geoscience and Mineral Resources, Seoul, Korea

akes obtained from the historical literature and instrumental earthquakes reported by worldwide seismological observatories.

The historical earthquakes begin from 2 A.D. to 1904, and the instrumental earthquakes are obtained from 1905 to 1977. In addition to the data which Wada (1952) and Musha(1949) extrated, we obtained the reported data from the following Data Center or Research Institute:

1) JMA (Japan Meteorological Agency)
2) ERI(Earthquake Research Institute, Univ. of Tokyo)
3) ISC (International Seismological Centre, England)
4) NEIC (National Earthquake Information Center, USA)

In order to study the spatial distribution of earthquakes, we divided the Korean peninsula into 70 meshes of 1°×1° mesh in the ranging 33°~43°N and 124°-131°E.

Since the only media of communication is decent upon the distribution of population in the ancient times, it is difficult to determine the exact epicenter, but it is possible to locate the approximate epicenter judging from the degree of damage within 1°×1° mesh.

It is also hard to determine the intensity of the historical earthquakes since the structure of the ancient architecture used to be weak and the occurrence of the destructive earthquake used to be interpreted as the punishment to the King or people due to His or their sins and then the damages of those earthquakes were discribed in exaggeration. The estimation of intensity describing the degree of demage was determined in JMA scale by the damage of properties and human lives described at that time. Another difficult problem to analyze historical earthquakes was to identify two more different events on the same day, which were easily considered as the same events. The more probable epicenters of these events were discriminated by information of the damage within the mesh (1°×1°) on the map.

In order to determine magnitude of the earthquake, which describes the energy or size of the event, it is necessary to read seismograms, but the magnitudes of the historical earthquakes were uniformly determined from the empirical formulae of intensity-magnitude such as the following procedures:

(A) It is usually reliable to determine magnitudes from various seismograms and there are serveral formulae. Gutenburg (1945) determined body wave magnitnde from a few cycles of the first arrivals of P waves as follows:

$$m_b = \mathrm{Log}\frac{A}{T} + Q\ (\Delta,\ h) \cdots\cdots\cdots\cdots\cdots\cdots\cdots (1)$$

,where A=max. amplitude (μ)

T=period (sec)

Q(Δ, h)=caliberation function depending upon epicentral distance (Δ) and depth (h), tabulated on Richter (1958). Surface wave magnitudes in the near field (Nattli and Kim, 1975) and the far field (Bäth, 1969) are derived as follows:

$$M_s = \mathrm{Log}\left(\frac{A}{T}\right) + 1.07\ \mathrm{Log}\Delta + 4.16\ (10° \leq \Delta \leq 30°) \cdots\cdots\cdots\cdots (2)$$

$$M_s = \mathrm{Log}\left(\frac{A}{T}\right) + 1.66\ \mathrm{Log}\Delta + 3.30\ (25° \leq \Delta \leq 140°) \cdots\cdots\cdots (3)$$

where A is the max. amplitude (μ) at period of 20 seconds in Rayleigh Waves or Love Waves. In order to determine magnitude, Japanese seismologists always employ the modified Tauboi's formual for shallow-focuss earthquakes($h \leqq 60$Km) since 1954 due to the big differences between magnitudes determined from the past and the present.

$$M=1.73\ \mathrm{Log}\ D+\mathrm{Log}\ A-0.83 \cdots\cdots\cdots (4)$$

,where D is the epicentral distance (km), and A is maximum amplitude of the horizontal component ($\sqrt{NS^2+EW^2}$).

This magnitude is equivalent to the revised magnitude of Richter (1958). Revised magnitude is associated with m_b and M_s as follows:

$$M=\frac{1}{4}M_s+\frac{3}{4}(1.59m_b-3.97),\quad (h\leq 40\mathrm{km}) \cdots\cdots\cdots (5)$$

$$M=1.59m_b-3.97,\ (40\leq h\leq 60\mathrm{km}) \cdots (6)$$

(B) The magnitued of earthquakes is also determined by felt area. Nuttli and Zollweg (1974) derived a formula in relation to felt area in the mid-west of the United States.

$$M=2.65+0.98\ f+0.054\ f^2 \cdots\cdots\cdots (7)$$

,where $f=\mathrm{Log}(\pi R^2)$

R=radius of the felt area (km)

(C) Magnitudes of earthquakes are also determined by inferring the isoseismal maps of the earthquakes (T. Utsu, 1956)

$$M=0.5\ I_J\ (D)+2.30\ \mathrm{Log}\ D+0.00083D+0.16 \cdots\cdots\cdots (8)$$

,where I_J is the intensity of JMA and D is the epicentral distance (km). Gupta and Nattli (1976) found that maximum ground motion is due to high-msde surface waves ($D\leq 25$Km) except for the epicenter when the earthquake occurrs. Therefore we often acknowledge that the intensities from the historcal data are away from the epicenter than at the very epicenter.

It is reasonable to use this formula beyoun 25km of the epicentral distance ($I_J\geq 3$).

(D) Finally, we can determine magnitude of the earthquake if we know the intensity at the epicenter (I_o).

$$M=1+\frac{2}{3}I_o,\quad I_o=1.5I_J+0.5 \cdots\cdots\cdots (9)$$

Among the above techniques, the method (A) is the most reliable and the method (D) is the most unreliable. The magnitude determination from seismograms allow the confidential level $\pm\frac{1}{4}$unit, but the other method will be larger than these values(≤ 1).

We should take into account energy released by earthquakes besides magnitude and intensity. Its relation is given by Gutenberg and Richter (1956).

$$\mathrm{Log}\ E=1.5M+11.8\ (\mathrm{ergs}) \cdots\cdots\cdots (10)$$

In probabilistic study(an a posterioristudy) of earthquake engineering. it is important to estimate magnitude and return period of the future destructive earthquakes. The recurrence rate of magnitude M or greaten earthquake during t years in a certain district

$$N\ (M,t)=\frac{r(M)}{T}t \cdots\cdots\cdots (11)$$

,where $\frac{n(M)}{T}$ is average frequency per annum of M or greater earthquake in a certain district. T is the total year of study.

III. Seismicity and Seismotectonic provinces.

The seismicity of Korean can be explained into three regions according to the characteristics of earthquakes and the attenuation of elastic waves. As shown on Fig. 1, it is convnient to describe the seismicity by dividing the Korean peninsula into NE Seismotectonic province, W Seismotectonic province, and SE Seismotectonic province. In the N.E Seismotectonic province, two deep-focus earthquake zones, Kuriles-Kamchatka-Honshu zone of a fast descent (7.5 cm/yr.) and Izu-Bonin-Marianas zone of a slow descent (1.2cm/yr.) join near 42° N and 130° E in the Sea of Japan (Toksoz, 1975). They coexist of one continuous system of the Pacific Plate, but of discont-

Tab. 1 Destructive Earthquakes.

Century	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Eq.	3	2	0	2	2	2	1	2	0	0	2	0	3	2	2	8	12	2	0	4

inuity for the distribution of earthquakes. Earthquakes occurred in this province are not interpreted as destructive earthquakes because of their deep-focus earthquakes (300≤h≤700km). The earthquakes occrred in W or SE Seismotectionic provinces, however, are referred to frequent destructive earthquakes owing to their shallow-focus earthquakes (h≤60km).

The seismicity of the Korean peninsula was active the 13th century through the 17th century for about 400 years, and it became quite in the beginning of the 18th century (see, Tab. 1). This agrees not only with the global seismicity (Personal Communication with T. Usami), but also with the last volcanic eruption of 1668, 1702 and 1724. Consequently we believe that the tectonic activity was most active during the period 13-14th century.

Fig. 2 shows occurrence-frequencies of earthquakes within 1°×1° mesh. We note that the most occurence-frequencies appear in Seoul and Gyunggi district and next Gyungnam and Chonra district. And we also understand that Gaema plateau of Hamnam district is very stable. Taking into account the special distribution of destructive earthquakes for the pariod 2AD-1977, we see that the highest seismic zones are R_1 district(Gyungam and Chonra region)

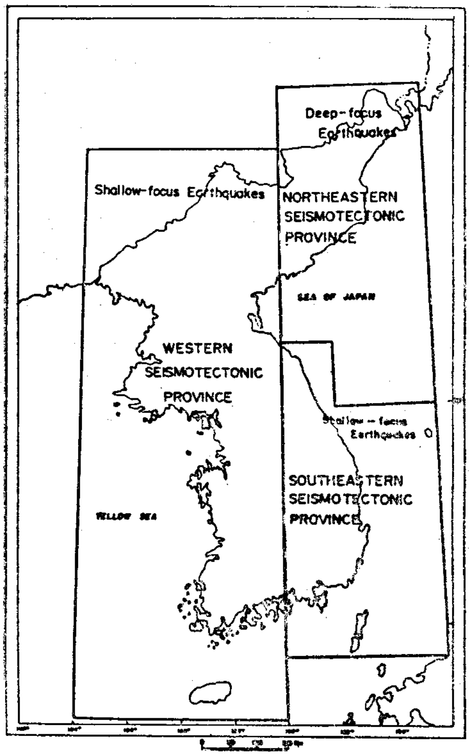

Fig. 1. Seismotectonic provines of the Korean peninsula.

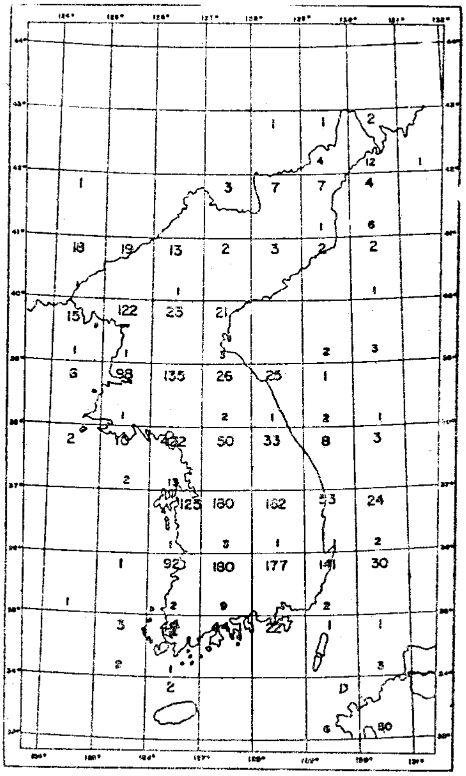

Fig. 2. Frequency distribution of earthquakes for the period 2AD-1977. Upper and lower numbers indicate the period 2-1904 and 1905-1977, respectively.

and next R_3 (Gyunggi and Seoul region), the lowest R_7 (Pyongbug) and R_8 (Hamnam) (See Figure 3). This has an agreement with study of Rustanovich *et al.* (1961) It is, however, unreasonable to dudge that the seismicity in Seoul and Gyungsang region were very active only with this study, for these regions kept the ancient historical culture safely without being invaded by foreign powers, and for the media of communication was enough available owing to the dense population in the ancient time. From Tab. 2, the energy released by earthquakes per annum is about 10^{19} ergs, which is much lower than that by the global earthquakes per annum($9\times lo^{24}$ergs). This proves that the seismicity of the Korean peninsula is below the average of the world. The expected magnitude for a return period 100 years is 7.26 in R_9 district, which is the largest magnitude. However, we do not consider this earthquake as a destructive earthquake because earthquake occurred in this district are deep focus earthquakes. Consequently, the highest seismic risk zones are R_2 and R_3 districts of 5.26 and 5.54 respectively, and the lowest R_7 and R_8 districts of 42.4 years and 52.6 years are shortest, except for R_9 district of 6 years, those for R_7 and R_8 districts of 490 years and 1316 years are longest. These findings are probabilistic result inferring

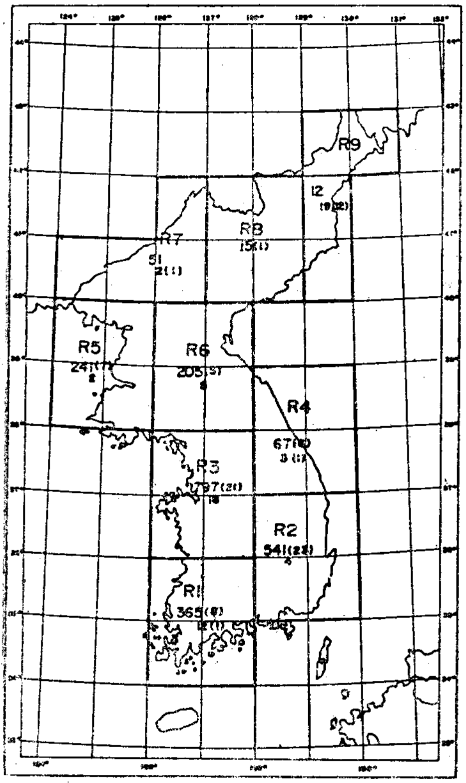

Fig.3. Seismic hazard zones in the Korean peninsula. Upper and lower numbers are the total number of earthquakes for the period 2-1904 and the period 1905-1977, respectively. Numerals in the parentheses are the total number of major earthquakes in both cases.

Tab. 2. Probable magnitude, return period, energy, and frequency of major earthquakes.

Rei-gn	Magnirude	Return peirod(yr)	* Energy per annum(erg)	Frequency of major earthquakes *
R_1	5.00	68.9	5.82×10^{19}	8
	5.32	100	5.24×10^{19}	1
R_2	5.00	42.4	1.32×10^{19}	23
	5.62	100	1.02×10^{15}	0
R_3	5.00	52.6	1.32×10^{19}	21
	5.54	100	5.40×10^{16}	0
R_4	5.00	202	2.89×10^{19}	6
	4.20	100	6.12×10^{18}	1
R_5	5.00	96.2	6.13×10^{18}	7
	5.04	100	3.57×10^{16}	0
R_6	5.00	187	2.29×10^{18}	5
	4.52	100	6.85×10^{14}	0
R_7	5.00	490	1.65×10^{18}	0
	3.44	100	1.15×10^{20}	1
R_8	5.00	1316	4.66×10^{16}	1
	2.34	100		0
R_9	5.00	6	$1\ 12\times10^{15}$	0
	7.26	100	1.92×10^{21}	12

* Upper and lower values indicate duration for the period 2-1904 and 1905-1977, respectively.

from an a posterior knowledge.

Microearthquakes of earthquake swarm were observed at Sangwon, Pyongnam form September 6, 1565 to January 26, 1566 and sometimes its recurrence frequency reached 23 times a day. The similar earthquake swarm was also observed in Seoul district the 18th century through the 20th century.

According to the present model study of the earthquake swarm (David, 1977), the earthquake swarm is believed to occur at the transition zone between center of spreading and transform fault.

Sangwon of the high microseismicity like Ganghwa, Seoul, and the southern part of Hwanghae may be attributed to a transition zone between centers of spreading and transform faults that are not discovered yet. This transition zone may be probably initiated along the Chungaryung rift valley stretched from Seoul to Wonsan and also postulates the starting point of sea-floor spreading in the Sea of Japan.

Major earthduakes of the Korean peninsula occurred at W Seismotectonic province (Ssanggye-sa earthquake of July 4, 1936 and Sariwon earthquake of March 7, 1937). Especially Ssanggye-sa earthquake occurred near Mt. Chiri is the largest earthquake which gives the most reliable information on the earthquake in the recent time. The isoseismal maps for Ssanggye-sa and Sariwon earthquake are drawn from the reported data at that time on Fig. 4 and 5. The radiation patterns of energy are stretched in the NW-SE direction and the pressure axes of these two earthquake are considered in the NW-SE direction.

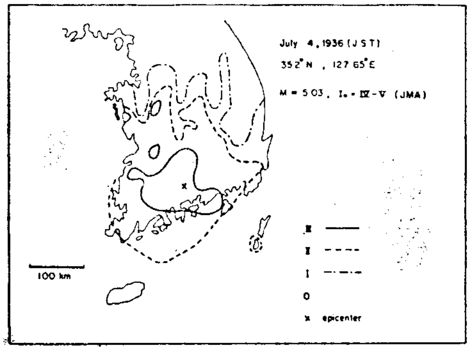

Fig. 4. Isoseismal map of Ssanggye-sa earthquake

It is found that some earthquakes within the Eurasian continent are intraplate earthquakes of small source dimension, and most of earthquakes in the plate boundary of the New Hebrides Islands are interplate earthquakes of large source dimension (Kimand Nuttli, 1977). If we also intreprete the characteristics of the Korean earthquakes in the light of geometrical distribution for seismicity in the Far East, it is probable to presume that earthquakes in W and SE Seismotectonic provinces are intraplate earthquakes and NE. Seimotectonic province, interplate earthquakes. It is, however, necessary to investigate further with seismograms in time and frequency domain in order to verify these characteristics of earthquakes.

IV. Plate tectonics of the Korean peninsula

The Korean peninsula is located at the east of Sino-Korean paraplatform and belongs to the Mesozoic Belt of the Marginal Pacific Tectonic Domain. This Mesozoic Tectonic Belt consists of uplifting and depression trending toward NE or NNE which are formed of fold, fault, pacific type volcanics, and granitoids intrusion. Consequently the tectonic line of NE or NNE is coincident not only with series of roughly parallel uplift and down-faulted through striking NE-SW in the average in the northeastern China, but also with mountains

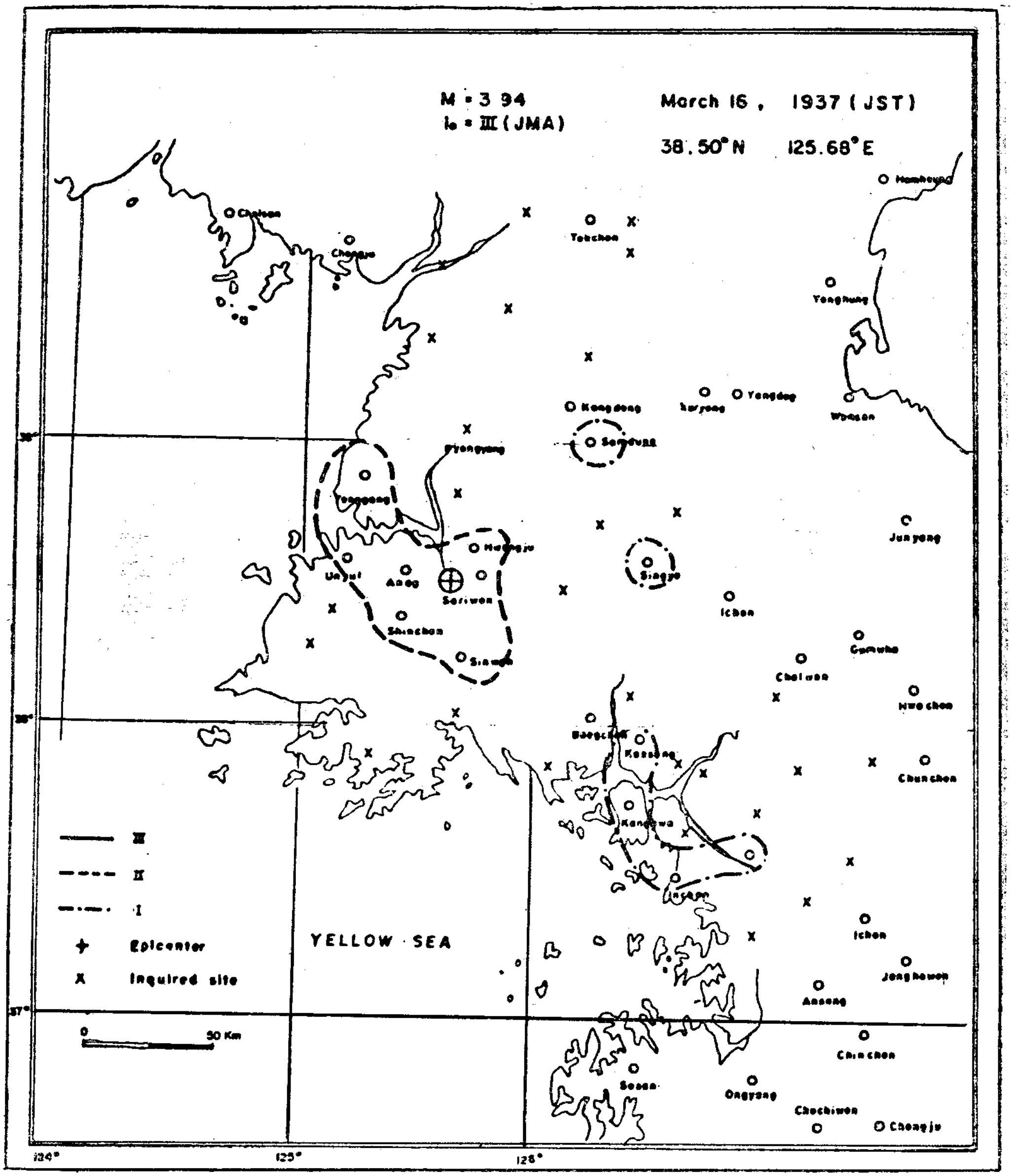

Fig. 5. Isoseismal map of Sariwon earthquake

in the Korean peninsula trending toward NE or NNE. The uplifting of the eastern part in the Korean peninsula trending toward NE or NNE comes from the dynamic force of the underthrusting Pacific plate facing E-W (See Fig. 6) or the Philippine plate moving NW. The focal mechanism studies of earthquakes occurred in Manchuria (Inouye, 1971) and sea of Japan (Ichigawa, 1971) indicate that their hypocenter are subjected to pressure on the NE-SE side and tension on the NW-SW side.

It is possible to regard the uplift of the east coast and submergence of the west coast as tectonic origin. Especially what is more important is that the Japanese Island was drifted toward east or southeast sometime in Mesozoic and Tertiary. The Sea of Japan was a shallow basin in late Tertiary and abrupt subsidence occurred in Quarternary and early Tertiary. Taking into account high heat-flow, 2.22±0.53 s.d. HFU in the Sea of Japan (Uyeda and Vacquier, 1968), the origin of the Sea of Japan is interpreted by speculation sea-floor spreading that the Japanese Islands moves away from the Asian Contient. At the same time, the crust and upper mantle are kept braking and sinking into the mantle, taking remodeling process sinking the crust. The Sea of Japan, therefore, is the disintegration of the Continental crust and the deep through belong to the suboceanic crust.

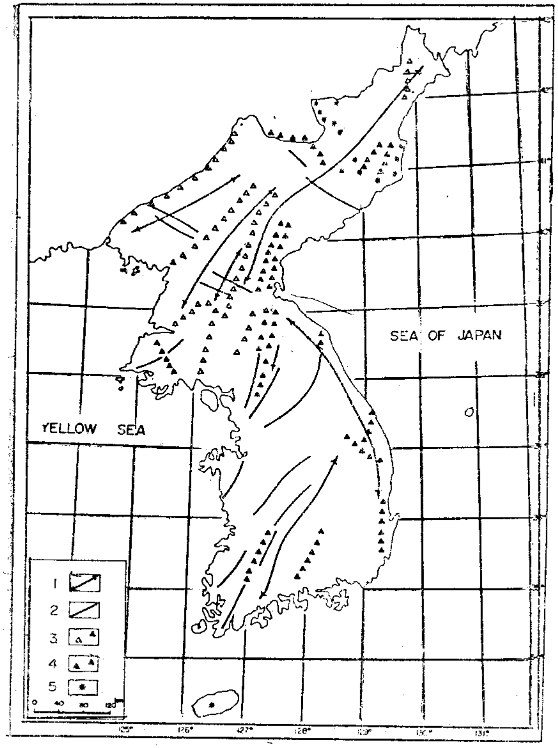

Fig. 6. Tectonic map of the Korean peninsula 1- axes of the Pliocene and Quarternary uplifiting; 2- the most important fault zones and faults of the Mesozoic; 3- ditto, but rejuvenated in the Cenozoic; 4- the most improtant Cenozoic fault zones and faults; 5- centers of volcanic eruptions

Yasui *et al.* (1967) investigated the total magnetic anomalies in the Sea of Japan and found that the lineation lies parallel to the NE direction in the southwestern Japan of 36°-44°N, coinciding with the regional planetary field and the tectonic line of the Korean peninsula. However it was found the lineation to be northsouth in the northeastern Japan. Since the magnetic lineation such as mid-Atlantic ridge has not been found, it is necessary to have further survey on magnetic anomalies to prove the seafloor spreading in the Sea of Japan.

The reason of very low seismicity in the east of the Korean peninsula is that the resistance against the plastic deformation of the crust is weak and such abyssal process has been completed. On the other hand, the west of the Korean peninsula or Yellow Sea is associated with the Quarternary submergence of Sino-Korean paraplatform and is just submerged like the Korean Strait

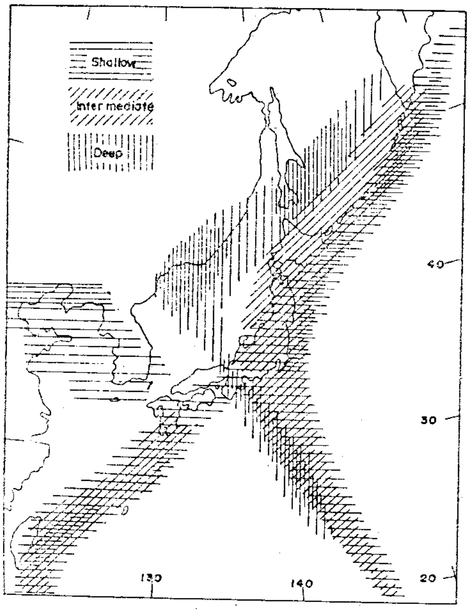

Fig. 7. Schematic map of seismic zones in the Far East (after Katsumata, 1970)

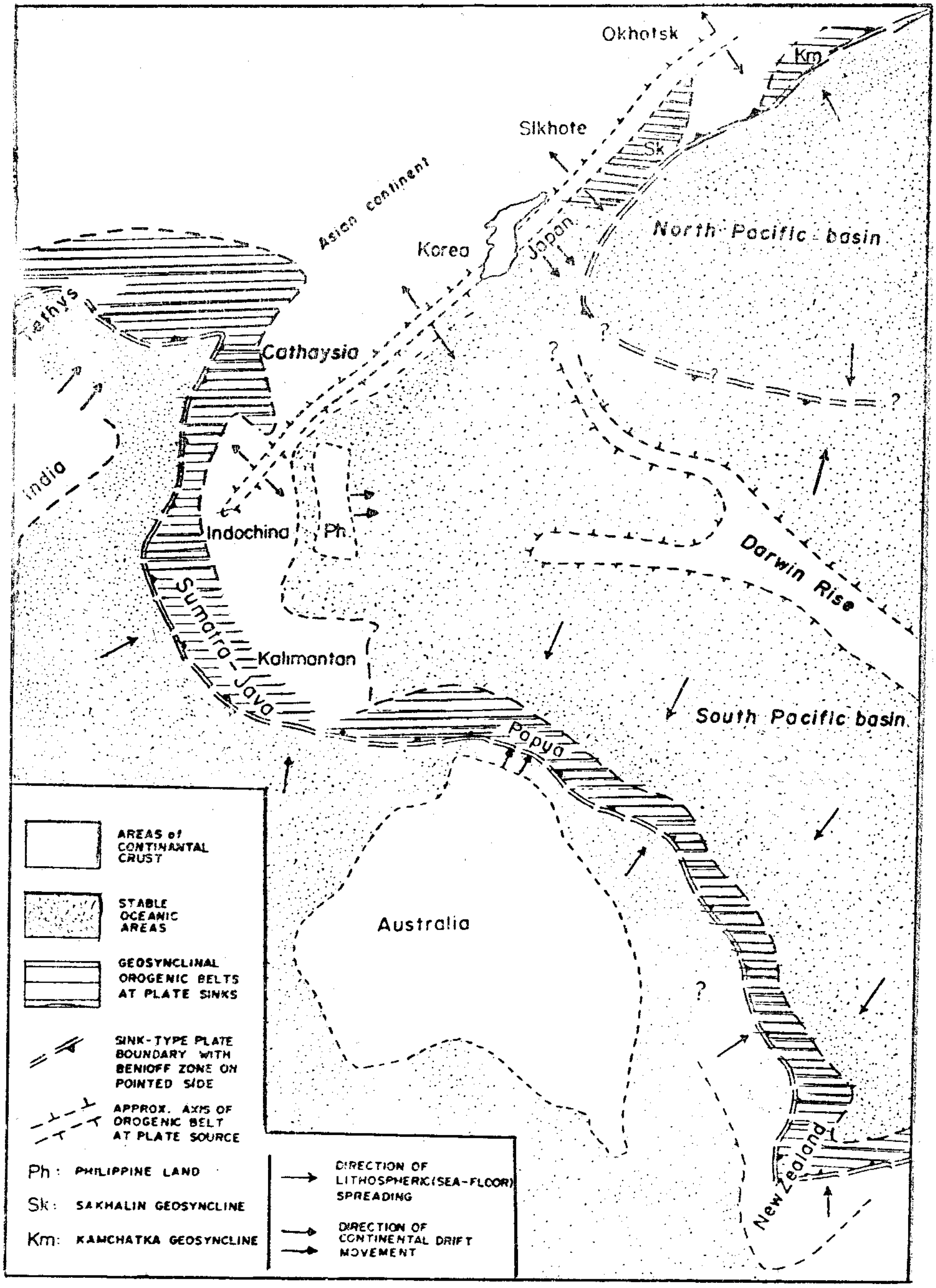

Fig.8. Tectonic map of the Southeast Asia.(after Workman, 1972)

of in the south of the Korean peninsula. The reason of little high seismicity in these places is that the resistance against the plastic deformation of the crust is strong (Rustanovich *et al.*, 1967).

V. Discussion and Conclusion

The seismicity of the Korean peninsula can be explained as three regions such as NE., W., and SE., Seismotectonic provinces and their distributions are related to the seismicity of the Far East as shown on Fig. 7.

In the light of temporal distribution of earthquakes the seismicity of the Korean peninsula was active the 13th century through the 17th century and the contemporary seismicity is relatively calm, belonging to the seismic gap. The highest seismic risk zones are found to be R_1 district(Gyungnam and Chonra) and R_3 district (Gyunggi and Seoul) except for R_9 district (Hambug), and the lowest R_7 district (Pyongbug) and R_8 district (Hamnam). Since earthquakes of R_9 district are deep-focus earthquakes ($300 \leq h \leq 700$km), they are not considered as distructive earthquakes.

Since the Japanese Island Arc tends to separated slowly from the Asiatic continent from Sea-floor Spreading? Hypothesis, the upper mantle of the Korean peninsula would experience the plastic flow rather than the abrupt fracturing. The Korean peninsula like the Indochina peninsula belongs to the tension axis of spreading (see Fig. 8) and keep less stress accumulation. Consequently the seismicity of the Korean Peninsula is lower than the average seismicity of the globe.

Acknowledgments

One of authors (S.G.K.) is deeply indebted to professor T. Usami of University of Tokyo and Dr. M. Ichigawa of JMA for their supplying him with earthquake data of the Korean peninsula.

References

Bäth. M (1969), Handbook of magnitude determination, Seismological Institude, Uppsala, Sweden.

Ben-Avraham, Z. and S. Uyeda (1973), The evolution of the China basin and the Mesozoic plaeogeograph of Borneo. Earthand plantary Sci. Letters. vol. 18, pp. 365-376

David, P. H. (1977), A model for earthquake swarms, Jour. Geophys. Res. 82, pp. 1347-1352

Geller, R. J. and H. Kanamori (1977), Magnitude of great shallow-earthquakes from 1904 to 1952, Bull Seism. Soc. Am. 67, pp. 587-598

Gutenberg, B. and C. F. Richter (1956), Magnitude and energy of earthquakes, Annali di Geofisica 9, 1-15

Ichigawa, M. (1970), Relanalyses of mechanism of earthquakes which occurred in and near Japan, and statistical studies on the nodal plane solutions obtained, 1926-1968. Geopys. Mag., 35^m, pp. 207-273.

Inouye, W. (1971), Earthquakes in Manchuria: In geology and mineral resources of the Far East, edited by Tsuomu Ogura, vol. 3, Univ. of Tokyo press.

Manour Katsumata (1970), Seismicity and some related problems in and near the Japanese Island. 35 3, 4 72-142.

So Gu Kim and Otto W. Nuttli (1977), Spectral and magnitude characteristics of anomalous Eurasian-earthquaks, Bull. Seism. Soc. Am. 67, pp. 463-478

Musha, K. (1949) A chronological table of earthquakes, eruptions and other ordinary phenomena occurring in Japan and its adjacent areas, 520 B.C. to 1968 A.D. historical documents of earthquakes in Japan, The Mainichi Press, Tokyo.

Nettli, O. W. and S.G. Kim (1975), Surface wave magnitude of Eurasian earthquakes and explosions, Bull. Seism. Soc. Am. 65, 693-709

Nuttli, O. W. and J. E. Zollweg(1974), The relation between felt area and magnitude for central United States earthquakes, Bull. Seism. Soc. Am. 64, pp. 73-85

Richter, C. F. (1958), Elementary seimology W.H. Freemen Co, San Francisco, Calif. U.S.A.

Rustanovich, D.N.V.L. Masaitis, and H. S. Chon (1961), IZV Geophysics ser. pp. 1441-1463

Shirokova, E. I. (1959), Determination of the stresses effective in the foci of the Hindu Kush earthquakes, IZV. Acad. Sci. USSR Geophys. Ser. 10, pp. 1224-1225

Toksoz, M. N (1975), The subduction of the lithosphere. Sci. Am. 233, pp. 88-95

Utsu, T(1977) 地震學, 共立出版株式會社,

Gupta, I. N. and O.W. Nuttli (1976), Spatial attenuation of intensities of central U.S. earthquakes, Bull. Seirm. Soc. Am. 66, pp. 743-751

Uyeda, S. and vacquier, V. (1958), Geothermal and geomagnetic data in and around the Island Arc of Japan, in Knopoff, L, et al., editors, pp. 349-366 The crust and upper mentle of the Pacific area, Geophysics monograph 12, American Geophysical Union, Washington, D.C.

Wada, Y. (1912), Les tremblements de terre en Coree. Scientific memoirs of the meteorological observationsof the governmental general of korea, vol. II

Workman, R. (1972), The tectonic settingof the mesozoic granites of Korea, Jour. Geol. Soc. Korea, 8, pp. 67-76

APPENDIX

Major Earthquakes (I24, M25.0) in the Korean Peninsula.

Serial no	M-D-Y	H-M-S	Region	I(JMA)	M	Quality
1	27		Gwangju	5	6.08	C
2	34		Gyongju	5	6.08	C
3	89		Gwangju	5	6.08	C
4	100		Gwangju	5	6.08	C
5	123		Gyongju	5	6.08	C
6	304		Gyongju	4	5.40	C
7	304		Gyongju	5	6.08	C
8	458		Gyongju	5	6.08	C
9	471		Gyongju	5	6.80	C
10	501		Pyongyang	5	6.08	C
11	510		Gyongju	5	6.08	C
12	9-12-664		Gyongju	5	6.08	C
13	769		Gyongju	5	6.08	C
14	780		Gyongju	5	6.08	C
15	1002		Cheju	4	5.40	C
16	7-23-1036		Gaesong, Gyongju	5	6.68	B
17	11-05-1226		Gaesong	4	5.40	C
18	6-24-1260		Ganghwa	4	5.40	C
19	3-06-1298		Gaesong	5	6.08	C
20	11-12-1311		Gaesong	5	6.08	C
21	8-01-1385		Gaesong	4	5.40	C
22	5-23-1416		Andong, Chongdo Chungju, Danyang	4	6.21	B
23	1-23-1416		Gwangju, Goksong Namwon	5	6.68	B
24	7-02-1518		Baegchon, Gaesong Seoul	5	6.08	C
25	6-27-1546	16h	Seoul	4	5.40	C
26	6-30-1546		Pakchon, Kangso Sunghon, Unsan, Anju	5	6.46	B
27	7-04-1546		Ganghwa	5	6.08	C
28	3-02-1553		Gyongnam & Chunnam bd.	4	5.40	C
29	7-20-1594		Chonju, Hongsong (Chungnam)	4	6.68	B
30	2-21-1596	16h	Pyongchang, Chongsun (Gangwon)	4	6.21	B
31	10-08-1597	14h 18h 22h 24h	Samsu (Hambug)	4	5.40	C
32	3-07-1601	14h	Hayang, Taegu (Kyongbug) Yongdam (Chonbug)	4	5.40	C
33	3-19-1601		Songju	4	5.40	C
34	6-9-1643		Chinju,8Hypochen	5	6.68	B
35	7-24-1643		Taegu,Andong,Kimhae Kimhae, Ulsan	4	6.21	B
36	4-21-1662		Taehung	4	5.40	C
37	8-12-1664		Chonju, Chinan	5	6.08	C
38	7-31-1668		Cholsan	4	6.46	B

Serial no.	M-D-Y	H-M-S	Region	I(JMA)	M	Quality
39	10-08-1669		Phongyang, Sunan Sukchon	4	5.82	C
40	10-30-1670		Gosan (Chonbug) Gwangju Gwangjin, Sunchang	4	6.46	B
41	11-15-1670		Cheju-do	4	5.40	C
42	6-20-1681	4h	Gwangju, Hangsong,	4	5.40	C
		16h	Gangwon-do, Hwanghae-do	4	5.40	C
43	6-26-1681		Yangyang, (Gangwondo) Mt. Sorak Sinhung-sa, Samchuk, Pyongchang, Chongson	4	6.46	B
44	4-29-1700		Taegu, Chinju, Sachun	4	5.43	B
45	6-27-1727		Hamhung	4	5.33	D

Serial no.	M-D-Y	H-M-S	LAT(N)	LONG(E)	I	M	Quality
46	1-25-1905	02-11-	33.2	130.5	3	5.5	A
47	8-25-1905	09-46-45.0	43.0	129.0		6.75(PAS)[b]	A
48	3-14-1916	21-45-	33.0	130.9		5.3	A
49	7-31-1917	03-23-10.0	42.5	131.0		7.50(PAS)	A
50	2-9-1918	20-46-26.0	43.0	130 0		6.50(PAS)	A
51	12-18-1920	22-51	33.3	130.8		5.9	A
52	7-26-1923	23-27-60	43.0	130.0		5.75(PAS)	A
53	8-28-1924	23-50-36.0	33.5	131.0		6.0(PAS)	A
54	12-21-1928	23-17-	33.1	130.9		5.2	A
55	1-01-1929	16-40-	33.1	130.9		5.4	A
56	2-05-1930	13-28	33.5	130.3		5.1	A
57	3-25-1933	12-50-	33.0	130.9		5.0	A
58	7-14-1933	16-03-33.0	43.0	131.0		5.50(PAS)	A
59	7-24-1933	08-37-57.0	42.5	131.0		5.75(PAS)	A
60	1-29-1934	01-38-	33.0	131.0		5.3	A
61	3-28-1935	23-47-51	43.0	131.0		6.25(PAS)	A
62	7-03-1936	21-02	35.2	127.6	4-5	5.03	A
63	12-19-1944	14-08-56.0	39.0	124.0		6.75(PAS)	A
63	5-05-1949	09-27-06.0	41.0	131.0		6.70(PAS)	A
65	5-17-1950	11-46-45.0	39.4	130.3	3(MM)[a]	6.70(PAS)	A
66	10-29-1959	14-30-24.0	43.0	131.0	3(MM)	6.25(PAS)	A
67	10-08-1960	05-53-11	40.0	129.7	4(MM)	6.63(PAS)	A
68	9-06-1963	06-03-52.1	36.47	130.76		m_b=5.40, 6.1	A
69	9-07-1963	01-16-55.1	36.53	130.79		m_b=5.30, 6.2	A
70	11-27-1969	00-30-	34.12	127.73		5.1	
71	9-10-1973	07-43-30.5	42.5	130.9		5.57	A
72	9-29-1973	00-44-08	41.89	130.87		6.37	A
73	6-29-1975	10-37-41.4	38.76	129.39		5.89	A

a: Mercalli Intensity Scale
b: Pasadena, Calif.