EXPLANATORY TEXT
FOR TECTONIC MAP OF KOREA

1:1,000,000 scale

Edited by Dr., Assistant Prof. Ri Juk Nam and
Asso. Dr. Ri Jong Chol

Cartographic Design and Production by
Choe Nam and Ri Sil Hun

Central Geological Survey of Mineral Resources
Ministry of Natural Resources Development

Pyongyang

Democratic People's Republic of Korea

1994

CONTENTS

PREFACE

This text, attached to the 1:1,000,000 scale Tectonic Map of Korea, summarises the tectonic features of Korea. This is the first official tectonic map published in English by the authority of the Democratic People's Republic of Korea in order to accommodate the need of overseas scientists and organizations.

As detailed in another pair text (Geological Map of Korea), Korea's geological survey started from almost zero: When Korea became free from Japanese imperialists in 1945, there were only a few geologists, and none of satisfactory geological maps existed.

A large stride in geological survey has been made in the last half century, and today our work to exploit mineral resources has reached its highest stage of progress. The great achievements have been attained by the Juche Idea.

The present tectonic map is firmly grounded on vast amounts of field and laboratory works. It has largely revised and up-graded the former version of "Tectonic Map of Korea" published in 1970 in Korean language, and contains many new informations and concepts. These new informations were brought to light during geological surveys to inventory all mineral resources and to study regularities that control their distribution in 1970s and 1980s.

The major highlights of new discoveries are as follows:

1. The geosynclinal Devonian-Carboniferous Rimjin System has been newly added in the central Korean Peninsula, indicating that the Korean Peninsula is not a single old massif.
2. Upper Ordovician and Silurian formations have been discovered in the Korea-China Paraplatform sedimentary cover.
3. Mesozoic and Cenozoic tectonic movements in Korea are characterized by superimposed vertical block movement, different from typical geosynclinal or platform tectonics.
4. The areas of the Mesozoic and Cenozoic tectonic movements coincide with those of active neotectonics. Therefore, the topographic features of Korea as seen today have been primarily derived directly from neotectonic activities.

I. MAJOR CHARACTERISTICS OF TECTONIC EVOLUTION OF KOREA

The Korean Peninsula, situated on the eastern fringe of the Asian continent, may be tectonically regarded as a geological-tectonical concentration of East Asia. The geological constitution of Korea is so much variegated and the characteristics of its tectonic evolution are unique.

At the end of the Late Proterozoic era, most of the crust turned into more stable zones similar to the platform by a powerful tectonic movement (the Ongjin Orogenic Movement). Even after Late Proterozoic, however, individual areas of the paraplatform again became mobile-belts similar to geosyncline or parageosyncline.

During the Late Proterozoic (including the Riphean), the central part (the Haeju Subsidence in the Phyongnam Synclinorium) and the northeastern part (the Hyesan-Riwon Subsidence in the Rangrim Anticlinorium) of our country became the subsidence region similar to parageosyncline by a large-amplitude rhythmic movement. Marine sediments with clear rhythmic cycle were accumulated, and volcanism and stratiform intrusive activities also took place in these basins.

During this time, the carbonate-dominated Sangwon Group (south type, see text for Geological Map of Korea) was formed with the thickness of over 8,000 m. If the Kuhyon Group is added, the Upper Proterozoic sediments in Korea reach nearly 10,000 m in thickness.

During the Early Paleozoic, however, all regions of our country were in a state of platform and went through the typical stage of platform-type development.

The Lower Paleozoic Erathem including the Silurian system forms the typical sedimentary cover. The discovery of the Upper Ordovician and Silurian systems in 1975-1976 required to revise formerly-held views on the constitution of sedimentary cover in Korea-China Paraplatform and its age.

Before the discovery, it had been generally believed that the Korea-China Paraplatform was subaerially exposed during the Middle Ordovician to the Middle Carboniferous.

In the Devonian period, individual regions which had been in the state of platform were reactivated and turned into the geosynclinal-type mobile-belt again.

This is the Rimjingang Foldbelt which covers the southern part of South Hwanghae Province, the city of Kaesong, middle part of North Hwanghae and Kangwon Provinces. The foldbelt develops with an E-W strike.

In the Devonian, thick marine sedimentary piles, mafic and intermediate (green schist) and felsic volcanic piles accumulated in the foldbelt, and a strong folding and a local magmatism followed.

Geosyncline-type foldbelt was also formed during the late Paleozoic. This is the Hambuk Foldbelt in the northeastern Korea, which is connected with the Hercynian Foldbelt covering the Chinese and Russian coastal areas.

Thick Permian sedimentary and mafic-intermediate volcanic piles were accumulated in the Hambuk Foldbelt. The intrusive activities of ultramafic rocks of ophiolite series and granitoids widely developed and the deposits were strongly folded and metamorphosed.

The Korea-China Paraplatform suffered twice from geosynclinal activities during the Middle to the Late Paleozoic. Further consideration should be given to the large scale subsidence during the Late Proterozoic that resulted in the over 8000 m thick sediments.

During the Mesozoic, all the regions of the country suffered many times from strong tectonic movements. Under their influence the Archean and Lower Proterozoic metamorphic complexes forming folded basements as well as the sedimentary covers of the paraplatform were intensively folded and metamorphosed.

The Mesozoic tectonic movements took place widely regardless of the tectonic units formed earlier. During the Mesozoic tectonic movements, sedimentary covers on the paraplatform were folded and deformed. Many tectonic basins were formed, in which thick terrigenous sedimentary-volcanic piles were accumulated. Along with these, there occurred many fault-type intrusive activities.

As stated above, the Mesozoic tectonic movements are characterized by the appearance of fault blocks, and thus differ from the geosyncline-type tectonic movements that took place in Paleozoic.

The fault-block movements which began from the Mesozoic continued into the Cenozoic, well reflected in neotectonic movements.

The stages of the crustal development in our country are synthetically shown in Fig. 2. Such a complex process of the

Tectonic Cycles of Korea

Fig.2

Era		Age Ma	Period	Epoch	Tect. Cycle	Intrusives	Tect. Mvnt.
Cenozoic		1.5 ± 0.5	Q	Q_{1-4}	Ryanggang	Hoeryong	Neotectonic
		9 ± 3	N	N_2			
				N_1	Hamgyong		
		25 ± 2	₽	₽$_3$		Chilbosan	Cenozoic
		37 ± 2		₽$_2$	Anju		
		58 ± 4		₽$_1$		Hangmusan	Hangmusan
Mesozoic		67 ± 5	K	K_2	Taebo		
				K_1		Amnokgang	Jaeryong
		110 - 120	J	J_3	Jasong		
				J_2		Tanchon	Taebo
				J_1	Taedong		
		195 ± 5	T	T_3			Songrim
				T_2			Tumangang
				T_1		Tuman	
Paleozoic	Upper	245 ± 10	P	P_2	Phyongan / Tuman	Chongjin	
				P_1			
		285 ± 10	C	C_3			
				C_2			Rimjingang
				C_1			
	Middle	345 ± 10	D	D_3	Rimjin	Namgang	
				D_2			
				D_1			Erosion
		400 ± 10	S	S_2			
				S_1			
	Lower	440 ± 10	O	O_3			
				O_2	Hwangju		
				O_1			
		500 ± 14	€	€$_3$			
				€$_2$			
				€$_1$			Erosion
Proterozoic	Upper	550	PR_3^2 (V)		Kuhyon		Myoraksan
		580 - 600	PR_3^1		South Sangwon	Yonsan	Ongjin
	Middle	1000 - 1100	PR_2		North Sangwon	Ongjin, Pyoksong	Machonryong
	Lower	1600 - 1700	PR_1		Machon - ryong	Riwon, Sakju	Ryonhwasan
Archean		2500 - 2600	AR		Rangrim	Ryonhwasan, Andol	

crustal development shows that the Korea-China Paraplatform differs from the platform or geosyncline in a typical classical sense.

Therefore, we are going to apply several principles as shown in Fig. 3 in dividing tectonic units in order to reflect such unique structural features in making the tectonic map.

II. PRINCIPLES EMPLOYED IN DIVIDING TECTONIC PROVINCES

1. Division of provinces based on the age of major folding or orogeny.

This is the principle of division with regard to tectonic province which has been traditionally applied in many countries. It is used in dividing tectonic areas based on the age of tectonic movement when the mobile-belt (a geosynclinal area for example) was changed into a stable area (similar to a platform).

In accordance with this principle, we grouped tectonic areas into foldbelts formed before the Late Proterozoic (the massifs of the Korea-China Paraplatform), in the Middle Paleozoic (Rimjingang Foldbelt) and in the Late Paleozoic (Hambuk Foldbelt), as seen in Tab. 1.

As mentioned above, it is especially significant in making the tectonic map of East Asia and, in particular, the Korea-China Paraplatform, that the Middle Paleozoic foldbelt has been placed in the central part of Korea (as done in 1964 tectonic map of Korea).

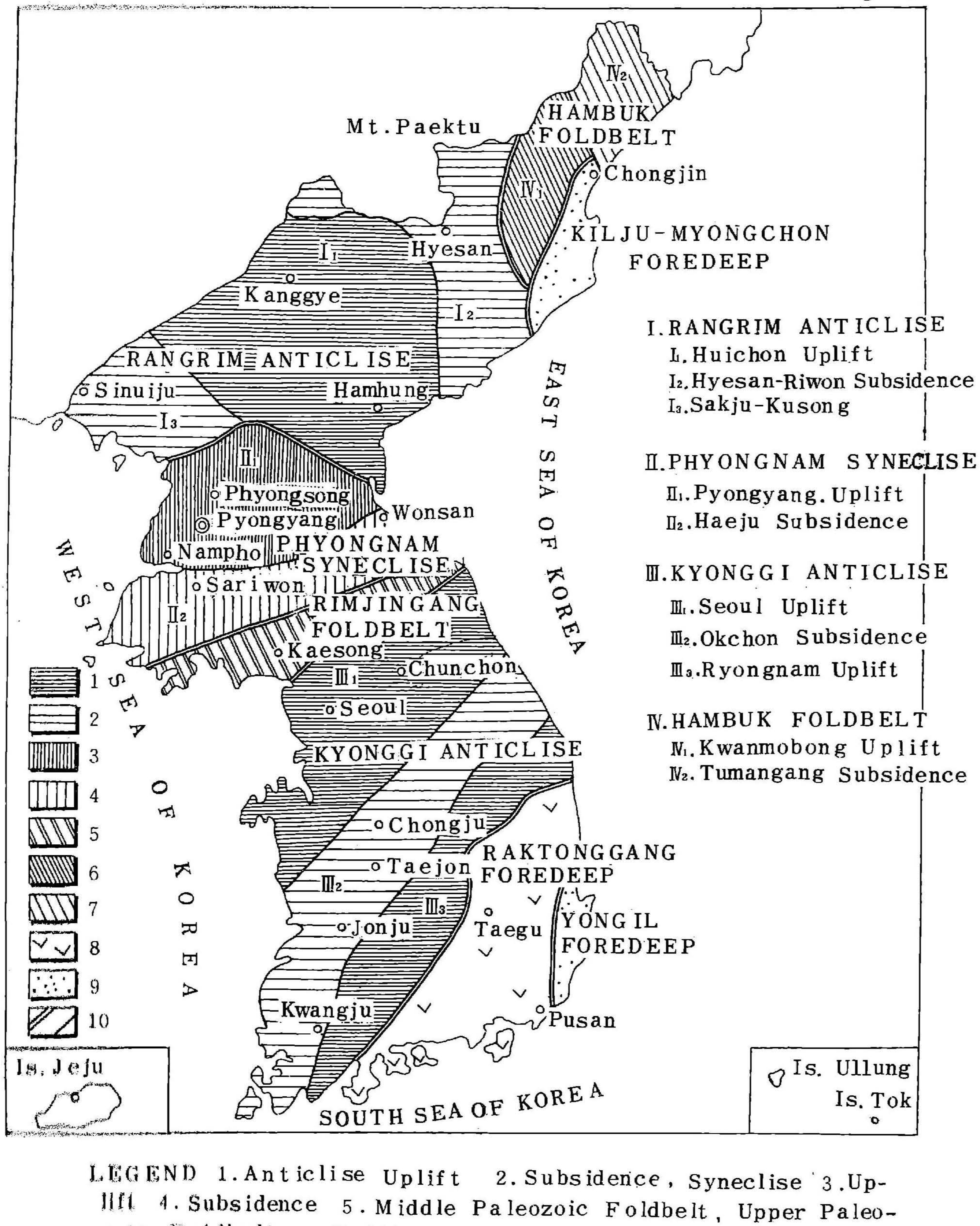
Foredeeps were established as main tectonic provinces on the new tectonic map. They may be regarded as tectonic regions having come into being under the influence of the Meso-Cenozoic Circum Pacific Foldbelt.

There, thick marine and terrestrial sedimentary rocks were deposited with felsic-intermediate volcanic rocks. It accompanied magmatism without strong folding.

Unlike the Meso-Cenozoic superimposed structures on land, the foredeeps occupy coastal regions in contact with the Korea East Sea, forming distinct belts.

The Cenozoic foredeeps are in Kilju-Myongchon and Yongil regions. They are geographically apart from each other, but are

Tectonic Units of Korea Fig. 3



LEGEND 1.Anticlise Uplift 2.Subsidence, Syneclise 3.Uplift 4.Subsidence 5.Middle Paleozoic Foldbelt, Upper Paleozoic Foldbelt 6.Uplift 7.Subsidence 8.Mesozoic Foredeep 9.Cenozoic Foredeep 10.Boundaries of tectonic units

Tab. 1 Principles Employed in Dividing Tectonic Provinces

<table>
<tr><th>Classes</th><th>First Class</th><th>Second Class</th><th>Third Class</th><th>Fourth Class</th></tr>
<tr><td rowspan="7">Names of Tectonic Units</td><td rowspan="4">Paraplatform massif

(Pre-China folded belt)</td><td rowspan="2">anticline (folded basement structure)</td><td>uplift</td><td rowspan="7">swells, rift zone

(fault massif)</td></tr>
<tr><td>subsidence</td></tr>
<tr><td rowspan="2">syncline (folded structure of sedimentary covers)</td><td>uplift</td></tr>
<tr><td>subsidence</td></tr>
<tr><td colspan="2" rowspan="2">folded belt

(fore deep included)</td><td>uplift</td></tr>
<tr><td>subsidence</td></tr>
<tr><td colspan="3">paraplatform superimposed structure</td></tr>
<tr><td>Principles for Division</td><td>a. timing of major folding (folded belt of paraplatform massif)
b. features of tectonic movements (superimposed structures)</td><td>a. configuration of folded structures of crustal surface (folded basement structure area, folded structure area of sedimentary covers)
b. features of paraplatform evolution</td><td>features of the formation of sedimentary covers (thickness of formations, etc.)</td><td>a. features of Meso-Cenozoic fault massif movements
b. features of paraplatform folded basement and of distribution of sedimentary covers</td></tr>
</table>

tectonically connected, developed at the boundary between Korea-China Paraplatform and the Circum Pacific Foldbelt.

2. Division of provinces based on characteristic features of tectonic movements.

The second principle is to reflect characteristics of tectonic movements which occurred widely during Mesozoic - Cenozoic. The whole Korean Peninsula is characterized by Mesozoic to Cenozoic tectonic activities, and so it can be expressed as the Meso-Cenozoic foldbelt.

However, because the fault block movements that reactivated the paraplatform differ from the earlier geosynclinal type tectonic movements, we established the fault block movements as independent tectonic units and gave proper legends for them on the ground of following two reasons.

1) The structures formed by Meso-Cenozoic magmatism and sedimentation are left in only limited areas.

2) Unlike the pre-Mesozoic foldbelts, they do not occupy certain areas, but occur superimposed on the pre-Mesozoic fold structures.

Therefore, we established such tectonic units as the third independent tectonic unit, and referred to them as superimposed structures of the paraplatform, although they are very small in distribution in comparison with the paraplatform massifs or foldbelts.

In doing so, we intended to show more clearly the characteristics of tectonic movements in the Korea-China Paraplatform.

3. Division of tectonic regions based on patterns of crustal surface structures.

If we classify tectonic units only according to the major folding ages in a small region with complex geological structures, we cannot show the characteristics of detailed geological structures, which are economically significant. Oversimplified tectonic maps published in overseas coloured Korea as a shield of old foldbelt or an old platform craton.

To overcome such defects, we grouped the paraplatform massifs into the area with folded basement and that with folded sedimentary covers. The former is characterized by multi-folds, and the latter by simple linear folds.

Because geological structural patterns of the crustal surface have greater significance, we applied the above classification to express them in the form of independent tectonic units.

All regions of Korea are divided into blocks without exception due to the Meso-Cenozoic and subsequent neotectonic movements. Old folded basement appears in uplifted blocks, and sedimentary cover on paraplatform crops out in subsided blocks. Each tectonic block is bordered by faults without exception, the strike of which is generally NE-SW and NW-SE.

In blocks where fold basements crop out, fault structures develop, and intrusive rocks appear. But blocks forming sedimentary covers are characterized by linear folds, bedding faults and thrust-nappes.

Because the multi-fold structures also develop in areas where folded Lower Proterozoics distribute, the first and the second order folds are discernible in such areas. Examples are seen in Rimjingang and Hambuk foldbelts, where Mesozoic folding structures are superimposed on those of the basement.

The Meso-Cenozoic superimposed structures consist of fault troughs filled with sedimentary-effusives and intrusives in uplifts. Therefore, superimposed structures are closely related with the major fault structures in space and genesis.

III. DESCRIPTION OF MAJOR TECTONIC UNITS

1. Paraplatform massifs

These are the tectonic regions which became stable after the tectonic movement (Ongjin Tectonic Movement) at the end of Early Proterozoic and did not suffer from a strong tectonic movement after Late Proterozoic (including Riphean) until the Latest Paleozoic.

Therefore, the paraplatform massifs are tectonic regions which clearly show ancient folded basements (Archean and Lower Proterozoic) and sedimentary cover ranging from Upper Proterozoic to Lower Triassic in age.

However, the constitution of structural stage of the Korea-China Paraplatform massifs differs from that of typical platforms. Firstly, both of the folded basements and overlying sedimentary covers were intensively folded and deformed in the former. Secondly, not only sedimentary covers consist of deposits with different ages, but also they are very thick, even as thick as 10 to 12 km.

Sedimentary covers are divided into several substructural stages by prominent unconformities, such as those between, 1) the Sangwon (Middle-Late Proterozoic) and Kuhyon Systems (Riphean), 2) Kuhyon and Cambrian systems, and 3) Middle Paleozoic (Devonian) and Upper Paleozoic (Carboniferous to Lower Triassic).

As already mentioned elsewhere, the presence of marine Upper Ordovician and Silurian in the Phyongnam Synclinorium proves that Early to Middle Paleozoic seas covered wide areas of the present Korean Peninsula and its adjacent continental margins.

In Korea anticlinorium is represented by Rangrim and Kyonggi Anticlinoria, and synclinorium by Phyongnam Synclinorium. In previous publications Hyesan-Riwon and Okchon Synclinoria have been set forth. However, in this map, both are treated as subsidences developed in anticlinoria.

In anticlinoria folded basements in the paraplatform region are mainly exposed, and sedimentary covers are left in narrow strips. As confirmed by detailed geological data, it is true that sedimentary covers had once deposited on the paraplatform. However, the area has been as a whole the region of uplift throughout the crustal history, notably in Mesozoic and Cenozoic time. Because of this, sedimentary covers had been eroded away and presently their vestiges are seen only in local troughs.

The core of the Rangrim Anticlinorium (called Huichon Uplift) has been intensively uplifted, and the Archean folded basements are exposed there. However, in subsidence areas adjacent to the anticlinorium (Hyesan-Riwon Subsidence) developed Lower Proterozoic and younger formations.

In dividing uplifts and subsidences in an anticlinorium, we laid emphasis on the intensity of uplift and subsidence that took place throughout the crustal history and on the state of sedimentary covers.

The Phyongnam Synclinorium is divided into the Pyongyang Uplift (northern part) and the Haeju Subsidence (southern part). In the Early Late Proterozoic subsidence was already prevailing and tectonic activities were intensive in the Haeju Subsidence in comparison with the Pyongyang Uplift. This resulted in the difference in thickness in two regions; thick Upper Proterozoic sediments in the Haeju Subsidence, and thin in the Pyongyang Uplift. Following is a table showing other differences in Upper

Proterozoic formations between the two regions.

	Pyongyang Uplift (North type)	Haeju Subsidence (South type)
1. Stratigraphic sequence	Whole succession of Sangwon Group, Missing Kuhyon Group	Whole succession of both Sangwon and Kuhyon Groups. Unconformity between them
2. Thickness	1,700 - 3,500 m	5,600 - 8,200 m
3. Degree of metamorphism	Biotite-chlorite facies. Relatively high.	Sericite-phillite facies. Relatively low.
4. Igneous rocks	Stratiform, mafic-acid intrusives	Stratiform, mafic intrusives
5. Metavolcanics rocks	Mafic-interm. submarine effusives (green schist)	Absent
6. Degree of folding	Complex multi-fold structure	Simple linear fold structure
7. Isotope age	Jikhyon; 1,200 - 1,400 Ma	Jangbong 853 Ma Unjoksan 900 Ma Chongsokduri 800 Ma
8. Stratigraphic correlation	Upper part of Groups Hwanghae, Huchang and Yulri, Chunchon, Liaoyang or Luoling groups in China	Groups Xihe, Wuhangshan and Jinxian of Qingbaikou and Sinian systems in China

Like the above differences within the Phyongnam Synclinorium, the Hyesan-Riwon Subsidence and the Huichon Uplift in the Rangrim Anticlinorium differ from each other in many aspects. The stratigraphic sequences in Upper Proterozoic in the Hyesan-Riwon Subsidence surrounding the Huichon Uplift are somewhat similar to those in the Haeju Subsidence in the Phyongnam Synclinorium. A ubiquitous occurrence of the unconformity between Sangwon and Kuhyon Systems in both Rangrim and Phyongnam regions led to the proposal to divide the Middle and Upper Proterozoic in Korea. A national symposium of geological prospectors held in 1979, however, decided to postpone the conclusion until more solid data are accumulated, and for the time being to divide the Upper Proterozoics into the "south type" (subsidence region) and the "north type" (uplift region).

To highlight both crustal evolution of each region and paraplatform's geological structures in the tectonic map, we emphasized some details or regrouped some units. The folded basements in the anticlinoria were subdivided, and some locally occurring sedimentary covers were integrated.

For example, the Upper Proterozoics and the Lower Paleozoics are clearly separated stratigraphically. However, because their distribution is limited, they were integrated into one unit in the map. Here, however, due to the cardinal importance of geological structures of sedimentary covers, we subdivided them into units of structural stage as much as possible, or reversely combined some folded basements into a single group.

2. Foldbelts

Foldbelts are the areas which had been stable in the Early Late Proterozoic, but were later reactivated to become foldbelts similar to geosyncline during the Paleozoic. They, in turn, indicate once again that the Korea-China Paraplatform is different from "platform" in a classic sense. Therefore, the constitution of structural stage of such foldbelts is variegated and complex (Fig. 4).

1) Middle Paleozoic foldbelt, Rimjingang Foldbelt

The Rimjingang Foldbelt in central Korea is an area which became a geosyncline-type foldbelt through reactivation of a part of paraplatform massifs during the Middle Paleozoic (Devonian). This foldbelt is a mobile belt formed by deep faults in E-W direction, and is a zone with a fly-type sedimentation and strong submarine volcanism, which later subjected to folding and metamorphism. In the region characteristic magmatism (felsic and alkaline) occurred, and green schist-type volcanic piles and sulfide deposits were formed.

The Rimjingang Foldbelt is an eastern extension of the Qinling Geosyncline in China, and it is connected to the Hambuk Foldbelt. They have similar tectonic characteristics with each other, but with a difference in the timing of folding.

Tectonic Stage of Korea

Fig. 4

Tectonic Units / Stage of tectonic evolution (Structural formation)		Paraplatform Massifs			Foldbelts		Foredeeps	
		Rangrim Anticlise	Phyongnam Syneclise	Kyonggi Anticlise	Rimjin-gang Foldbelt	Hambuk Foldbelt	Raktong-gang Foredeep	Kilju-Myongchon, Yongil Foredeeps
Cenozoics	Q	Continental and marine deposits, volcanic Rocks						
Meso-Cenozoic tectonic reactivation, Superimposed Structure of Paraplatform	N_{1-2}	Hyesan. Paegam		Samchok ser.		Saeppyol Jungsan		Hamgyong Group
	P_2-P_3	Sangdan Ser.	Anju Gr. Pongsan Ser.				Pulguksa Ser.	Janggi Ser. Jaedok Ser.
	K_{1-2}	Taebo Group				Seson Ser.	Kyongsang Group	
	J_{2-3}	Jasong Gr.			?	Ryongnam Ser.	?	
	T_3-J_1	Taedong Gr. Junggang, Chongjin, Jangphari. Pansong Ser.						
Paraplatform Sedimentary Covers, Partially Folded Complexes (Rimjin, Tuman Gr.)	C_2-T_1 (C_2-P_2)	Phyongan Gr. Sedimentary Cover type				Tuman Gr. Geosyncl. type		Tuman Gr.
	D_2-C_1				Rimjin Gr. Geosyncl. type			
	S_{1-2}		Wolyang Koksan Ser.		?			
	$Є_1-O_3$	Hwangju Gr.						
	PR_3 2		Kuhyon Gr.	Okchon Gr.	Kuhyon Gr.			
	PR_3 1	South type Sangwon Gr.			South Sangwon			
	PR_2	Huchang Gr.	North Sangwon, Hwanghae Gr.	Chunchon Gr.	Hwanghae Gr.		Yulri Gr.	
Folded Basement — Upper	PR_1	Machonryong Gr.	Met. Comp.	Ryonchon Gr.		Machonryong Gr.	Jirisan Gr. Machonryong Gr.	
Folded Basement — Lower	AR_{2-3}	Rangrim Gr.		Kyonggi Met.Comp.			Wonnam Gr.	

The Rimjingang Foldbelt is underlain by older formations with various ages; Lower-Middle Proterozoic (Hwanghae Group), Upper Proterozoic (as paraplatform sedimentary cover) and Lower Paleozoic rocks. The Devonian sequence, Rimjin Group, was folded in the Late Devonian to Early Carboniferous. Therefore, the Upper Proterozoics under the Rimjingang Foldbelt were subjected to folding twice in Devonian and Mesozoic periods, forming compound folding structures.

The above-mentioned Devonian Rimjin Group was first discovered in Kaesong, Kumchon, Thosan and Cholwon districts during the course of 1:200,000 scale geological mapping in 1962. The Group contains numerous fossils, well enough to determine its accurate age. Further detailed geologic survey for 1:50,000 maps revealed that the Devonian sequence extends into Ongjin and Kangnyong districts. This discovery was very significant, because it had been generally believed that Devonian deposits were missing in the Korean Peninsula. It also showed that geosyncline-type mobile belt (like aulacogen) was formed in Devonian. The typical section of the Devonian is shown in Fig. 5.

The Rimjingang Foldbelt is characterized by complex folds and listric faults with alkaline ingenious activity (Phyonggang Complex).

2) Upper Paleozoic foldbelt, Hambuk Foldbelt

This foldbelt belongs to the Upper Paleozoic Hercynian Foldbelt, and is an extension of the Mongolia-Okhotsk Foldbelt (=Ji-Hei Foldbelt in China). In this foldbelt, the age of folded sediments gets younger eastward; Silurian and Devonian in the Ji-Hei Foldbelt, and Early Permian in the Hambuk Foldbelt.

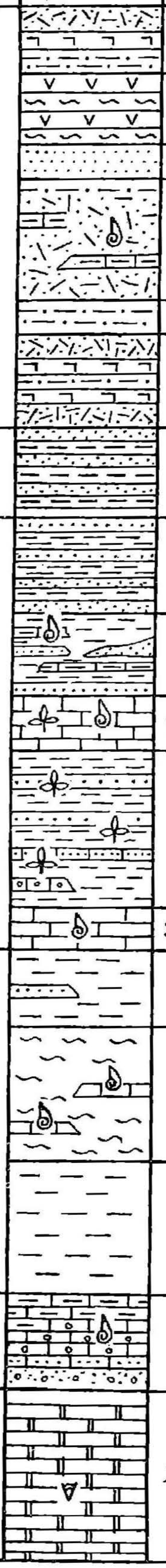
The Hambuk Foldbelt is a typical geosynclinal belt. It has ophiolitic ultramafic-mafic-intermediate volcanic rocks, thick fly-type sediments, and characteristic intrusive rocks, all of which are typically seen in a geosyncline.

In the pre-Upper Paleozoic time, the area had been uplifted, having resulted in erosion of sedimentary covers and exposure of the Lower Proterozoic basement. A renewed transgression brought the deposition of geosynclinal sediments (Tuman Group) in Permian.

This foldbelt turned to a stable block after the Tumangang Tectonic Movement that occurred from the Late Permian to the Early Triassic. In Mesozoic era, the area was again subjected to block movement. Therefore, the Permian Tuman Group (System) displays strong folding, disturbance and metamorphism, as well as multi-fold features.

Stratigraphic Sequence of Rimjin Group

Fig.5



Series	Formation	Thic. (m)	Lithology and Fossils
Sangnyong ($C_1^1 - C_1^2$)		200 <	Alternating dark-grey siliceous schist, chert, green stone, keratophyre,
		80 - 100	Alternating grey-green chlorite schist, green stone (greenschist)
		20 - 30	Grey-brown sandstone, sandy quartzite
		150 - 200	Dark-grey siliceous schist, chert with limestone, and coaly sandstone interbeds Fauna: *Cyclocyclicus* sp., *Hexacrinites* sp., *Atrypa* sp.
		100	Grey-brown silty sandstone
		250 - 350	Alternating dark-grey massive chert, siliceous schist and keratophyre
Puapsan ($D_2^3 - C_1^1$)	Upper	200 - 250	Grey, grey-brown sandy-quartzite, phyllite interbed
	Lower	250 - 300	Alternating black schist, phyllite grey-brown sandstone
		250 - 300	Alternating black slate, siltstone, sandstone, with limestone interbed, brachiopoda fossils
		70 - 85	Dark grey limestone, flora and fauna: *Sycidiummelo* Var. *pskowensis*, *S. reticulatum*, *Tropidodiscus* SP.
		200 - 250	Alternating black slate, calcareous sandstone and conglomerate Flora: *Psilophyton goldshmidti*, *Asteroxylon elberfeldense*, *Protocephalopteris praecox*, *Taeniocrada decheniana*
		30 - 50	Dark-grey layered limestone Fauna: *Pentagonocyclicus paucus*, *P. jucundus*, *P. imatschensis*, *Tropidodiscus curvilincatis*
Anhyop ($D_2^1 - D_2^2$)	Upper	80 - 100	Grey-green sericitic phyllite with sandy quartzite interbed
		200 - 250	Dark-grey layered limestone Fauna: *Cyclocyclicus* sp., *Pentagonocyclicus* sp.
		300 - 350	Grey-green schist
	Lower	80 - 120	Basal conglomerate, calcareous congl., clay stone, limestone Fauna: *Atrypa dowrilli* Var. *Pentagonocyclicus levidensis* *P. glaber*, *P. jucundus*
			Unconformity
Myoraksan	Upper-Proterozoic	> 500	Dolomite including algal remains

In Korea there are two different types of Upper Paleozoic sequence; one paraplatform cover - Phyongan System in the Phyongnam Synclinorium that hosts high grade coals, and another geosynclinal Tuman Group.

The Hambuk Foldbelt is divided into Kwanmobong Uplift and Tumangang Subsidence. The Kwanmobong Uplift, underlain by folded basement, is composed of Upper Paleozoic and Mesozoic intrusives as well as local Tuman Group sediments. Whereas, in the Tumangang Subsidence, folded Permian sequences and intrusives widely occur, and older metamorphic rocks crop out in local highs.

3. Foredeeps

Foredeeps are basins formed under the influence of the Circum Pacific Foldbelt, and are characterized by the accumulation of thick marine and continental sediments and wide development of intermediate-felsic volcanism.

The Circum Pacific Foldbelt differs from the typical geosyncline-type foldbelt in that the former has weak folding tectonic movements and lacks in contemporary intrusion.

The Korean foredeeps have been formed in two stages; Mesozoic (Jurassic-Cretaceous), and Tertiary (mainly Miocene). Three foredeeps are discernible. They are Raktonggang (Mesozoic), Yongil foredeeps (Cenozoic), and Kilju-Myongchon Foredeep (Cenozoic).

1) Raktonggang Foredeep

The Raktonggang Foredeep covers the environ of South and North Kyongsang Provinces and is underlain by the Archean and Lower Proterozoic folded complexes. Volcanogenic sediments started to be laid from Middle to Late Jurassic in wide areas of the Kyongsang Basin. There, intermediate-felsic volcanism was most predominant during the Cretaceous period.

Unlike intra-continental basins corresponding to superimposed structures, this foredeep is closely related with intermediate-felsic intrusion in time and space. Tectonic movement was dominated by faultings with minor foldings. Sediments mildly tilt southeastward with discontinuous, incomplete folding structures.

From the tectonic viewpoint, the Raktonggang Foredeep may be connected to the South China Foldbelt in the south, and Sikhote-

Alin Foldbelt in the north. In this connection, it is noteworthy that Mesozoic intrusives and effusives in northeastern corner of Korea (Sonbong County, Rajin-Sonbong City) where deltas develop show close association with those in Sikhote-Alin.

2) Kilju-Myongchon Foredeep

The Kilju-Myongchon Foredeep covers both the Kilju-Myongchon Trough (basin) and the Chilbosan Massif in former publications. It is a different structural unit from Tertiary intracontinental basins. The Foredeep is a Tertiary marine basin that is connected with the Korea East Sea, and further, is related with Tertiary coastal basins in Japan.

In the past, we regarded the Chilbosan Uplift as an emergence of old folded basement, and the Kilju-Myongchon Foredeep as a graben-type trough. However, detailed geological prospecting proved the presence of Miocene marine sediments inside the Chilbosan Uplift. This indicates that the Chilbosan Uplift was formed as a result of neotectonic activities, and thus it should naturally be included in the Kilju-Myongchon Foredeep.

Recent submarine seismic studies imply the presence of Miocene marine sediments that are well correlatable to those in Kilju-Myongchon Foredeep under the Korea East Sea continental slopes.

The Foredeep is fundamentally different from intracontinental basins in that most of the Miocene sequences (mainly lower part) of the former are shallow marine deposits and composed of thick felsic, alkaline and mafic volcanic rocks.

The upper Miocene consists of shallow water, swamp deposits that intercalate brown coal measures. The Pliocene volcanism in the Foredeep accompanied shallow intrusion.

The Upper Oligocene thick basalt (Namsok Series) carries several intercalating layers such as coal seams (Ryongdong Series) and clastic sediments. It is unconformably covered by Miocene basal conglomerate. This fact means that this area had been subaerially exposed during most of the Paleogene time, but turned to marine condition in early Miocene.

Numerous pre-existing data indicate that Miocene shallow marine deposits accompanied with basal conglomerate distribute widely throughout the coast of the Korea East Sea.

The Oligocene and Miocene deposits forming the Foredeep are not folded, but have mild, monoclinal or incomplete fold structures. Neotectonic features are characterized by several NE-SW and NW-SE fault blocks.

Basement rocks underneath the Kilju-Myongchon Foredeep is made of Lower Proterozoic Machonryong System and Upper Paleozoic and Mesozoic intrusives.

3) Yongil Foredeep

The Yongil Foredeep covering Pusan and Phohang regions is tectonically connected to the above Kilju-Myongchon Foredeep. The presence of Miocene marine deposits, Pliocene volcanic rocks and younger intrusive rocks support that the area can be included in the foredeep different from intracontinental fault trough.

4. Superimposed paraplatform structures

Superimposed structure is the third tectonic unit of the paraplatform, other two units being paraplatform massif and foldbelt. The superimposed structure was formed as a result of thorough tectonic reactivation of paraplatform in Mesozoic and Cenozoic.

As mentioned already elsewhere, however, the Mesozoic-Cenozoic tectonic movements in Korea are totally different from geosynclinal tectonic movements in many points.

(1) Tectonic movements took place ubiquitously throughout the Korean Peninsula.
(2) Sedimentation proceeded in non-marine basins (rarely shallow marine).
(3) Igneous intrusion took place along fracture zones.
(4) Several major tectonic movements occurred with certain intervals.
(5) The tectonic movement started from folding (Songrim Movement), then shifted chiefly to fault tectonic movement.
(6) Sedimentation took place in fault troughs which were formed by preceding fault tectonic movement.

The Meso-Cenozoic tectonic movements show clear fault-block patterns. Therefore, the tectonic units formed as a result of the tectonic movements are fault troughs and upheavals, which are the direct reflection of vertical movements.

Sedimentary basins were formed in subsided blocks bounded by faults without exception. Intrusives are distributed mainly in uplifted blocks where folded basements are exposed. Faults that formed these fault block structures have an extension of several tens to hundreds of kilometers, and cross pre-existing tectonic units, showing superimposed structures.

These complex superimposed features, represented by troughs and intrusives, required us to classify them based on their ages of tectonic activities and to display with different colours and symbols in the map.

In the past, both domestic and overseas geologists speculated that the Meso-Cenozoic basins in Korea would have been originally formed as small intermountain basins. Therefore, they believed only molïase-type clastic sediments were deposited in such fault troughs. However, in-depth research on neotectonics demonstrated that the Meso-Cenozoic basins covered much wider areas than previously thought.

These basins were originally narrow and small, and filled with coarse clastic materials. They, however, gradually expanded and became wide stable basins in the end. We discovered several salt deposits with lime rich sediments, together with Mesozoic deposits left as relic of denudation on mountain crests. Therefore, we can interprete that many of these presently-isolated Mesozoic-Cenozoic basins had originally been connected with each other.

The Mesozoic tectonic movements occurred in four major stages; Songrim (Middle Triassic), Taebo (Middle Jurassic), Jaeryonggang (Latest Jurassic to Early Cretaceous), and Hangmusan (Late Cretaceous to Early Paleogene). In Cenozoic, several movements which interrupted sedimentation occurred.

1) Superimposed structures formed during the Songrim Tectonic Movement

The Songrim Movement is significant in two points. First, it folded sedimentary covers (ranging in age from Late Proterozoic to Triassic) on paraplatform. Second, it is the beginning of the Mesozoic reactivation tectonics. It started with fold movement, but later shifted to fault movement that accompanied acidic intrusive activities (Hyesan Intrusive Complex, 189-290 Ma).

The basins formed by fault movements hosted clastic sediments. They are called Taedong System. This system had been considered to be Late Triassic to Early Jurassic in age. However, it is now confirmed to be Early Jurassic on the basis of reliable paleontological evidence. But, Rampho Series in south Korea has still been considered to be Late Triassic in age.

Most of the Lower Jurassic formations in Korea have been eroded, and are left only in main fault zones forming fault wedges.

2) Superimposed structures formed during the Taebo Tectonic

Movement

The Taebo movement took place in the Middle Jurassic and is characterized by block faulting and felsic intrusion (Tanchon Intrusive Complex). Many new basins appeared in subsided blocks. They gradually expanded and fused with each other to form relatively wide basins.

In the basins abundant acidic to intermediate effusives accumulated with terrigenous clastics. These sediments used to be included in the Taebo System. However, recent studies revealed that the Taebo System can be divided into two main units bounded by a clino-unconformity based on paleontological evidence. The lower unit, Jasong System, having the age of Middle to Late Jurassic, and the upper, Taebo System in strict sense, Early to Late Cretaceous, have been formally established in 1979.

The Jasong System consists of clastic sediments in lower section, and mainly of acidic-intermediate effusive layers in the upper. It develops in Jagang and Ryanggang Provinces, northernmost Korea.

Intrusive rocks pertinent to the Taebo Movement are mostly acidic. They distribute along major deep fracture zones. The isotope ages range from 150 to 160 Ma.

3) Superimposed structures formed during the Jaeryonggang Tectonic Movement.

The Latest Jurassic to Early Cretaceous Jaeryonggang Movement is characterized by fault movements and felsic-intermediate intrusives. The intrusives are called Amnokgang Intrusive Complex with the isotope age of about 120 Ma.

The Taebo System (Lower and Upper Cretaceous) was deposited in fault troughs, and is made of terrigenous clastics and volcanogenic rocks. It distributes in wide areas including Jaeryonggang, Taedonggang and Ryesonggang basins. The system is considered to have been deposited in wide, stable shallow-water basins. This assertion is supported by the presence of evaporites (gypsum and salt), distribution of sediments and sedimentary features as well as fossils.

The basins that harboured the Taebo System was later divided into several fault troughs as a result of tectonic movements.

Cretaceous sediments are also present in the Okchon Subsidence in south Korea.

4) Superimposed structures formed during the Hangmusan Tectonic Movement.

This movement which occurred in Latest Cretaceous to Early Paleocene, was accompanied by felsic and alkaline intrusions called Hangmusan Intrusive Complex and volcanisms.

The whole country had been uplifted during this movement, resulting in the total absence of Paleocene deposits throughout Korea.

5) Superimposed structures formed during Cenozoic

The Cenozoic superimposed structures are divided in the tectonic map into the basins formed in Eocene, Oligocene, Miocene, Pliocene and Quaternary.

As seen in the map, Paleogene tends to develop in the western coast, but the Neogene in the eastern coast. The Eocene (Sinri Series) is widely distributed in the basin along the River Chongchon, Anju Basin and the West Korea Coastal Basin. It is composed of muddy sediments interbedded with basalt. The Eocene sediments are also known in adjacent north China and Bohai Bay.

The Oligocene sediments widely distribute in the Anju Basin and the West Korea Coastal Basin. The Oligocene in these basins hosts major coal seams. The Oligocene in Anju is divided into Ryongrim and Changdong Series. Sediments with same age are preserved also in Sariwon (Pongsan Series) and the lower reaches of the River Amnok. These basins are divided into many fault blocks.

In the eastern coastal areas, the Oligocene to early Miocene? deposits are tagged as Ryongdong and Namsok Series.

Miocene deposits in the realm of superimposed structure occur mainly in the East Sea region, In particular, they are widely distributed in Thongchon and Anbyon in Kangwon Province, Hamju and Sinhung in South Hamgyong Province, and a basin in the vicinity of the River Tuman. These Miocene deposits are non-marine, unlike those in Kilju-Myongchon Foredeep.

Pliocene terrigenous deposits occur only in limited regions on land. Their main distribution is seen in Paegam County and Hyesan City in Ryanggang Province. Thick Pliocene deposits were accumulated only in parts of the east and west coasts of Korea. The characteristics of neotectonic movements in Korea are not shown in the attached tectonic map. Neotectonic maps will be published separately in near future.

The neotectonic movement occurred very strongly throughout the country. Particularly, the Quaternary neotectonic is an important tectonic movement which modified and completed geomorphological features of Korea as seen today.

Until recently domestic and overseas geologists thought that modern relief in Korea was formed through a long geological history, and Korea was regarded as part of Pre-Cambrian craton or shield in the Korea-China Platform. However, studies on neotectonics showed that the modern Korean geomorphological features have been formed in Quaternary.

The Pliocene peneplanation provided wide terrestrial basins in the early Quaternary. In these basins basalt and clastic sediments such as conglomerate, sandstone, clay, diatomite earth and peat have accumulated.

Tectonic movements occurred in the middle and the late middle Quaternary uplifted the lower Quaternary deposits to various elevations. This neotectonic movement framed the present-day geomorphological structures of Korea.

The neopeneplain inscribed at the boundary between lower Quaternary and Pliocene sediments is presently left as relic in crests and slopes of the Hamgyong, Pujonryong, Ryonhwa and Rangrim mountain ranges at over 2,000-2,200 m above sea level, as well as in the Paektu and Pujon plateaux at 1,600 m above sea level.

Neotectonic movements inherited all the characteristics of the Meso-Cenozoic tectonic movements, and the forms of their movements are also characterized by linear uplift and subsidence due to faults, block uplift and block subsidence.

Therefore, major rivers and streams of our country are fault zones reactivated repeatedly since the Mesozoic period, and they are still subsiding in Quaternary. As a result, ridges between rivers also show linear trend.

As stated above, the present day Korean Peninsula is a neotectonic block bounded by NE-SW and NW-SE block faults. Although the original form was formed during the Mesozoic block fault movement, the geomorphological features as seen today were completed by Quaternary neotectonic movement. Like the Korean Peninsula which became an uplifted block by neotectonics, the Korea East Sea is considered to be a subsided block completed by neotectonic movement.

Stratigraphic Units of Korea

Fig. 1

Era	Period	Code	Group	Series	Thickness (m)	Correlated Series & Form	Tectonic Event
Cenozoic	Quaternary	Q_4		Volc. Rock			
		Q_3		Mar. Sed. Volc. Rock	10-30-300		Neotectonic III
		Q_2		Volc. Rock. Form	450		Neotectonic II
		Q_1		Sed. Rock Volc. Rock	200-600		
							Neotectonic I
	Tertiary	N_2		Paegam	80	Chilbosan, Hyesan	
		N_1	Hamgyong	Kidong	180	Jungsan, Saeppyol, Hamhung	
				Kocham	300-400		
				Kumso	100-200		
				Hamjin	120-140		
				Phyongryuk	800-1000		Cenozoic
		P_3		Namsok	1000	Anju (Ryongrim, Changdong)	
				Ryongdong	150		
		P_2		Sinri	250-300		
		P_1					Hangmusan
Mesozoic	Cretaceous	K_2	Taebo	Ryongban	950-1200	Ponghwasan, Sansongri Ser.	
		K_1		Pakchon	800-1200		
				Taebosan	1400-1600		
				Simchon	300		
	Jurassic	J_3					Jaeryonggang
			Jasong	Ryonmuri	1820-1920	Sinuiju, Ryongsong, Tochang	
		J_2		Jungam	200-300		Taebo
		J_1	Taedong	Songrimsan Pansong	> 1000	Jangphari, Chongjin, Rampho	
	Triassic	T_3					Songrim
		T_2					
		T_1					
Paleozoic	Permian	P_2	Phyongan	Taejawon	1000-1450	Tuman Grs. — Songsang Ser.	Tumangang
				Kobangsan	200-250	Tuman Grs. — Kyeryongsan Ser.	
		P_1		Sadong	150-300	Tuman Grs. — Amgi Ser.	
	Carboniferous	C_3		Ripsok	50-110		
		C_2		Hongjom	120-140		
		C_1					Rimjingang
	Devonian	D_3	Rimjin	Sangnyong	800-980		
				Puapsan	1000-1235		
		D_2		Anhyop	660-820		
		D_1					Erosion
	Silurian	S_2	Hwangju	Wolyangri	100-150		
		S_1		Koksan	45-55		
	Ordovician	O_3		Sangsori	400-480		
		O_2		Mandal	200-350		
		O_1		Singok	340-400		
	Cambrian	$Є_3$		Kophung	250-300		
		$Є_2$		Mujin	150-230		
				Hukgyo	175-185		
		$Є_1$		Junghwa	400-450		
							Erosion
Middle-Upper Proterozoic	Vendian	V	Kuhyon	Rungri	1000-1250	Okchon?	
				Pirangdong	300-350		
							Myoraksan
		PR_{2-3}	Sangwon — South type	Myoraksan	1000-1100		
				Mukchon	1700-1900		
				Chongsokduri	800-900		
				Tokjaesan	450-650		
				Unjoksan	450-500		
				Ansimryong	400-550		
				Jangsusan	1000-1150		
				Obongri	850-950		
				Jangbong	250-300		
			Sangwon — North type	Schist ser.	>800-1000		
				Sadangu	1600-2000	Hwanghae, Huchang Chunchon, Ryulri	Ongjin
				Jjkhyon	1000-1200		
							Machonryong
Lower Protero.		PR_1	Machonryong	Namdaechon	2000-3000	Musan, Uiju, Jirisan	
				Pukdaechon	5000-6000		
				Songjin	3000		
							Ryonhwasan
Archean		A_2		Rangrim Comp.	> 3000	Kyonggi gneiss Group	