Synopsis of the Geological Systems of Korea

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Introduction

It has been known since C. Gottsche published the first contribution on the geology of Korea in 1886 that Korean and Japanese geological characteristics are strikingly dissimilar, and that those of Korea and South Manchuria or North China are comparatively similar. In the intervening years, geologists have been able to study extensively the geology of these areas, but many problems of detailed comparison remain unsolved. This volume's research projects, suspended by World War II, are by no means an exhaustive treatment of East Asian geology; much remains for future study.

In this paper the writer intends to give a general idea of the sequence of geological events to which Korea was subjected. For this purpose I have drawn up a generalized table, compiled on the basis of up-to-date information and some revised considerations by the writer.

Before presenting the table, however, I wish to point out briefly the principal differences and similarities in the geology of Korea and Japan, and Korea and South Manchuria or North China, and to discuss some important problems of the stratigraphy and crustal movements of Korea. Such comparisons and discussion, together with the table, may be of significance not only with reference to Korea, but the vaster area of East Asia as well.

Comparison with Japan

Comparing the geology of Korea with that of Japan, we can easily find marked dissimilarities in such aspects as the areal distribution of dominant rocks, sedimentation environments, crustal movements, epochs and lithological characteristics of igneous activities.

Mesozoic or older rocks, including neo-granites which may be from the later Cretaceous to the beginning of the Tertiary, are extensively distributed in Korea. Pre-Cambrian granite-gneisses and crystalline schists, together with granites, the majority of which may belong to the neo-granite referred to above, cover more than half of all Korea. Terrain with eruptive rocks of the Tertiary or later is much narrower than that of Japan; the rocks occupy isolated and narrow areas, or thinly cover older rocks. In this connection, however, the writer must point out the noteworthy phenomena that Cenozoic andesites, very common and widespread in the Japanese archipelago, are distributed in a far narrower area in Korea;[1] multifarious alkaline volcanic rocks, probably of the late Tertiary or Pleistocene, are widely distributed in northeastern Korea and form an essential portion of the petrographic province of alkaline rocks in East Asia; and that there are fairly extensive areas of basaltic lava in North Korea, one of which extends far into Manchuria as a basaltic lava plateau surrounding Mt. Paektu, and the outpouring of this lava may suggest some genetic connection with a crustal condition under which the land was diversely disjuncted by normal faults and tilted.

In sedimentary environments there are also various differences between Korea and Japan which are worthy of special notice. Korea was subjected to large-scale transgressions of oceanic water at least twice during the Pre-Cambrian and twice during the Paleozoic, which left thick deposits of marine sediments. But, after the sea retreated from Korea in the Late Paleozoic, the environment was greatly changed and the land was never again covered extensively by marine water. During the Mesozoic, the land was often covered by more or less extensive lacustrine or partly littoral water; and in the Cenozoic only the marginal terrains were under lacustrine, lagoonal, or littoral water. In Japan, however, extensive terrain was almost continuously under sea water from the Silurian to the Tertiary or later.

Paleogeographic changes: Of course, paleogeographic changes of land and water were not the same in Korea and Japan. For instance, the Upper Paleozoic sediments of the Kitakami mountainland in northern Japan are interrupted by four or more stratigraphic hiatuses, while in Korea, the Upper Paleozoic Heian[2] system shows only one doubtful hiatus for the Uralian interval. The Tertiary formations of Japan have such variable rock facies and are so diversely divided by frequent unconformities that it seems a difficult and laborious task for geologists to work out stratigraphic relations within a single basin or among beds in different basins. Other instances of paleogeographic diversity may be suggested by the Mesozoic stratigraphy in Japan. In general, diversity and frequency of paleogeographic changes in Korea were minor but the changes themselves seem to have occurred in far more extensive areal units than in Japan.

[1] Among the Cenozoic lavas in Korea, which have generally been called basalt, there are some which are two-pyroxene andesite. Except for these, andesite is found mainly in association with the Tertiary beds in the Yŏnil district of North Kyŏngsang-do. In Korea, andesitic rocks are widely distributed in the terrain of the Cretaceous Shiragi series.

[2] Formation names in Korea were often originally formed by Japanese readings of Korean geographic names and have been widely introduced in Japan and abroad by these names; examples are (Korean reading is in parentheses):

Shōgen (Sangwŏn) system; Chōsen (Chosŏn) system; Heian (P'yŏngan) system; Daidō (Taedong) series; Shiragi (Silla) series; Bukkokuji (Pulguksa) group; Taihō (Taebo) disturbance; Shōrin (Songnim) disturbance; Ennichi (Yŏnil) group; Meisen (Myŏngch'ŏn) group; etc.

I have used the Japanese readings throughout this paper.

Crustal movement: In Korea, Jurassic strata or, strictly speaking, strata of the Middle Jurassic or older were strongly folded and thrusted and, due to repeated thrusts, often exhibit "schuppen" structures. Younger strata, however, are more or less tilted with angles of less than 30° or are nearly horizontal, although these are frequently disrupted by faults, dominantly normal, and exhibit insignificant folding.[3)]

We may conclude from these facts that Korea was under compressive stress until the middle Mesozoic, but subsequently changed into an area in which the land was faulted and tilted, block by block, and had also some subordinate folding of strata. The present geomorphologic features of Korea are considered to have originated largely in these block movements.

The crustal movements thus suggested by studies of Korean geology may be classified as follows:

1. Orogenic movements of the early Mesozoic (post-Heian and pre-Daidō), namely the Shōrin disturbance as defined by T. Kobayashi (1930). The movement may be comparable in time to the Akiyoshi disturbance in Japan and the Tsingling movement in North China, which has been interpreted as a prolongation of the worldwide Helcynian movement.

2. Orogenic movements of the late Jurassic period (post-Daidō and pre-Rakutō), namely, the Taihō disturbance as defined by E. Konno (1928). The disturbance can be correlated to that of the Ōga phase of the Sakawa orogenic cycle in Japan, and may represent an earlier phase of the East Asiatic Yenshanian movement in Korea.

3. Two phases of inland (?) basin subsidence in which Flysch-type sediments of the Rakutō and Shiragi series were deposited, accompanied by a widespread effusion of intermediate or basic lavas in the Shiragian phase. Both may also represent phases of the Yenshanian movement.

4. Block movements closely related to the large-scale intrusion and extrusion of acidic rocks of the Bukkokuji group. Subsidence of the Tsushima basin, in which thick sediments of the Taishū group were deposited, is an event which may be included in the same phase as the block movements. The movement may be interpreted as a prolongation of the Yenshanian movement of China, and is roughly comparable in age to the North American Laramide Revolution (Tateiwa, 1934).

5. Block movements of the middle Tertiary, the essential portion of which probably began in the Oligocene and lasted to the pre-Ennichi stage of the Miocene. The movement resulted in local extrusions of basaltic and other lavas, faulting dominantly in the Sinian direction (approximately NE–SW) and a conspicuous warping of the Miocene terrain in the Kilchu–Myŏngch'ŏn district, North Hamgyŏng-do.

3) In an exceptional case, later Mesozoic overthrusting was indicated by old massifs thrust at a low angle over the later Mesozoic Shiragi series in the northern part of North Kyŏngsang-do, and some faults in the Sinian direction (NE–SW) in South Korea are observed to have moved in the reverse direction.

The movement may be a prolongation of the Nanling movement of China which is considered to be a part of the Himalayan movement. In Korea, however, it seems to be more closely related in genesis to the Ōyashima movement, in which strong pressure toward the Pacific Ocean up-folded the Japanese archipelago.

Of these, the former two are separated by an intervening phase of inland basin subsidence in which terrestrial sediments of the lower Jurassic Daidō series were deposited. The sediments are more than 2,600 m thick in South Ch'ŭngch'ŏng-do, South Korea.

The fourth series of movements was followed by stages of epeirogenic movements and widespread peneplanation. Remnants of the erosion are observable in limited patterns on the Kaema plateau and on the tops of some high mountains. It may be correlated with the Peitai stage of peneplanation in North China.

Phases 2, 3, and 4 are undoubtedly closely related in time and may represent as a whole the Yenshanian movement in Korea and its prolongation. The Yenshanian movement in Korea thus defined is correlated in time with the Sakawa orogenic cycle in Japan described by T. Kobayashi (1941). Summarizing what has been emphasized concerning the crustal movements of Korea, the present writer has drawn up the following table:

1. Shōrin disturbance 2. Taihō disturbance, preceded by a phase of inland basin subsidence 3. (a) Rakutō phase (b) Shiragi phase 4. Bukkokuji disturbance, followed by a stage of widespread peneplanation, *i.e.* the Peitai stage. The disturbance may be roughly correlated in time with the North American Laramide Revolution.	Yenshanian and its prolongation
5. Nanling movement, a part of the Himalayan (Ōyashima) movement.	

Crustal movements are also thought to have occurred in the Pre-Cambrian. The entire situation and characteristics of these movements, however, remain obscure.

A noteworthy phenomenon is that the bedding planes of strata dating from the Lower Cambrian to the Triassic in Korea are found parallel to each other, although they are interrupted by one or two stratigraphic intervals. Moreover, as far as I know, the Lower Cambrian beds lie disconformably against the Late-Proterozoic Sinian system which, in turn, undoubtedly rests disconformably upon the complex of crystalline schists in the terrain between Sunch'ŏn and Sukch'ŏn and in the eastern part of Sŏngch'ŏn-gun, South Pyŏngan-do. The facts suggest that no conspicuous orogenic movements occurred in Korea from the Late Proterozoic until sometime in the Triassic, and in South P'yŏngan-do the quiescent age goes back still farther.

Volcanic activity and earthquakes: In historical times, volcanic activity was insignificant in Korea. There are only two sets of legends which convincingly indicate volcanic activity. According to one set of legends, the dormant volcano Halla-san (1,950 m) on Quelpart Island became active and exploded in 1002 and 1007 A.D.

Other, less convincing legends suggest volcanic activity at Mt. Paektu (2,744 m) in 1597 and 1702 A.D. Data for 1702 indicates that the mountain did explode, resulting in the deposition of whitish volcanic ash.

Korea has no active volcanoes at present, and this, together with the low frequency of earthquakes, signifies the dissimilarity of Korean and Japanese geology.

Korean records show that earthquakes have occurred on 1,661 days of the 2,000 years since the era of the Three Dynasties; of these, approximately forty earthquakes were more or less violent and resulted in the destruction of some buildings or injury of people (WADA, 1912).

The actual number of earthquakes in Korea may be larger than the above figure, for it is not improbable that two or more earthquakes occurred on the same day, records of earthquakes may have been lost, and all earthquakes were not necessarily recorded. Nevertheless, it is certain that the frequency of earthquakes in Korea is far less than in Japan. In fact, I experienced only one earthquake in Korea during my twenty-eight years there, which I experienced at Changgi, Yongil-gun, on the eastern coast of North Kyŏngsang-do.

Mineral resources: Korea's mineral resources differ from those of Japan. She lacks, first of all, oil fields and sulphur deposits; and she is comparatively rich in anthracite but poor in brown coal. The country is extremely poor in resources of tin, manganese, antimony and mercury.

Korea is rich, however, in tungsten, gold, magnesite, apatite, graphite, mica, barite, fluorite, alunite, talc, cyanite (together with sillimanite and andalusite), and rare-element minerals (monazite, zircon, allanite, beryl, various lithium minerals). Especially noteworthy are the rich deposits of magnesite and tungsten; numerous deposits of crystalline and earthy graphite, of which total annual production has often been the highest in the world; and extensive placers of heavy minerals which rare generally rich in monazite and zircon in close association with fergusonite, samarskite, columbite, gold, etc. There seems to be no great difference between Korea and Japan in ore reserves of the other important minerals.

Finally, it must be noticed that most of the important mineral deposits in Korea are believed to have originated in the later Mesozoic, namely the period of acidic rocks of the Bukkokuji group or earlier. In this regard, Korea seems similar to Manchuria and other East Asiatic continental areas, but different from the Japanese archipelago and the Philippine Islands, where minerals of Cenozoic origin are dominant.

Comparison with South Manchuria and North China, with Special Reference to Pre-Cambrian Stratigraphy in Korea

Geological maps of East Asia illustrate the striking differences in Korean and Japanese geology, as stated above, and the many similarities between Korea and South Manchuria or North China. Such a distinct contrast, revealed in the geology on both sides of the Tsushima Strait, seems to be due largely to the unique situation of Japan on the periphery, and consequently the unstable portion, of the Asiatic continent, while Korea and its adjoining lands, including South Manchuria and North China, are more or less away from the peripheral zone of the continent.

The most obvious similarities are shown by the five major units of the stratigraphic columns common to these continental areas, *i.e.* the thick sediments of the Upper and Lower Paleozoic and the Upper and Lower Proterozoic, of which the Upper Proterozoic is separated into two parts by a clino-unconformity. The sediments of these major units in Korea are so similar in rock sequence, lithological nature, and fossils to corresponding sections in South Manchuria or North China that they may be interpreted as portions of a common and widespread sedimentation which successively prevailed over these areas.

Geologists have proposed diverse terms, however, for these stratigraphic units, and such a diversity of terminology has seemed unavoidable because of inconclusive field observations.

For uniformity of terminology, the writer has selected tentatively terms from those already proposed for the above five stratigraphic units, as follows:

Heian system (Middle Carboniferous—Triassic)
Chōsen system (Lower Cambrian—Middle Ordovician)
Sinian system (Upper Proterozoic) } Shōgen system or Sinian system
Huto system (Upper Proterozoic) } in a wide sense
Wutai system (Lower Proterozoic)

Of these, the term Heian was proposed by R. KODAIRA (1924) and Chōsen by K. INOUE (1907); both are well known among Japanese geologists who are interested in the Paleozoic stratigraphy of East Asia. The Sinian is here taken in a strict sense and applied to the Kuken series of the Shōgen system; the Huto (B. WILLIS and E. BLACKWELDER, 1907) for the Shidōgū and Chokken series of the Shōgen system; and the Wutai, an old term proposed by F. VON RICHTHOFEN (1882), for all metamorphosed sedimentaries represented by the Matenrei system in the northeastern part of North Korea, the Yokusen system diagonally traversing South Korea, and the Jōsuiyō series scattered in the western part of N. P'yŏngan-do.

The Rensen system, a term proposed by S. KAWASAKI[4] for the oldest complex of

[4] The term was probably first used in the explanatory text for the geological map of Korea shown at the memorial exhibition of the fifth anniversary of the new administration of the Government-general of Chōsen (in Seoul) in 1914.

crystalline schists in Korea, is being tentatively retained. S. NAKAMURA and S. MATSUSHITA (1940) proposed another term, the Keirin system, for the Korean complex which includes all pre-Shōgen metamophosed sedimentaries, and determined its age as Archean. Aside from the chronological interpretation put forth by the two authors, the term may be conveniently used for any complex of metamorphosed sedimentaries in Korea which cannot be differentiated into Upper and Lower Proterozoic and the Rensen system.

According to some authors, the Shōgen system is divided by a stratigraphic hiatus in its upper portion. If the hiatus is as great as S. MATSUSHITA (1947) insists, the system should be divided into two parts as he has already done. MATSUSHITA proposed that the Sinian in a strict sense be used for the upper part and that the old term, Huto, proposed by B. WILLIS and E. BLACKWELDER in 1907, be used for the lower part.

One of the striking phenomena of East Asian stratigraphy is the fact that Middle Carboniferous sediments rest disconformably upon Middle Ordovician limestone throughout the area. In Korea, however, the existence of Silurian terrain has been suggested since 1934, when S. SHIMIZU, K. OZAKI and T. OBATA (1934) reported the unexpected discovery of fossils from limestone pebbles of the basal conglomerate of the Lower Jurassic Daidō series near Kyomip'o, Hwanghae-do.[5] From these fossils, the authors have identified eighteen coralline species and four species of cephalopods, and contend that the fauna suggest the Silurian period.

A paper by T. YAMAGUCHI (1951) reports the discovery of doubtful fossils from a thin bed of arenaceous slate and limestone in Kŭmch'ŏn-gun, Hwanghae-do. According to him, the collection contains a form comparable to *Monograptus priodon* BRONN. and some forms which can be assigned to a certain species of *Cypridea*, and the meager collection as a whole suggests the Silurian. The fossil-bearing bed is intercalated in a thick series consisting largely of phyllites with or without pebbles, ottrelite-bearing clay slate, quartzite and limestone. Except for the fossils discovered by YAMAGUCHI, there has been no age measurement available for the thick series, although it was formerly assigned to the Kyūzan formation of the Heian system because of its inferior anthracite seams (GEOLOGICAL SURVEY OF CHŌSEN, 1928), and later to an upper part of the Shōgen system because of its lithological and stratigraphical resemblances to the latter (S. MATSUSHITA, 1941). According to YAMAGUCHI therefore, the Kyūzan formation or a part of it is probably Silurian and the upper portion of the Rensen system, discussed by S. KAWASAKI (1916), is younger, for that segment of the Rensen system rests, showing no evidence of tectonic contact, upon the fossil bearing bed of the Kyūzan formation.

Taking all these matters into consideration, geologists must revise the stratigra-

[5] The authors had considered the conglomerate with the fossiliferous limestone pebbles as Silurian sediments, but, soon after the publication of their paper, T. KOBAYASHI visited the locality and affirmed the younger age of the conglomerate. (KOBAYASHI, T., Is the limestone conglomerate at Kyomip'o Gotlandian sediments?: *Jour. Geol. Soc. Japan*, v. 47, p. 362.)

phic interpretations already reported concerning the Sinian and the Rensen systems in the area around Kŭmch'ŏn-gun. Limited by the present state of knowledge, however, the writer hesitates to follow YAMAGUCHI in considering the entire Kyūzan formation Silurian, although he cannot necessarily deny the probability of Silurian terrain in Kŭmch'ŏn-gun.[6] As for YAMAGUCHI's chronological conclusions on the Rensen system, which consists essentially of highly metamorphosed crystalline schists intricately injected by grey granite-gneiss, the present writer adheres to a quite different view.

Another question for future study concerns the existence of Devonian sediments in Korea, which was suggested by a few forms of corraline fossils reported by H. YABE and T. SUGIYAMA (1939) from Ch'ŏnsŏng-ni, Sunch'ŏn-gun, South P'yŏngan-do, where both the Heian and the Chōsen systems are exposed side by side but separated by a narrow area with no outcrops of bedrock. The fossils were reported to have come from a limestone block on the ground. In this case also, the limestone strata from which the fossils were derived have not been disclosed.

In South Manchuria a bed of limestone conglomerate over 10 m thick has been found between Middle Ordovician limestone and the Middle Carboniferous Penshi series in disconformity to both series (NODA, 1952). In Shantung province, North China, a similar bed disconformably rests on the Middle Ordovician Chenan limestone (NODA, 1952). No fossils have been discovered as yet, however, from these beds.

As to the stratigraphic correlation of the Korean Pre-Cambrian beds with those in South Manchuria, differing views have been published and many questions remain as yet unsolved. However, it seems reasonable to correlate three sub-divisions of the Korean Sinian system, *i.e.* the Kuken, the Shidōgu and the Chokken,

[6] The fossil bed in question is found in a broad shear zone trending from east to west. In the Chŏngok district in the southern part of Yŏnch'ŏn-gun, a little to the south of the shear zone, there is Lower Jurassic shale with plant fossils, together with conglomerate. According to my observations, the Jurassic beds are intercalated as more or less narrow bands in the complex of mica-schists which belong to the Upper Rensen system described by S. KAWASAKI. The Jurassic beds are generally sheared and often phyllitic, the plane of foliation being parallel to the general trend of the Jurassic bands and to the foliation of the mica-schists. Tectonic contact between the Jurassic bands and the mica-schists is often verified, but the exact position of the contact is often obscure because of the complicated phyllitic structure of both the Jurassic bands and the mica-schists.

That the mica-schists are quite different in age from the Jurassic beds was suggested to me at Munsan, about 25 km sw of the Chŏngok district. At Munsan, there are similar Jurassic beds containing plant fossils with a marked basal conglomerate, and the beds rest with profound clino-unconformity upon a complex of mica-schists apparently similar to those in the Chŏngok district. Is there no room for doubt about the occurrence of the fossil bed reported by YAMAGUCHI?

Another point which needs attention is that there is no possibility of assigning the Rensen system to an age younger than the fossil bed reported by YAMAGUCHI or the Kyūzan formation intercalating the fossil bed. The major portion of the Rensen system is intimately intruded by the gray granite-gneiss, and gneisses quite similar to it are discordantly covered by the Lower Paleozoic Chōsen system or the Upper Proterozoic Shōgen system, in various places of Korea. YAMAGUCHI, however, did not state in his paper that the gray granite-gneiss or the portions of the Rensen system invaded by gneisses are younger than the fossil bed.

with the Nanshan, the Kuantung and the Tahoshangshan of the corresponding South Manchurian section.

The Matenrei system, a representative complex of the Korean Wutai system, may safely be correlated with the Liaoho system of South Manchuria and the Wutai system of North China, and its three sub-divisions, the upper, the middle and the lower, investigated by Y. KINOSAKI (1932, 1938) with the Kaiping, the Tashihchiao and the Hsiangshuitzu series of the Liaoho system in South Manchuria.

The South Manchurian Hsiho series has been correlated with the Tahoshangshan by S. MATSUSHITA (1952) and R. SAITO (1952). There are, however, some doubts about the stratigraphic interpretation of the Hsiho on the opposite side of Chasŏng district in Korea beyond the upper reaches of the Yalu River; in the adjacent Kanggye and Huch'ang districts, the Chōsen system, with fossils, rests directly upon the erosion surface of granite-gneiss and crystalline schists without any intervening Sinian sediments. Similar beds in the Chasŏng district, which are no doubt a continuation of the so-called Hsiho series on the opposite side of the Yalu River, have been compared with the Chōsen system by K. NAKAMURA (1942) and T. KOBAYASHI (1952). It seems more probable that the series under consideration in these districts correspond either to the Chōsen system, as NAKAMURA and KOBAYASHI insist, or to a part of the Wutai system which was not intensely metamorphosed, as in the case of the Jōsuiyō series of the Korean Wutai system along the lower reaches of the Yalu River.

Pre-Cambrian Granites in Korea

There are more difficult and important problems in the chronological interpretation of Pre-Cambrian granites in Korea.

S. NAKAMURA proposed the term "Kokulian granite" for Korean pre-Sinian granites except the Seikoshin gneiss in Hamhŭng district, South Hamgyŏng-do, which is clearly later than the Kokulian in origin. The granite has gray to dark gray feldspars with large crystals of grayish microcline sporadically scattered in the rock and often has garnet, cordierite, graphite or tourmaline as important accessories; its quartz is commonly gray, sometimes rose and occasionally tinged with violet. The rock generally contains many accidental xenoliths, mostly of sedimentary origin, and exhibits a more or less distinct banded flow structure.

Such granites are discordantly covered by Lower Cambrian beds of the Chōsen system in various places in Korea and have been well known among Korean geologists under the name of "gray granite-gneiss," the typical granite being the Kankō gneiss which the writer (1926) discovered in the Hamhŭng district, South Hamgyŏng-do.

The Kokulian granite has been often correlated with the Kungchangling granite of South Manchuria or the Taishan granite of North China. But it is highly probable that granites quite different in age have been imprudently grouped together under the term Kokulian granite. The author is of the opinion that the granite should be classified into at least two large groups: the younger (Proterozoic) intruded into the Wutai and the Rensen systems but the older (Archean?) intruded into only the Rensen system and may be discordantly covered by the Wutai, although the chronological as well as stratigraphical relationship between these two groups has not actually been verified.

Other Pre-Cambrian granites in Korea which may belong to the younger group are the tourmaline granite and the schistose granite of P'ungsan-gun, South Hamgyŏngdo described by Y. Kinosaki (1938) and the red granite described by S. Kawasaki (1916); the latter includes Koho granite, Ryūyōri granite and Meisen schistose granite, all discussed by Y. Kinosaki (1932), together with the schistose granite of the Ch'ilbo-san district reported by the author (1925). All of these examples were found within or adjacent to the extensive terrain of the Matenrei system, and in places piercing the latter or enclosing xenoliths of crystalline schists which are more or less lithologically similar to the Matenrei system.

Of the granites enumerated above, some types described by Y. Kinosaki do not differ essentially from the Kankō gneiss of Hamhŭng district, while the others differ by having reddish instead of gray to dark gray feldspars.

Classified with those granites is the Ritsura granite described by S. Matsushita (1943) in the central part of Hwanghae-do, which is covered unconformably by the Shōgen system.

Examples of the older group of granites are found intricately intruding into the Rensen system. In my study, however, the granite presumably of the older group could not be distinguished in lithological character from the gray granite-gneiss of the younger group. The areal distribution of the older granites, therefore, has remained quite uncertain.

One more example that suggests Pre-Cambrian igneous activity in Korea is the nepheline syenite of P'yŏnggang district in the northern part of Kangwŏn-do.

The extensive terrain extending from Kŭmch'ŏn district of Hwanghae-do easterly to Kŭmhwa district, Kangwŏn-do, throughout P'yŏnggang district, is occupied largely by thick beds of mica-schists, phyllite, limestone and dolomite, with intercalating manganese beds. These beds lack fossils but probably belong to the Shōgen system as previously designated by S. Nakamura. The strata are undoubtedly intruded by masses and dikes of nepheline syenite with more or less distinct gneissic structure. The Pre-Cambrian origin of the syenite may be suggested by the fact that no examples with the gneissic structure seen in the nepheline syenite are known among the rocks intruding the Paleozoic or later strata in Korea. In short, if the thick beds truly belong to the Shōgen, as is highly probable, the writer does not hesitate to designate the age of the nepheline syenite as Pre-Cambrian. However, so far as the stratigraphic hiatus in the upper part of Shōgen system is taken into consideration, the age of the syenite may not be settled, because the relation between the syenite and the upper part of Shōgen system has not been clarified. In this paper I have tentatively considered the syenite to be of an age corresponding to the interval in the upper part of the Shōgen system, viz., between the Kuken and Shidōgu series.

In gneissic structure, the syenite is comparable to the Seikoshin gneiss which is clearly younger than the gray granite-gneiss (Kankō gneiss) in the Hamhŭng district.

Pre-Cambrian granites are known as Kungchangling and Tuimenshan granites in South Manchuria, and Taoke and Taishan granites in North China. At present there seems to be no doubt that the Kungchangling and Taoke granites originated later than the Tuimenshan and Taishan granites.

Kungchangling granite has been correlated with the Taishan granite by S. MATSUSHITA (1952). R. SAITO (1952), however, classified the former into a younger, Hsienglushan granite and an older, Hsiaolikou granite and correlated them with the Taoke and Taishan granites of North China.

Provisional conclusions about the chronological interpretation of granites in Korea, South Manchuria and North China are shown in the following table.

Upper Proterozoic	Sinian system in a narrow sense (Kuken series of the Shōgen system in Korea)
	Nepheline syenite and Seikoshin gneiss of Korea; Kungchangling granite in part, namely Hsienglushan granite of South Manchuria; Taoke granite of North China
	Huto system (Shidōgu and Chokken series of the Shōgen system in Korea)
Lower Proterozoic	Kokulian granite in part (Kankō gneiss), Red granite and Ritsura granite of Korea; Kungchangling granite in part, namely Hsiaolikou granite of South Manchuria; Taishan granite of North China
	Wutai system (Crystalline schists series of the Matenrei, the Yokusen and the Jōsuiyō in Korea)
Archean	Kokulian granite in part of Korea; Tuimenshan granite of South Manchuria; "oldest gneissose rocks of North China"
	Rensen system

Synopsis of the Geological Systems of Korea

Subdivision and geological age		Distribution, kind of dominant rocks and thickness	Mineral resources and miscellaneous remarks
Quaternary system	Alluvial series	Sand, gravel, clay and peat, forming alluvial plains and terraces; talus and fan deposits; some besaltic lavas of Cheju-do. Very extensive in distribution, but thin in thickness, generally 30 m or less, except the basaltic lavas.	Placers of gold, magnetite, illmenite and some special heavy minerals, dominated by monazite and zircon; quartz sand and ballstone (for ball-mills), etc.
	(Para- or Clino-unconformity)		
	Pleistocene series	Terrace deposits with mammalian fossils at Tonggwanjin, Chongsŏng-gun, N. Hamgyŏng-do; basaltic lavas and gravel beds on the Kaema plateau in S. and N. Hamgyŏng-do, Koksan-gun, in Hwanghae-do, and Ch'ŏlwŏn district in Kangwŏn-do; basalt flows on the Tertiary sediments in Changgi district, N. Kyŏngsang-do; trachyte flows on the coast of Myŏngch'ŏn district, N. Hamgyŏng-do, and Hamhŭng district, S. Hamgyŏng-do; shell beds (SEIKIHO formation), trachy-andesite and basalt of Cheju-do etc.	Gold placers, diatomite and peat.
(Unknown relation)			
Tertiary (?) system		Diatomite deposits of Anbyon, S. Hamgyŏng-do,[7] and Ch'ŏlwŏn, Kangwŏn-do; lignite beds of Kowŏn-gun and Chongp'yŏng-gun, S. Hamgyŏng-do.	Diatomite and lignite.
(Unknown relation)			
Upper	Shichihōsan (Ch'ilbo-san) series *Pliocene?*	Alkaline liparites, alkaline trachyte, basalt, tuffs, gravel beds, etc., the majority of which belong to the Shichihōsan group in N. Hamgyŏng-do and Tōryūsan group in S. Hamgyŏng-do. Alkaline volcanics of Paektu-san may also belong to the series.	Moonstone in an alkaline rock as a semiprecious stone. The alkaline volcanics are highly variable in petrological nature, the comenditic ones, however, being most common.
	(Clino-Unconformity?)		
Upper	Ennichi (Yonil) series.[8] *M. Miocene*	P'ohang district, N. Kyŏngsang-do. Upper: Shale and siltstone, rich in animal and plant remains. Lower: Conglomerate, sandstone and shale, conglomerate being dominant. Thickness: 600 m or less	Fossils are especially abundant in the Upper, dominant ones being marine molluscs and plants, the majority of the latter being more or less comparable to living species of the warm temperate zone of eastern Asia.

System		Series	N. Kyŏngsang-do	N. Hamgyŏng-do	Remarks
Tertiary System		Epi-Chōkian interval (Stage of peneplanation)	(Clino-unconformity) Strata of the Upper series are in general nearly horizontal or dipping at a very low angle and rarely faulted, while the Middle and Lower series are much disturbed by faults (mostly normal faults), warping and insignificant foldings, the strata generally being tilted at angles of about 20° or less. In some places the sediment of the Middle series is accompanied by flows of basaltic and some other volcanic rocks. Clino-unconformity is clearly observable between the Shichihōzan and Meisen group in North Korea, and between the Ennichi and Chōki series in South Korea.		The main part of the crustal movement which disturbed the older series probably began in the Oligocene. It may represent the Nanling movement, a part of the Himalayan movement in Korea. The Korean movement, however, seems to have a more intimate genetic relationship to the Ōyashima movement of Japan, which is also a part of the Himalayan movement.
	Middle	Chōki[9] (Changgi) series *Miocene～ Oligocene*	Bonkokuri (P'omgong-ni) group: Andesite, liparite, parlite, tuff, conglomerate, sandstone and shale; volcanic rocks being dominant. (Clino-unconformity) Chōki group: Conglomerate, sandstone, shale, various tuffs, coal, diatomite and interstratified basaltic flows; rich in plant remains, the flora being the Arctic Miocene type, somewhat modified; poor in animal remains which are represented by *Vicarya callosa* JENKINS and some other molluscan remains yielded from definite horizons. Thickness (except the basaltic flows): about 1,400 m.	Meisen (Myŏngch'ŏn) group Conglomerate, sandstone, shale, siltstone, coal and interstratified basaltic flows; rich in animal and plant remains, the former being represented by forms of marine molluscs and the latter by a flora which consists largely of forms of Arctic Miocene flora mixed with those comparable to living species of a temperate zone. Thickness: about 1,800 m. (Clino-unconformity)	Coal and diatomite The Chōki group covers a strikingly uneven surface of rocks of the Bukkokuji group, while the basement of the Ryūdō group referred to below is exceedingly flat. The flora of the Chōki series is especially rich in remains of beech (*Fagus*), containing various forms of the genus.

			Ryūdō (Yong-dong) group: Upper: Thick accumulation of basaltic lavas and basaltic tuffs, tuff breccia, and thin beds of sandstone. Lower: Shale, sandstone, conglomerate and coal; rich in plant remains. The fossils flora is of the Arctic Miocene type. Thickness of the Lower: 600 m or less.	Coal and clays ("Gairome" and "Kibushi"), the coal being important in the northeastern part of Korea.
		(Unknown relation)		
	Lower	Hōzan (Pongsan) series *Upper Eocene*	Hwanghae-do Conglomerate, sandstone, shale and coal; rich in animal and plant remains, the former being represented by fresh water molluscs and some mammalian species and the latter by flora of the Arctic Miocene type. The Tertiary beds constructing the Anju coal-field of S. P'yŏngan-do may belong to this series. Thickness: over 350 m.	Coal of the Hōzan (Pong-san) series with that of the Anju coal field are important in the coastal regions facing the Yellow Sea.
Epi-Bukkokujian interval (Stage of epeirogenic movements and widespread peneplanation–Peitai stage)	(Unknown relation)		The crustal movements are considered to have begun at the beginning of the Rakutō series and lasted in the block movements closely accompanied by widespread eruption of the comagmatic acidic rocks of the Bukkokuji group, the last phase of the movements being the Bukkokuji disturbance. The disturbance was preceded by two phases of subsidence of regional or isolated basins, the Rakuto and Shiragi phases respectively. During the Shiragi phase an enormous amount of intermediate or rather basic lavas were poured out. The Bukkokuji phase was followed by a stage of peneplanation, the remnant of the peneplain being observable in very limited patterns on the Kaema plateau and on tops of high mountains in various places in Korea.	The phases of the crustal movements may represent the East Asiatic Yenshanian movement in Korea and its prolongation. The last phase, viz., the Bukkokuji disturbance, may be correlated with the North American Laramide Revolution.
		Bukkokuji (Pulguk-sa) series *Eocene?~ Uppermost Cretaceous*	Bukkokuji group: N. and S. Kyŏngsang-do, N. and S. Chŏlla-do N. Ch'ungch'ŏng-do, N. and S. P'yŏngan-do, etc. Granite, grano-diorite, diorite, liparite, feldspar porphyry and various dike rocks; granite, liparite and feldspar porphyry prevail; liparite and feldspar porphyry are generally dark gray, dark brown or dark green in colour and often show flow structure, and are grouped under the name of black felsophyre.	Various kinds of deposits of gold, tungsten, molybdenum, lead, zinc, copper, fluorite, alunite, etc. are found in close association with the intrusives of this group, the age of the Bukkokujian igneous activity being the most important metallogenetic epoch in Korea.

		The granite piercing the Taishū group may also belong to this group.	
		(Intrusive contact)	
		Taishū group: Tsushima (Japan), S. Cholla-do (?), S. Kyŏngsang-do (?) Shale, mudstone and sandstone, often with ripple marks and sun cracks; molluscan (mostly fresh water species) and plant remains (mostly dicotyledonous) are sparingly preserved. In Korea, it is often accompanied by tuffs. Thickness: over 600 m in Tsushima.	The chronological relationship between the Bukkokuji and Taishū groups seems to be more intricate than is shown in this table. In other words, the two groups seem to be partly contemporaneous and stratigraphically inseparable with each other.
Keishō (Kyŏngsang) system *Eocene?*～ *L. Cretaceous* or *U. Jurassic*	(Para-unconformity?) Shiragi (Silla) series *U. Cretaceous*	N. and S. Kyŏngsang-do, N. and S. Chŏlla-do, N. and S. Ch'ungch'ŏng-do, Hwanghae-do, S. P'yŏngan-do, etc. Shale, mudstone, sandstone, conglomerate, tuff, tuff breccia and andesite; often reddish, purplish or greenish; ripple marks and sun cracks are very common; generally poor in fossils, but a rich dicotyledonous fossil flora was yielded from a black shale in the upper part of the series; animal remains are represented by non-marine molluscs and *Estheria*. Thickness (except andesitic flows): over 3,000 m in N. Kyŏngsang-do.	The series has a thick bed of conglomerate at the base and is accompanied by thick accumulations of andesitic lavas, intercalated, or constructing the top of the series. Various terms for the series in various districts in Korea have been suggested, for instance, Upper Daidō formation or Taihō (Taebong) system in the districts along the Taedong-gang, Chin-an series in N. Chŏlla-do, and Eidō series, excluding its lowest subdivision, in N. Ch'ungch'ŏng-do.
	Rakutō (Naktong) series *L. Cretaceous* or *L. Cretaceous*～ *U. Jurassic*	N. and S. Kyŏngsang-do, N. Ch'ŭngch'ŏng-do, N. P'yŏngan-do. Shale, sandstone, conglomerate and inferior anthracite, with a striking bed of basal conglomerate; shale and sandstone, often reddish. Except for the reddish beds, the series is rich in remains of non-marine molluscs and plant fossils; ripple marks are seen in places. Thickness: over 3,950 m in N. Kyŏngsang-do.	The series is divided into two red and two blackish formations in alternation, with a blackish formation at the base. The basal formation is especially rich in remains of plants (Nakong flora) and non-marine molluscs, and corresponds to the Naktong (Rakutō) series, in a strict sense, by H. YABE.
Epi-Daidoan interval	(Clino-unconformity)	The strata of the Keishō system are generally tilted at low angles, less than 30°, or nearly horizontal, but show no marked folding; while the Daidō system is strongly disturbed by conspicuous foldings and reverse faults or over-thrusts. The orogenic movements which disturbed the Daidō system were great and widespread, and were preceded by phases of subsiding movement of basins where the Daidō sediments were laid down.	The disturbance has been known under the name of Taihoan by E. KONNO and may be chronologically correlated with that of the Ōga phase in Japan. It is interpreted as the first orogenic phase of the East Asiatic Yenshanian movement in Korea.

Daidō (Taedong) system *M. Jurassic~ L. Jurassic*	Daidō series	N. and S. Ch'ŭngch'ŏng-do, Kyŏnggi-do, Kangwŏn-do, Hwanghae-do, N. and S. P'yŏngan-do, S. Hamgyŏng-do. Shale, sandstone and conglomerate in alternation; sandstone and shale most prevailing; often with anthracite seams intercalated; rich in plant remains. Thickness: about 2,650 m in S. Ch'ŭngch'ŏng-do.	Anthracite seams are workable in places, but not important in Korea. The series in the districts along the Taedong-gang has been called the Lower Daidō formation.
Epi-Heian interval	(Clino-unconformity)	The orogenic movement which resulted in this clino-unconformity is known as the Shōrin disturbance. The disturbance does not seem to differ in any essential characteristic structure from the Taiho disturbance, but is far smaller in scale than the latter. However, it is noteworthy that Korea has not been extensively covered by marine water since this disturbance.	The disturbance is thought to have begun in a later stage of the Heian system. It may be chronologically correlated with the Akiyoshi disturbance in Japan.
Heian (P'yŏngan) system[10] *Triassic~ M. Carboniferous*	Green series *Triassic*	S. P'yŏngan-do, Kangwŏn-do, N. Ch'ŭngch'ŏng-do, N. Kyŏngsang-do and S. Hamgyŏng-do. Sandstone, shale and conglomerate; sandstone, dark green to dark gray, rarely reddish, prevails. The Red formation, well known as the Taishiin series in the P'yŏngyang coal field, S. P'yŏngan-do, has been often correlated to the Green series, but the stratigraphic relationship between them is quite uncertain. The Red formation rarely contains silicified wood. Thickness: over 1,000 m in S. P'yŏngan-do (over 1,700 m in the Taishiin series)	
	Kōbōsan (Kobangsan) series *Triassic* or *Up. Permian* (or *Permo-Triassic*)	S. P'yŏngan-do, Kangwŏn-do, N. Ch'ŭngch'ŏng-do, N. Kyŏngsang-do and S. Hamgyŏng-do. Sandstone, shale, conglomerate and anthracite; sandstone and shale prevail; rich fossil flora of a Mesozoic type has been yielded. Thickness: 350–500 m in S. Pyŏngan-do; 700 m in Kangwŏn-do.	Anthracite
	Upper Jidō (Sa-dong) series *L. Permian* (*Artinskian*)	S. Pyŏngan-do, Kangwŏn-do, N. Ch'ŭngch'ŏng-do, N. Kyŏngsang-do and S. Hamgyŏng-do. Sandstone, shale and anthracite. The shale is generally carbonaceous and in cases strikingly aluminous; rich in plant and animal remains. Thickness: 30–100 m in S. P'yŏngan-do.	Anthracite of this series is very important in Korea. Aluminous shale is also important as a fire clay.
	Lower Jidō series *L. Permian* (*Sakmarian*)	S. P'yŏngan-do, Kangwŏn-do, N. Chŭngch'ŏngdo, N. Kyŏngsang-do and S. Hamgyŏng-do. Shale, sandstone, hornstone, limestone and anthracite; shale and sandstone are generally carbonaceous; rich in plant and animal remains. Thickness: 100–150 m in S. P'yŏngan-do.	Anthracite

		Epi-Kōten interval	(Para-unconformity?)	The para-unconformity is suggested paleontologically, but has not been stratigraphically verified as yet.	
		Kōten (Hongjŏm) series *M. Carboniferous* (*Muscovian*)		S. P'yŏngan-do, Kangwŏn-do, N. Ch'ŭngch'ŏng-do, N. Kyŏngsang-do and S. Hamgyŏng-do. Sandstone, shale, hornstone, conglomerate and limestone; limestone prevails; sandstone and shale are often reddish; rich in animal remains (marine), but exceedingly poor in plant remains. Thickness: 250–300 m in S. P'yŏngan-do.	
Epi-Chōsen interval. (Stage of widespread epeirogenic movement and peneplanation—Rakurō stage)	(Para-unconformity)			The para-unconformity was long believed to be so great as to indicate the age of dry land ranging from the U. Ordovician to the L. Carboniferous. However, the existence of the Silurian limestone was suggested in 1934 from the derived fossils discovered in the basal conglomerate of the Jurassic Daidō series in Hwanghae-do, and then coralline fossils, probably indicating the Devonian, were unexpectedly discovered in a limestone block on the ground in Sunch'ŏn-gun, S. P'yŏngan-do, although the limestones from which the above fossils were derived have not actually been disclosed as yet.	Doubtful fossils which suggest the Silurian have recently been discovered in a thin bed consisting of arenaceous clay slate and limestone in Kŭmch'ŏn-gun, Hwanghae-do.
Chōsen (Chosŏn) system *M. Ordovician*∼ *L. Cambrian*	Great Limestone series	Bantatsu (Mandal) series *M. Ordovician*		N. and S. P'yŏngan-do, Hwanghae-do, Kangwŏn-do, N. Kyŏngsang-do and S. Hamgyŏng-do. Limestone, mostly massive; rich in animal remains, predominantly remains of cephalopods and molluscs. The uppermost portion lacks fossils. Thickness: about 600 m in S. P'yŏngan-do.	Limestone is important as a raw material for cement manufacturing and some chemical industries in Korea. Paleontologically the series corresponds to T. KOBAYASHI's Toufangian series (Caradocian—Llandelian)
		Sozan (Ch'osan) series *L. Ordovician*∼ *M. Cambrian*		N. and S. P'yŏngan-do, Hwanghae-do, Kangwŏn-do, N. Kyŏngsang-do and S. Hamgyŏng-do. Limestone, siliceous limestone, dolomite, shale and clay slate; more or less impure limestone prevailing. The limestone is thinly bedded, often carbonaceous and variable in lithological characteristics, including oolitic, cryptozoon (*Collenia?*) and vermicular limestones; the base consists of a thin but persistent bed of black shale (Rinson shale) rich in Middle Cambrian fossils. In general, the series is fairly rich in remains of Crustacea and others. Marine algae is known as a representative plant remains. Thickness: 900 m in S. P'yŏngan-do.	Paleontologically the upper and middle parts of the series correspond to T. KOBAYASHI's Wolungian (Skiddavian) and Wanwanian (Tremadocian) series, respectively.

	Yōtoku (Yangdŏk) series *M. Cambrian~ L. Cambrian*	N. and S. P'yŏngan-do, Kangwŏn-do, Hwanghae-do, N. Kyŏngsang-do and S. Hamgyŏng-do. Sandstone, shale, clay slate, quartzite and thin beds or lenses of limestone; shale prevails and is often sandy, rarely dark reddish; the base consists generally of quartzite, variable in thickness; shale, sandstone and limestone lenses are often rich in remains of Crustacea and Brachiopoda. Thickness: 400 m in S. P'yŏngan-do; 550 m in Kangwŏn-do.	
(Para- or Clino-unconformity)			
Sinian system *Upper-Proterozoic*	Kuken (Kuhyŏn) series	S. P'yŏngan-do, Hwanghae-do, Kangwŏn-do? and S. Hamgyŏng-do? Clay slate, shale, phyllite, pebbly phyllite (tillite?), quartzite and limestone; shale and phyllite dominates. Clay slate and shale often blackish. *Collenia* limestone is found in the basal horizon in some places. Thickness: 1,500 m in Hwanghae-do.	Insignificant iron formations in Kangdong district, S. P'yŏngan-do; marble, rosy or reddish orange, in Sŏngch'ŏn district, S. P'yŏngan-do; manganese deposits in Anhyop and Kŭmhwa districts, Kangwoñ-do.
	(Unknown relation)		
Sinian intrusive rocks		Nepheline syenite of P'yŏnggang district, Kangwŏn-do and hornblende-biotite granite (Seikoshin gneiss) of Hamhŭng district, S. Hamgyŏng-do.	Sodalite in the syenite (sub-precious stone)
	(Intrusive contact? Para- or clino-unconformity between the Kuken and Shidōgu series)		
Huto system *Upper-Proterozoic*	Shidōgū (Sadangu) series	S. P'yŏngan-do, Hwanghae-do, Kangwŏn-do? and S. Hamgyŏng-do? Essentially limestone and dolomite with thin beds of clay slate intercalated; thin beds of *Collenia* limestone are found at the middle and uppermost horizons. Thickness: 2,000–2,400 m in Hwanghae-do; 1,500 m in S. P'yŏngan-do.	Marble
	Chokken (Chik-hyŏn) series	S. P'yŏngan-do, Hwanghae-do, Kangwŏn-do? and S. Hamgyŏng-do? Clay slate, phyllite, mica-schist, quartzite and limestone, with conspicuous beds of quartzite generally at base. Thickness: 3,100–3,800 m in Hwanghae-do; 700 m in S. P'yŏngan-do.	
Epi-Kokulian interval (Stage of peneplanation?)	(Para or clino-unconformity)	The interval is suggested by observations in Sŏngch'ŏn-gun and Sangwŏn district of Chunghwa-gun, S. P'yŏngan-do, where the Chokken series rests directly upon a complex consisting of mica-schists or gray granite-gneiss.	In the chronological column of Korea, the interval may occupy a very wide range.

Lower Proterozoic granites		A part of the Kokulian granite or the gray granite-gneiss: tourmaline granite and schistose granite of P'ungsan-gun in S. Hamgyŏng-do, and Kankō gneiss of Hamhŭng district in S. Hamgyŏng-do. Red granite: Ryūyori (Yongyang-ni) granite of Tanch'ŏn-gun in S. Hamgyŏng-do, Meisen (Myŏngch'ŏn) schistose granite of the northwestern part of Myŏngch'ŏn-gun, N. Hamgyŏng-do, and schistose granite of the Ch'ilbo-san district in Myŏngch'ŏn-gun, N. Hamgyŏng-do. Ritsura granite in the central part of Hwanghae-do.	Crystalline graphite and micas (phlogopite is most important), chiefly in North Korea. Pegmatite dikes of Red granite often contain zircon and allanite, and dikes of gray granite-gneiss in Yongch'ŏn-gun, N. P'yŏngan-do contain large crystals of monazite.
(Intrusive contact)			
Wutai system *Lower Proterozoic*	Jōsuiyō (Sangsuryang) series[11]	Ch'angsŏng-gun, Sakchu-gun and Ŭiju-gun, N. P'yŏngan-do. Sandstone, hornfels, clay slate, mica-schist, epidote schist, limestone, dolomite and quartzite; base unknown. Thickness: over 4,800 m in Ŭiju-gun.	Crystalline graphite and sillimanite.
	(Unknown relation. Almost contemporaneous?)		
	Yokusen (Okch'ŏn) system[12]	N. and S. Ch'ŭngch'ŏng-do and N. Chŏlla-do. Upper: Sandstone, hornfels, phyllite, mica-schist, conglomerate, quartzite, hornblendite, limestone and iron formations. Of these, phyllite is most common. A thick bed of phyllite contains sparingly angular or subangular pebbles of quartzose rocks and seems comparable to tillite in its rock nature. Middle: Amphibole schist, limestone, mica-schist, phyllite and hornfels; limestone and amphibole schist being dominant. Lower: Sandstone, hornfels, metamorphosed clay slate and quartzite; the metamorphosed clay slate is often accompanied by deposits of earthy graphite. The base is not known. Thickness: very thick.	Earthy graphite and iron.
	(Unknown relation. Almost contemporaneous?)		
	Matenrei (Mach'ollyŏng) system[13]	N. and S. Hamgyŏng-do. Upper: Mica-schist, limestone, dolomite and various gneisses, the mica-schist being dominant. Middle: Limestone, dolomite, magnesite and mica-schist; limestone and dolomite prevail. A *Collenia* limestone is found intercalated in a middle horizon. Lower: Mica-schist, graphite schist, quartzite and dolomite; the mica-schist prevails; base unknown. Thickness: over 9,100 m.	Magnesite deposits, very large in scale; crystalline graphite; apatite. The large scale iron formation of Musan, N. Hamgyong-do is thought to be of the system, but is quite uncertain.

Ep-Archean interval		The interval has not been actually verified.	
Archean granites		A part of the Kokulian granite in the terrain of the Rensen system at least.	At present, it can not be differentiated petrographically from the grey granite-gneiss of the Lower Proterozoic age.
	(Intrusive contact)		
Rensen (Yonch'ŏn) system *Archean*		Kyŏnggi-do, S. Ch'ŭngch'ŏng-do and Kangwŏn-do. Upper: Mica-schist, phyllite and micaceous hornfels. Lower: Mica-schist, amphibole schist, hornblende pyroxene hornfels, quartzite and siliceous limestone, together with iron formations. Base unknown. Thickness: very thick.	Iron and sillimanite (cyanite).

7) According to B. V. Skvortzov, the diatom remains of Anbyŏn suggest the Upper Pliocene.
Skvortzov, B. V., 1936, The Neogene diatoms from the Ampen district, S. Kankyō-do, eastern coast of Chōsen: Bull. Geol. Surv. Chōsen v. 12.

8) The boulder deposits (Shinkō formation) unconformably resting upon the Chōki series (Chōhōri formation) in Sinhŭng district, S. Hamgyŏng-do, probably belong to the Ennichi series and may represent an early stage of it.

9) The major part of the Tertiary formations along the Tuman-gang, N. Hamgyŏng-do, are divided by a distinct unconformity into the Yūsen (Yusŏn) and Kōei (Haengyŏng) formations, which may be correlated with the Ryūdo and Meisen groups. Formations which may belong to the Chōki series commonly have coal seams and are found also in the Sinhŭng district (Chōhōri formation) of S. Hamgyŏng-do, the Tonch'ŏn district in the northern part of Kangwŏn-do, and the Samch'ŏk district in the southern part of Kangwŏn-do.

10) The Heian system in Korea corresponds to the South Manchurian type of Upper Paleozoic system of Manchuria. Another type of Manchurian Upper Paleozoic, the North Manchurian type, is represented in Korea by a thick series of shale and sandstone in the Tuman-gang river basin, and considered to be an extension of the Tuman formation, one of the North Manchurian Upper Paleozoic series.

11) Originally crystalline schists in the Ch'angsŏng and Sakchu districts were included in the series by Sh. Nakamura (Mineral Resources of Chōsen, v. 1, 1915). In comparison, the crystalline schists of neighboring Ŭiju district (E. Takahashi, Ŭiju sheet, scales 1:200,000, 1940) are not so intensely metamorphosed, but are considered part of the terrain of crystalline schists extending from Ch'angsŏng and Sakchu districts.

12) The Yokusen system comprises various metamorphosed sedimentaries as shown in the table and occupies an extensive belt, trending northeasterly through Okch'ŏn district in South Korea. A certain portion of the strata included in the Okch'ŏn series may belong to the Heian system, as pointed out by N. Kobatake (N. Kobatake: Considerations on the Yokusen [Okch'ŏn] system, *Sci. Rep. South Branch School, Ōsaka Univ.*, no. 1, 1952), and in other cases it can hardly be differentiated from the Cretaceous Shiragi series which suffered metamorphism through contact with the granite which invaded the series (Shimamura, S., Geol. Atlas of Chōsen, no. 5, 1925). However, the pre-Sinian age of the essential portion of the complex is suggested by the fact that the complex is invaded in some places by gray granite-gneiss (Nakamura, S., Mineral resources of Korea, v. 8, 1925).

13) According to Sh. Nakamura, it is highly possible that the Matenrei system in part in the northern part of S. Hamgyŏng-do belongs to the Chōsen system. The question, however, has remained unsolved.

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