Jour. Kor. Inst. Mining Geol.
v. 13, no. 1, (1980) pp. 51-63

Seismicity of the Korean Peninsula and Its Vicinity

So Gu Kim*

Abstract: The seismicity of the Korean Peninsula and its vicinity is investigated temporally (2 A. D. to 1978) and spatially to evaluate the seismic risk and to understand the neotectonics around the peninsula. The study has been conducted using macrocosmic data obtained from historical literature, and instrumental records recorded by the Worldwide Network of Standardized Seismographs (WWNSS).

The seismicity of the peninsula was active from the 13th through the 17th centuries. A seismic quiescence began at the onset of the 18th century, and has continued for the last 200 years. Presently, the seismicity region is found to be active again. The return periods are determined by a statistical method based upon the cumulative magnitude recurrence. They indicate that the seismic risk is greater in the south or west than in the north or east of the peninsula. Focal mechanism solutions demonstrate that the neotectonic stress distribution in the Japan Sea is greatly influenced by the subduction of the Pacific Plate under the Eurasian Plate or the Philippine Sea Plate, even though the predominate local paleotectonics is controlled by the spreading of the earth's crut.

1. Introduction

Although the Korean Peninsula is usually believed to have little seismicity, this is not accurate when considering its historical seismicity. According to historical records (2 A. D. -1904), strong earthquakes have caused considerable destruction and loss of life in the ancient kingdoms of the Korean Peninsula. The only scientific investigation of these earthquakes was conducted by *Rustanovich et al.* (1961). They dealt with historical earthquakes and the local geological tectonic interpretation. In this study, however, attempts were made to employ historical and instrumental data from earthquakes in and near the peninsula, not only to evaluate the seismic hazard on the peninsula, but also to correlate seismicity and global tectonics in the Far East.

The historical earthquakes are obtained from the collection that Wada (1912) and Musha (1951) extracted from ancient Korean literature and documents. Some of the data were also obtained directly through the ancient Korean folk literature. Korea, like China, has historical records extending back about 2,000 years. Consequently, analyses of historical earthquakes may be based on a long range of time. *Ambraseys* (1971) demonsted the usefulness of historical records in studying the contemporary seismicity of the Middle East. Because the record of historical earthquakes is neither accurate nor complete, there always exist insufficient data for interpretation. Magnitudes and intensities of historical earthquakes (Kim, 1978) are estimated from historical information and geological knowledge (see appendix). Return periods for earthquakes of the most hazardous seismic zone are determired by the statistical method based upon the cumulative magnitude recurrence. The instrumental records are obtained from the National Oceanic and Atmospheric Administration/National Geophysical and Solar-Terrestrial Data Center (NOAA/NGSDC) and from seismological bulletins from the U. S. S. R., China, and the International Seismological Centre.

---

* Department of Physics, Hanyang Univ. Seoul

Focal mechanism solutions are determined P-wave first-motion directions of the long-period records when possible, in some cases from short-period records or bulletins.

2. Spatial and temporal distribution of earthquakes

To study the spatial disrtibution of historical earthquakes in the peninsula, the peninsula is divided into 70 grids of 1°×1° area ranging from 33°~43°N and 124°~131°E. The epicenters are estimated within each grid by the given historical information of that time and the present geological structure. There are some difficulties in estimating epicenters and intensities and/or magnitudes in terms of the modern seismological concepts. First of all, the observations of the ancient earthquakes were not reported in all directions. As such, observations were dependent upon the distribution of population in that ancient time. Most epicenterrs are found to cluster at and near big towns or

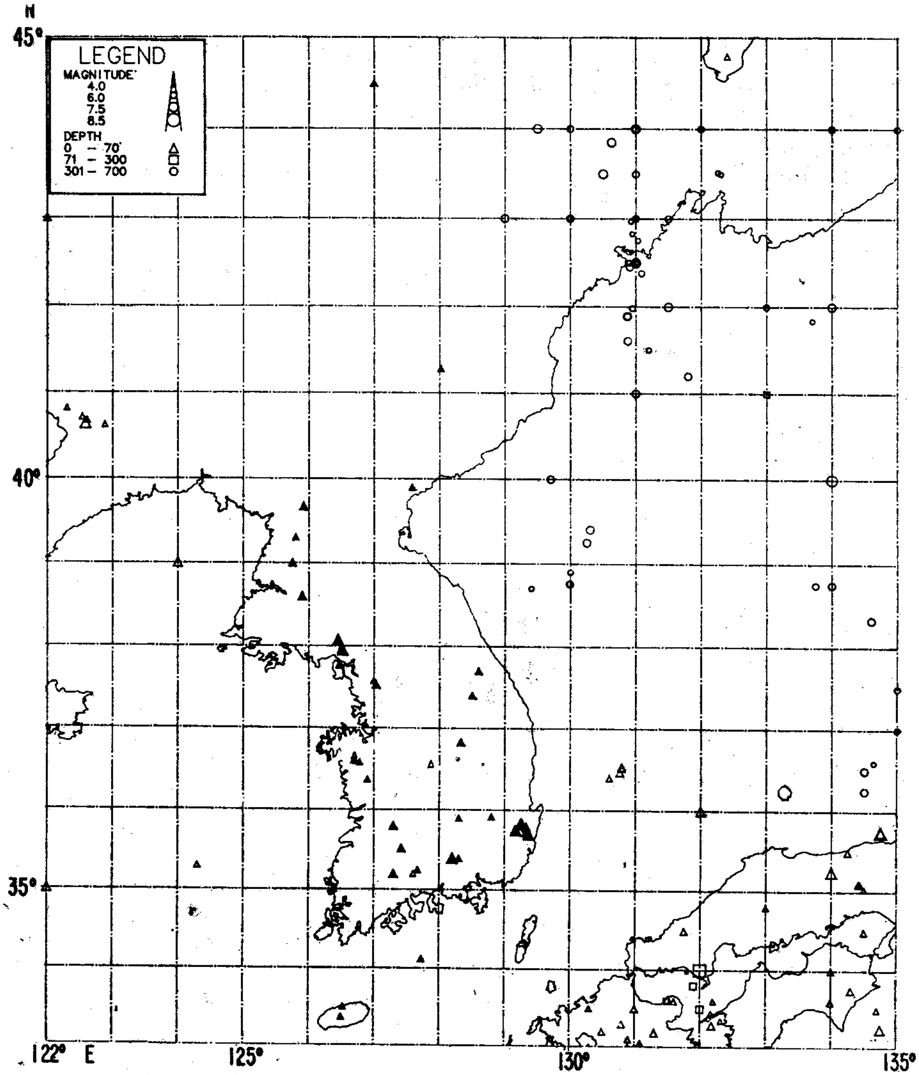

Fig. 1 Seismicity map of the Korean Peninsula and its vicinity. The closed and open symbols indicate the historical earthquakes (2 A. D.-1904) andt. the instrumental earthquakes (1905~1978), respectively.

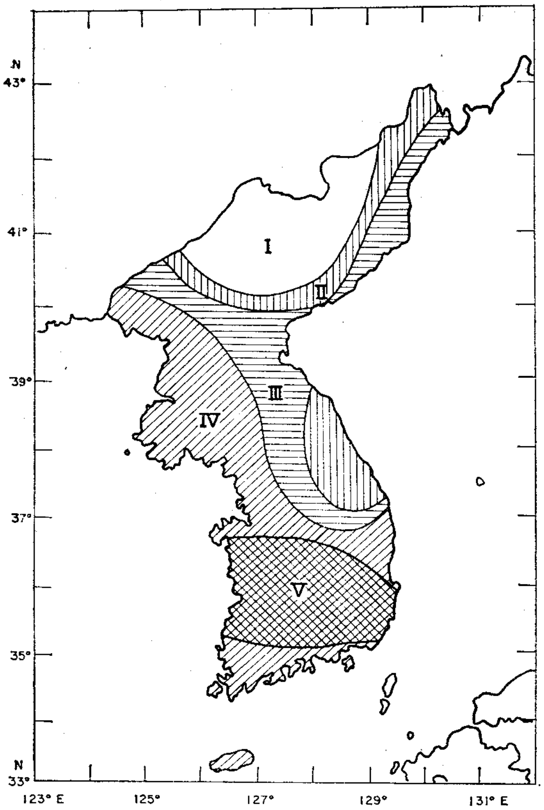

Fig. 2 Seismic zoning map of the Korean Peninsula. Roman numerals indicate intensity scale (JMA) of frequent major earthquakes for each zone

villages of that time (see figure 1). It it also found that any major earthquake could be felt in towns within the peninsula because of the peninsula. The descriptions of damage to people and properties are not accurate and complete. The ancient building structures (usually thatched or clay huts) can hardly be compared to modern building strutures. Furthemore, people interpreted the occurrence of a great earthquake as God's punishment for sins, and they exaggerated earthqake effects. Notwithstanding the difficulties of quantifying historical records into the modern seismological scale, attempts to locate epicenters and estimate intensities or/and magnitudes were made made by *Kim* (1978) in collaboration with with Korean historians.

Return periods are determined by the statistical method of the cumulative magnitude recurrence. One has the advantageous condition to use the earthquake records that cover about 2000 years in the Korean Peninsula. The frequency distribution of earthquakes obey the general magnitude-frequency relation within a small magnitude range (Ch'en and Lin, 1973).

$$\log n(x) = a - bx \tag{1}$$

$$\log N(x) = A - bx \tag{2}$$

$$n(x) = -\frac{dN(x)}{dx,}, \quad A = a - \log(b\ln 10) \tag{2'}$$

where $n(x)$ is called the earthquake magnitude frequency and $N(x)$ the cumulative frequency having magnitude$\geq x$. From equations (1) and (2), one can obtain the distribution function of earthquakes which is the probablity of earthquakes having magnitude$\leq x$.

$$F(x) = 1 - \frac{\int_x^\infty dN}{\int_0^\infty dN} = 1 - 10^{-bx} = 1 - e^{-\beta x} \tag{3}$$

$$\beta = b\ln 10, \quad x \geq 0 \tag{3'}$$

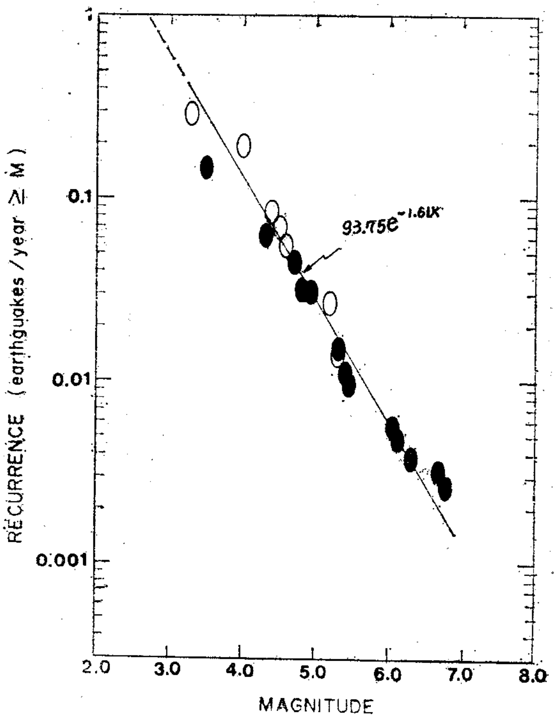

Fig. 3 Cumulative magnitude recurrence of the most hazardousmic zone (V). Closed and open ellipses indicate the periods 2 A. D. -1904 and 1905-1977

The number of earthquakes whose magnitude is greater than a certain given values is a Poisson variables. The probablity of k earthquakes taking place is

$$P(\xi=k)=\frac{\alpha^k e^{-\alpha}}{k!} \qquad (4)$$

where α is the average number of earthquakes occurring in the given time interval. The mathematical expection that all the earthquakes having magnitude$\leq x$ will follow within the time t (Gumbel, 1958)

$$G(x)=\sum_{k=0}^{\infty}\frac{\alpha^k e^{-\alpha}}{k!}[F(x)]^k$$

$$=e^{-\alpha e^{-\beta x}}=e^{-e^{\beta(x-u)}} \qquad (5)$$

$$\alpha=e^{\beta u},\ u=\frac{A}{b} \qquad (5)'$$

Hence the total number of earthquakes of magnitude$\geq x$ within time t is given by

$$N(x)=1-G(x)==\simeq\alpha e^{-\beta x} \qquad (6)$$

The constants, α and β are determined by cumulative magnitude recurrence rate rather than by the least squares or maximum likelihood regressions. The mean cumulative frequency of earthquakes data within the time t. From Fig. 3, the empirical equation of the cumulative magnitude rates is found to be

$$N(x)=93.75e^{-1.61x} \text{ or } \mathrm{Log}N(x)$$

$$=1.97-0.70x \qquad (7)$$

The cumulative magnitude recurrence rate for the highest risk seismic zone (V) is shown on Fig. 3. The recurrence rate of this zone for magnitude 5 or greater is estimated to be about 0.024 per year, corresponding to a 42 year return period after the Mt. Chiri earthquake of July 3, 1936.

The seismic risk map of the peninsula is done by estimating return periods and intensities of all the earthquakes for the period 2 AD to 1978 (see Fig. 2). From figure 2, the least hazard seismic zone is found to be Pyongbug and Hamnam Regions, while the most hazardous seismic zone is the southwest area of the peninsula (Kim, 1978).

The cumuative magnitude recurrence rate for the most hazard seismic zone (V) is shown in Figure 3. The return period of this zone for magnitude 5 or greater is estimated to be about 42 years. Several aftershocks occurred after two earthquakes occurred on September 16 (M=5.2) and October 7, 1978 (M=5.0) in zone V. The Mt. Chiri earthquake (M=5.3) of July 3, 1936, with intensity V (JMA), was followed by these two earthquakes after the return period of 42 years. The mainshock, Hongsung earthquake of October 7, 1978, with intensity V (JMA) is migrated about 100miles from Mt. Chiri to the northwest area of the peninsula. This earthquake caused surface fissres and destroyed most houses partially or totally near the epicenter. The further investiga tion for causes of this earthquake will be needed.

The statisticar approach of earthquake prediction may be useful in the long-term or intermediate-term program for the region where long historical documents can be traced, even though such an a posteriori study is a disagreeble method in physical science. It also noteworthy to compare the nature of animal precursors prior to the earthquake (Raleign et al., 1977) to that of precursors obtained by the statistical approach.

Seismicity in the Korean Peninsula was active from the 13th through the 17th centuries (see Table 1) and became quiescent at the beginning of the 18th century. These seismological phenomena also agree with the last volcanic eruptions of Mt. Paikdu (1668, 1702, and 1724)

Tab. 1 Destructive earthquakes [I_0 (JMA)$\geq$IV] in the Korean Peninsula

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

Tab. 2 Hypocentral coordinates and magnitudes of earthquakes studied

Event No.	Date	Origin Time (UTC)	LAT. (°N)	LONG. (°E)	Depth (Km)*	M_b
		hr min sec				
1	6 Sept. 63	06-03-52.1	36.4	130.6	33	5.40
2	7 May 64	07-58-14.3	40.4	139.0	33	6.20
3	7 May 64	20-12-49.3	40.5	139.0	33	5.90
4	10 Dec. 64	15-11-5.5	40.4	138.9	33	6.00
5	4 Feb. 75	11-36-7.5	40.641	122.580	33(22)	6.40
6	28 Feb. 66	02-02-13.5	43.8	139.6	224(229)	5.70
7	10 Jun. 71	19-59-52.5	41.134	138.421	226(229)	5.70
8	5 Sept. 73	00-30-53.5	40.657	139.552	191(208)	5.60
9	24 Jan. 64	17-17-45.5	38.7	129.4	542(576)	5.30
10	6 Aug. 65	18-15-11.3	41.5	131.2	553(605)	5.30
11	31 Mar. 69	19-25-27.2	38.326	134.603	417(401)	5.90
12	10 Apr. 69	14-54-3.9	41.982	130.949	555(556)	5.60
13	6 May 73	14-39-28.1	43.517	132.256	497(513)	5.30
14	10 Sept. 73	07-43-30.5	42.453	130.907	532(561)	6.00
15	29 Sept 73	00-44-0.8	41.891	130.872	575(596)	6.50
16	29 Jun. 75	10-37-41.4	38.759	129.990	560(547)	6.20

* Numbers in parentheses are redetermined by p P-P.

in the peninsula. Aseismic quiescence has existed for the last 200 years in the peninsula, however, Table 1 shows that at present seismicity of the peninsula again appears to be active.

3. Focal mechanism studies

The focal mechanism soltions of 16 earthquakes (see table 2) are determined by reading the first motions of P-waves from seismograms of the Worldwide Network of Standardized Seismographs (WWNSS). In case of insufficient data, readings from the seismogical bulletins of China, the U. S. S. R., and the International Seismological Centre, as well as the short-period records of WWNSS, were used. A physical relationship exists between the tectonic stresses and focal mechisms of earthquakes in certain areas of interest. The principal compressional tectonic stresses, which lie in the direction of the maximum pressure acting at the hypocenter, is in the direction where P-axes of focal mechanism solutions cluster.

The B-axes (nul vectors) tend, on the whole, to be orthogonal in the direction of the tectonic motion in the Japan Sea. These studies should yield findings meaningful to the understanding of the global plate tectonics theory.

As can be seen from figure 4 which follow (from the data presented in table 3), the direction of the maximum pressure of the deep-and intermediate-focus earthquakes is found to be directed nearly perpendicular to the deep-and intermediate-focus earthquake zone. These findings agree with *Honda* and *Masatsuka* (1962), *Ichikawa* (1971), and *Balakina et al.* (1964). Study of *Ichikawa* (1971) was dependent only upon the indirect readings obtained from various seismological bulletins and nearby stations which are not reliable. The maximum compression for the shallow-focus earthquakes southwest of the Japan Sea is directed mainly parallel to the island chain, or perpendicular to the Ryukyu or Izu Island Chain, which indicates that a part of Honshu Arc subducts the Philippine Sea Plate. On the

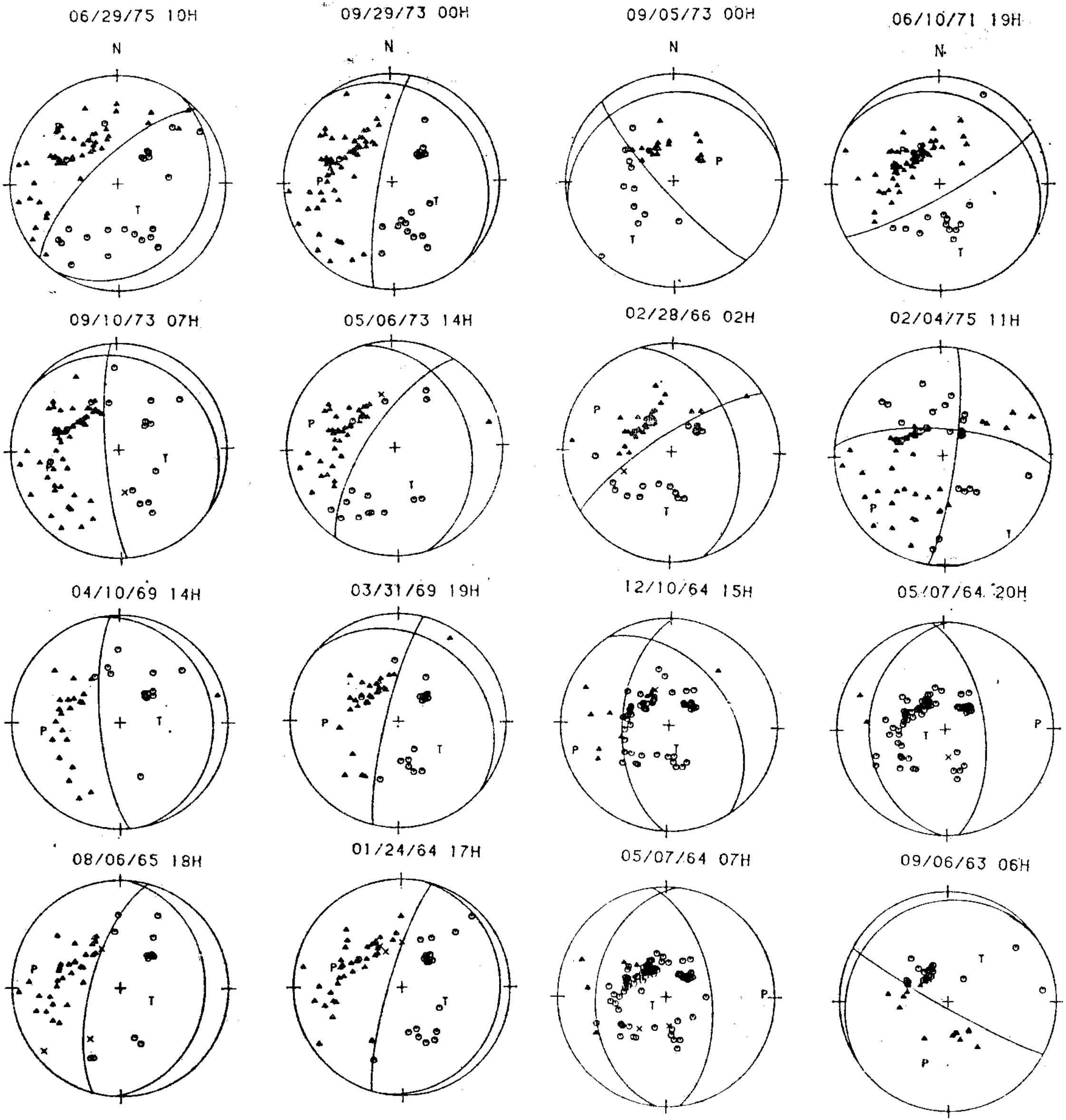
06/29/75 10H
09/29/73 00H
09/05/73 00H
06/10/71 19H
09/10/73 07H
05/06/73 14H
02/28/66 02H
02/04/75 11H
04/10/69 14H
03/31/69 19H
12/10/64 15H
05/07/64 20H
08/06/65 18H
01/24/64 17H
05/07/64 07H
09/06/63 06H

Fig. 4 Focal mechanism solutions illustrated on equal-area projections of the lower hemisphere of the focal sphere. Compressions are indicated by octagons, dilations by triangles and small amplitude arrivals by x's. P and T indicate the axes of compression and tension.

other hand, the Honshu Arc in the northeastern part of Japan has a low seismicity of shallow-focus earthquakes and produces shallow-focus earthquakes with the maximum compression directed perpendicular to the arc (Miyamura, 1966) The typical fault type of the deep- and shallow-focus earthuakes is also found to be predominantly reverse, except for the Haicheng earthquake which caused the left-lateral strike slip, whereas that of the intermediate-focus earthquakes is normal, suggesting extenional tectonics. Consequently, it is evident that earthquakes occurring near the peninsula are attributed to the tectonic stresses owing to the collision of the Pacific Plate against the Eurasian Plate or/and the Philippine Sea

Tab. 3 Focal mechanism solutions

DATE	HOUR	A		B		P		T		N		FT	FM	STA.
		DD	D	DD	D	ϕ	θ	ϕ	θ	ϕ	θ			
09/06/63	06	334	10	209	85	200	30	39	49	298	8	R	DS	39
05/07/64	07	277	35	82	55	88	10	237	78	357	6	R	DS	81
05/07/64	20	273	30	84	60	87	15	252	75	356	4	R	DS	66
12/10/64	15	274	50	58	45	253	12	161	71	348	18	R	DS	58
02/04/75	11	5	70	98	80	233	21	141	7	32	68	LS	SS	72
02/28/66	02	328	78	77	40	298	23	184	45	49	36	R	DS	50
06/10/71	19	151	80	20	20	313	52	164	34	63	15	N	DS	75
09/05/73	00	351	20	229	80	67	52	215	34	316	16	N	DS	32
01/24/64	17	103	10	287	70	286	35	108	55	16	1	R	DS	60
08/06/65	18	95	20	285	70	282	20	112	65	13	2	R	DS	49
03/31/69	19	284	80	43	20	268	33	124	51	10	17	R	DS	45
04/10/69	14	266	75	76	15	264	30	88	60	355	2	R	DS	35
05/06/73	14	305	70	74	30	288	21	158	59	27	21	R	DS	60
09/10/73	07	269	80	42	15	257	34	101	54	358	10	R	DS	70
09/29/73	00	282	80	52	15	271	34	115	53	9	11	R	DS	78
06/29/75	10	128	20	318	70	314	35	143	65	46	3	R	DS	71

Note: DD-dip direction, and ϕ-trend measured from the north; D-dip, and θ-plunge measured from the horizontal. N, R, and LS represent normal, reverse, and left-lateral and strike-slip faults, respectively. SS and DS indicate strike-slip and dip-slip, respectively.

Plate.

4. Origin of the tectonic stress

The Korean Peninsula lies east of the Sino-Korean paraplatform. The dominant teconic lines of uplifting and depression trend toward the northeast or northnortheast (see Fig. 5) To understand the configuration of the tectonnic settings in the peninsula, it is necessary to investigate the origin of the Japan Sea, since there must be a relation between the formation of upliftings in the peninsula and the subsidence of the Japan Sea. Several authors (Bersenev, 1972; Hilde and Wageman, 1973; Sugimura and Uyeda, 1973; and Melankhelina and Kovylin, 1975) have discussed the origin of the Japan Sea without any complete and concrete conclusions. Any close linkage between geological and geophysical observation and investigation has not yet been found. That is, most geologists have made attempts to delineate the origin of the Japan Sea by means of a posterior evidence such as faults, foldings, and upliftings in the peninsula and subsidence of the Japan Sea; whereas most geophysicists have not given enough explanation to the tectonic formation of the Japan Sea in their interpretation It is important to note the past and present tectonics of the Japan Sea and to synthesize its geological and geophysical interpretation.

The hypothesis of expansion (spreading) and contraction of the earth's crust has to be employed to depict the origin of the Japan Sea. The uniform uplift trending northeast in the peninsula may be attributed to the compression coming from the contraction of the earth's crust (see Fig. 5), and the expansion of the earth's crust from the extensional tectonic creating the suboceanic crust of the Japan Sea. The Chugaryong Rift Valley which stretches from Seoul to Wonsan, and the post-earthquake swarm at Sangwon in the middle of the peninsula indicate that the spreading might be initi-

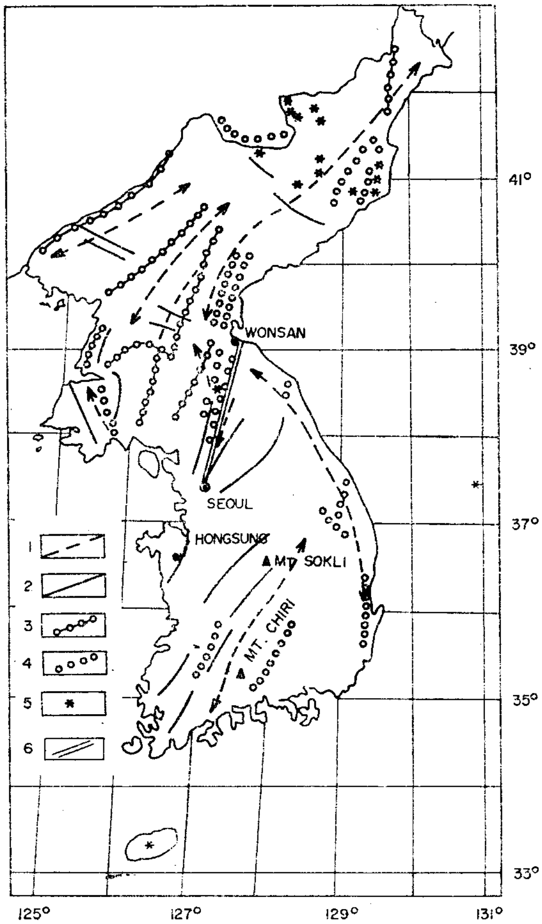

Fig. 5 Tectonic map of the Korean Peninsula (after Rustanovich et al., 1961; Kim, 1978). 1-axes of the Pliocene and Quaternary uplifting; 2-the most important fault zones and faults of the Mesozoic; 3-the same fault zones and faults, but rejuvenated in the Cenozoic; 4-the most important fault zones and faults of the Cenozoic; 5-centers of volcanic eruptions; 6-Chugaryong Rift Valley.

ated near the center of the peninsula. Furthermore, the post-volcanism in and near the peninsula and high heat-flow in the Japan Sea (Sugimura and Uyeda, 1973) disclose the thinning of the earth's crust and the continuous disintegration of the crustal rocks owing to the drift of the Honshu Arc from the Asian Continent.

Spreading of the earth's crust near the peninsula (Workman, 1972) began in the southeast direction during the late Cretaceous or Lower Tertiary Period. The deep subsidence in the Japan Sea and the upliftings uniformly trending northeast in the peninsula were formed by the tension and compression of reaction due to the drift near the Japan Sea at the Upper Tertiary Age. The spreading of the earth's crust, however, was confined to the Japan Sea since the Pliocene Age (Bersenev, 1972), and began to diminish gradually to the present state. Since the 18th century, the seismicity of the peninsula had remained quiet for the last 200 years. This may be related to the balance of the tectonic force between the tensional force spreading the Japan Sea and the compressional force subducting the Pacific Plate near the peninsula. Noting that most of the earthquakes occurring in the Japan Sea (see Fig. 6) are subject to pressure on the northwest-southeast or west-east sides (on the southwest-northeast in the southwest of the Japan Sea) and predominant fault type is reverse, the contemporary seismicity of the peninsula and the Japan Sea must be greatly influenced by the compressional force which comes from the collision of the subducting Pacific Plate under the Eurasion Plate or the Philippine Sea Plate.

Recently, major shallow-focus earthquakes (such as the Mt. Chiri earthquake of July 3, 1936, the Sariwon earthquake of Marcqh 7, 1937, and the Hongsung earthquake of October 7, 1978) occurred in the southwestern or western regions of the peninsula. This indiacates that the seimic hazard is probably greater in the southwest or west than in the northeast or east of the peninsula. The earthguakes occuring in the southwest or west of the peninsula may be called the intra-plate earthquakes (Kim and Nuttli, 1977) in the light of the geometrical view of the subducting motion of the Pacific

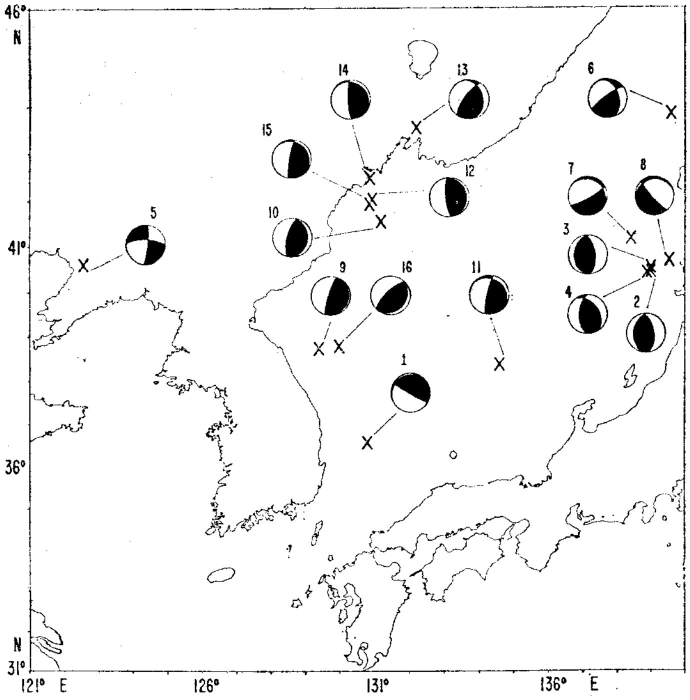

Fig. 6 Focal mechanism solutions for earthquakes near the Korean Peninsula (see tables 2 and 3 for the parameters and the source of the focal mechanism). Black areas on focal spheres are quadrants of compressional first motions.

Plate in the Japanese Island Arc, while the deep-focus earthquakes occurring in the northeastern border between the U. S. S. R. and the Korean Peninsula are found to be the inter-plate earthquakes. occurred in the plate boundary.

5. Conclusions

The following conclusions may be derived from this study. Some of the conclusions, (4) and (5), are somewhat speculative and further investigation is needed to verify them.

(1) Historical earthquakes are of great importance in the evaluation of earthquake hazards in a given area. Furthermore, the statistical aproach of historical earthquakes may be extended to earthquake predication a posterior. For example, the time of the Hongsung earthquake of October 7, 1978, was predicted by the statistical method based upon the cumulative magnitude recurrence. The Mt. Chiri earthquake of July 3, 1936, was followed by the Hongsung earthquake after 42 years, the exact return period calculated.

(2) The temporal seismicity of the Korean Peninsula was active from the 13th through the 17th centuries. The seismic quiescenc, however, began in the early 18th century and has continued into the 20th century. Now, the seismicity has become active again. The spatial seismicity has migrated from the east or southeast to the west or southwest area of the peninsula. Currently, most of the shallow-focus earthquakes are likely to occur near the edge of young folding mountain systems of the west or southwest area of the peninsula.

(3) The focal mechanism solutions of earthquakes occurring in the Japan Sea demonstrate that the maximum compressions in the deep- and the intermediate-focus earthquakes are directed perpendicular to the iso-focal depths.

i. e., perpendicular to the deep- and intermediate-focus earthquake zones. The maximum compression for the the shallow-focus earthquakes is also perpendicular to the Honshu Arc. In addition, the peredominat fault type is reverse. These findings imply the stress distribution near the Japan Sea is greatly affected by the collision of the Pacific Plate against the Eurasian Plate or the Philippine Sea Plate at the Japanese Island Arc.

(4) The hypothesis of spreading of the earth's crust is strongly recommended to explain the formation of the Chugaryong Rift Valley and the post-Sangwon earthquake swarm in the middle of the peninsula, high heat flow in the Japan Sea, and finally the creation of the suboceanic crust of the Japan Sea (Workman, 1972). Another hypothesis for the creation of the Japan Sea is the disintegration of the continental crust and upper mantle into blocks discussed by Kovylin and Stroyev (1976). Nonetheless, since positive proof of these hypotheses does not exist, further investigation (like linear magnetic anomalies and positions of poles of opening in the Japan Sea) is necessary in the future.

(5) Paleotectonics (defined as the tectonics before the Miocene age) was mainly influenced by the tensional driving force caused by the southeastward spreading of the earth's crust near the Japan Sea, whereas the compressional driving force which resulted in the subducting Pacific Plate has gradually increased since the Quaternary has confined the tensional driving force of paleotonics to the Japan Sea at the present time (Bersenev, 1972). The recent shallow-focus earthqakes of the west or southwest and the deep focus earthquakes in the notheast of the peninsula may be attributed to the recent crustal movement of the Pacific Plate.

6. Acknowledgments

The author thanks Alan Shapley, Director, Joe Allen, and Robert Ganse of the National Geophysical and Solar-Terrestrial Data Center for their many helpful comments. This work could not have been accomplished without the excellent computer assistance of W. Rinehart. C. Kisslinger and O. Nuttli reviewed this paper and provided helpful criticism. The author also gratefully acknowledges the financial support of the National Oceanic and Atmospheric Administration, the National Academy of Sciences, and the Cooperative Institute for Research in Environmental Sciences, University of Colorado.

References

Ambraseys, N. N. 1971. Value of historical records of earthquakes, in Natue 232, 375–379.

Balakina, L. M., L. A. Misharina, E. I. Shirokova, and A. V. Vvedensk 1969. The field of elastic stresses associated with earthquakes, in The Earth's Crust and Upper Mantle, Geophys. Monograph 13, P. J. Hart, ed., American Geophys. Union, Washington, DC, 166–173.

Bersenev, I. I. 1972. How did the Sea of Japan arise? Priroda 12, 52–59 (in Russian).

Gumbel, E. J. 1958. Statstics of Extremes, Columbia University Press, New York, NY, 375pp.

Gutenberg, B., and C. F. Richter 1956 Earthquake magnitude, intensity, energy, and acceleration, Bull. Seismological Socity Am. 46, 105–145.

Hilde, T. W. C., and J. M. Wageman 1973. Structure and origin of the Japan Sea, in The Western Pacific: Island Arcs, Marginal Seas, Geochemistry, University of Western Australia Press, 415–434.

Honda, H., and A. Masatsuka 1952. On the mechanisms of the earthquakes and the stresses producing them in Japan and its vicinity, in The Science Reports of the Tohoku University, Geophys. 4, 42–60.

Ichikawa, M. 1970. Reanalyses of mechanism of earthquakes which occurred in and near Japan, and statistical studies on the nodal plane solutions obtained, 1926–1968, Geopys. Mag. 35, 207–274.

Kim, So Gu, and Otto W. Nuttli, 1977. Spectral and magnitude characteristics of anomalous Eurasian earthquakes, Bull. Seismological Society Am. 67, 463-478.

Kim, So Gu, 1978. The Seismicity of the Korean Peninsula, Korea Res. Inst. Geosci. Min. Resour., Seoul, Korea, 200pp. (in Korean),

Kim, So Gu, 1979. Investigation on the Hongsung Earthquake, the Ministry of Science and Technology, Seoul, Korea, 321pp. (in Korean).

Kovylin, V. M., and P. A. Stroyev, 1976. The problem of development of the trough of the Sea of Japan, IGC, XXV session, Paleontology, Marine Geology, Nauka.

Melankholina, Ye. N., and V. M. Kovylin, 1975. Tectonics of the Sea of Japan, Geotectonics 9, 273-282.

Miyamura, S., 1969. The seismicity of Japan the surrounding area, Bull. (Izv.) Acad. Sci. USSR, Geophys. Ser. 7 (English edition), 21-50.

Musha, K., 1951. A Chronological Table of Earthquakes, Volcanic Eruptions, and Other Phenomena Occurred in Japan and Its Adjacent Areas, The Japanese Historical Documents of Earthquakes, The Mainichi Press, Tokyo, Japan, 350pp. (in Japanese).

Raleigh, B., T. Hanks, A. Nur, P. Molnar, F. Wu' J. Savage, C. Scholz H. Craig, R. Turner, and G. Bennett, 1977. Prediction of the Haicheng Earthquake, EOS. Trans. Am. Geophys. Union 58, 236-272.

Rustanovich, D. N., V. L. Masitis, and Chon Heng Suk, 1961. The seismicity of Korea and aspects of its seismotectonics and seismic zoning, Bull. (Izv) Acad. Sci. USSR Geophys. Ser. 10 (English edition), 1441-1463.

Sugimura, A., and S. Uyeda, 1973. Island Arcs: Japan and Its Environs, Developments, in Geotectonics 3, Elsevier Scientific Publishing Co., Amsterdam, 240pp.

Utsu, T., 1977. Seismology, Public Publishing Co., Tokyo, 286pp. (in Japanese).

Wada, Y., 1912. The earthquakes in Korea, The Scientific Memoirs of the Meteorlogical Observation of the Governmental General of Korea 2, 16-30 (in Japanese).

Workman, K., 1972. The tectonic setting of the Mesozoic granites of Korea, J. Geol. Soc. Korea 8, 67-76.

한반도와 그 인접지역의 地震活動

김소구

요 약 : 한반도 주위의 새로운 구조력(neotectionics)을 이해하고, 지진 위험을 평가하기 위해서, 한반도와 그 인접지역의 지진활동을 시간적 및 공간적으로 조사 연구한다. 본 연구는 역사적문헌에서 얻은 기술적인 지진자료와 세계지진 관측망(WWSSN)에서 얻은 기록등을 사용하여 수행되었다.

한반도의 지진 활동은 13세기부터 17세기까지에 가장활발하였다. 지진정지기(seismic quiescence)는 18세기에 들어와서 시작하여 약 200년동안 계속되었다. 최근에와서 지진활동은 다시 활발하다는 것이 발견되었다. 지진의 위험 분포와 지진회복주기(return period)는 축적규모진도수에 의한 통계학적 방법에 의해서 결정되었다. 최근 한반도에서 지진 위험지역은 반도의 서남부 및 서부지역에서 더욱 크다는 것이 발견되었다. Focal mechanism에 의한 일본해 부근의 지진잠재력(neotectonic stress)에 관해서 고찰하면, 옛날의 Paleotectonics의 주력은 지구의 crust의 확장설(expanding)에 의해서 큰 지배를 받았지반, 최근은 태평양 plate가 유라시아 대륙이나 필립핀 plate 밑으로 충돌하여 들어가는 subducting motion에 큰 지배를 받고 있다는 것이 발견되었다.

a. normal focal depth ($h \leq 60$km)
b. very shallow focal deph

A : instrumental Earthquakes
B : $M=-3.0+3.8\log R$ (Gutenberg and Richter, 1956)
R = radius of felt area, $5.0 \leq M \leq 7.0$

Appendix A

Major earthquakes (I ≥ IV : M≥5, 0) occurred in the Korean peninsula and its vicinity.

No.	DATE M-D-Y	Origin time H-M-S	LAT. (°N)	LONG. (°E)	Depth (km)	I_0 (JMA)	M	Quality
1	27		37.53	127.03	N[a]	V	6.1	D
2	34		35.83	129.25	N	V ~ VI	6.8	E
3	89		37.53	127.03	N	V	6.1	D
4	100		35.80	129.33	N	V	6.1	D
5	123		35.82	129.27	N	V	6.1	D
6	304		35.83	129.25	N	IV	5.4	D
7	304		35.82	129.28	N	V	6.1	D
8	458		35.78	129.33	N	V	6.1	D
9	471		35.70	129.37	N	V ~ VI	6.8	E
10	501		39.00	125.75	N	V	6.1	D
11	510		35.83	129.25	N	V	6.1	D
12	09-12- 664		35.72	129.33	N	V	6.1	D
13	769		35.81	129.26	N	V	6.1	D
14	780		35.83	129.26	N	V ~ VI	6.8	E
15	1002		33.37	126.50	SFC[b]	IV	5.4	D
16	07-23-1036		35.83	129.25	N	V	6.7	B
17	11-05-1226		37.96	126.52	N	IV	5.4	D
18	06-24-1260		37.77	126.47	N	V	6.1	D
19	03-06-1298		37.95	126.52	N	V ~ VI	6.8	E
20	11-12-1311		37.95	126.52	N	V	6.1	D
21	08-01-1385		37.96	126.50	N	V	6.1	D
22	05-23-1416		36.83	128.33	N	IV	6.1	B
23	01-24-1455		35.52	127.42	N	V	6.1	D
24	07-02-1518		38.07	126.45	N	V ~ VI	6.8	E
25	06-27-1546	16 h	37.58	127.00	N	IV	5.4	D
26	06-30		39.67	125.92	N	V	6.4	B
27	07-04		37.77	126.47	N	IV	5.4	D
28	03-02-1553		35.25	126.67	N	IV	5.4	D
29	07-20-1594	02 h	36.37	126.90	N	IV	5.4	D
30	02-21-1596	16 h	37.40	128.50	N	IV	5.3	E
31	10-08-1597	14 h 18 h 22 h 24 h	41.28	128.02	SFC	IV	5.4	D
32	03-07-1601		35.92	128.80	N	IV	5.4	D
33	03-19-1601		35.90	128.30	N	IV	5.4	D
34	06-09-1643		35.40	128.20	N	V ~ VI	6.8	E
35	07-24-1643		35.75	129.17	N	V ~ VI	6.8	E
36	04-21-1662		36.58	126.78	N	IV	5.4	D
37	08-12-1664		35.80	127.30	N	V	6.3	E
38	07-31-1668		38.60	125.90	N	IV	6.4	B
39	10-08-1669		39.30	125.80	N	IV	5.4	D
40	10-30-1670		35.20	127.30	N	V	6.3	E

No.	M-D-Y DATE	Origin time H-M-S	LAT. (°N)	LONG. (°E)	Depth (km)	I₀ (JMA)	M	Quality
41	11-15-1670		33.50	126.53	SFC	IV	5.3	E
42	06-20-1681		36.60	126.70	N	IV	5.4	D
43	06-26		37.70	128.60	N	IV	5.3	E
44	04-29-1700		35.40	128.30	N	IV	5.3	E
45	06-20-1727		39.90	127.58	N	IV	5.3	E
46	01-25-1905	02-11	33.2	130.5	N	III	5.5	A
47	08-25	09-46-45.0	43.0	129.0	470		6.75 (PAS)	A
48	03-14-1916	21-45	33.0	130.9	N		5.3	A
49	07-31-1917	03-23-10.0	42.5	131.0	460		7.50 (PAS)	A
50	02-09-1918	20-46-26.0	43.0	130.0	450		6.50 (PAS)	A
51	12-18-1920	22-51	33.3	130.8	N		5.9	A
52	07-26-1923	23-27-60	43.0	130.0	430		5.75 (PAS)	A
53	08-28-1924	23-50-36.0	33.5	131.0	N		6.0 (PAS)	A
54	12-21-1928	23-17	33.1	130.9	N		5.2	A
55	01-01-1929	16-40	33.1	130.9	N		5.4	A
56	02-05-1930	13-28	33.5	130.3	20		5.1	A
57	03-25-1933	12-50	33.0	130.9	20		5.0	A
58	07-14	16-03-33.0	43.0	131.0	530		5.50 (PAS)	A
59	07-24	08-37-57.0	42.5	131.0	550		5.75 (PAS)	A
60	01-29-1934	01-38	33.0	131.0	20		5.3	A
61	03-28-1935	23-47-51	43.0	131.0	550		6.25 (PAS)	A
62	07-03-1936	21-02	35.2	127.6	10	V	5.3	A
63	12-19-1944	14-08-56.0	39.0	124.0	N		6.75 (PAS)	A
64	05-05-1949	09-27-06.0	41.0	131.0	580		6.70 (PAS)	A
65	05-17-1950	11-46-45.0	39.4	130.3	600	III (MM)	6.70 (PAS)	A
66	10-29-1959	14-30-24.0	43.0	131.0	550	III (MM)	6.25 (PAS)	A
67	10-08-1960	05-53-11	40.0	129.7	608	IV (MM)	6.63 (PAS)	A
68	09-06-1963	06-03-52.1	36.47	130.76	60		$m_b=$ 5.40 6.1 (JMA)	A
69	09-07	01-16-55.1	36.53	130.79	40		$m_b=$ 5.30 6.2 (JMA)	A
70	11-27-1969	00-30	34.12	127.73	50		5.1	A
71	09-10-1973	07-43-30.5	42.5	130.9	532		5.57	A
72	09-29-1973	00-44-08	41.89	130.87	575		6.37	A
73	06-29-1975	10-37-41.4	38.76	129.99	560		5.89	A
74	09-15-1978	17-07-5.77	36.49	127.88	34		5.2	A
75	10-07	09-19-52.1	36.55	126.67	5.4	V	5.0	A

C : Nuttli and Zollweg (1974)
$M=2.65+0.98f+0.054f^2$
$f=\log(\pi r^2)$, r=radius of perceptibility

D : $M=0.5I(\text{JMA})_{\Delta=D}+2.30\log D+0.00083D+0.16$ (Utsu, 1977)
D=epicentral distance

E : $M=1+2/3[1.5I_0(\text{JMA})+0.5]$ (Gutenberg and Richter, 1956)

N. B. The origin times represent LST (local standard time) for the historical earthquakes and UTC (Universal time Coordinate) for the instrumental earthquakes.