Jour. Korean Inst. Mining Geol.
V. 19, Spec. Iss., p. 73-95, 1986

Metallogenesis in Korea
—Explanation of the Metallogenic Map of Korea—

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Abstract: In order to make preparation of the Metallogenic Map of Korea, the writer have to collect and review the data of general geology and ore deposits of Korea which have been published up to date. The geology of Korea has been briefly simplified and grouped into the 15 formations so as to provide the base geologic map for making the Metallogenic Map of Korea.

Geologic provinces of south Korea are divided into four, that is, Gyeonggi-Ryeongnam province, Ogcheon geosynclinal province, Gyeongsang basin province and Tertiary province. In the view of tectonics and related granites, the major orogenies in south Korea are as follows; Ryeongnam orogeny, Taebaeg disturbance, post-Sangweon disturbance, post-Joseon disturbance, Bulgugsa disturbance and Yeonil disturbance. Metallogenic epochs might coincide with the period of syntectonic or subsequent igneous rock intrusions accompanied with the above listed orogenies and disturbances. Thus, metallogenic epochs that are certain in Korea so far are; Precambrian periods, Paleozoic periods, Jurassic to early Cretaceous periods, late Cretaceous to early Tertiary periods, Quaternary periods and age-unknown periods.

The Metallogenic Map of Korea shows 444 ore deposits and/or mines by symbols on a background adopted from the existing geologic and tectonic map. The 444 metallic and non-metallic deposits are categorized by the commodities they contain, size, geologic environment, mineralized age and mineralogic nature.

INTRODUCTION

The main purpose of this Metallogenic Map of Korea is to identify the 444 mineral deposits in Korea which are shown in the map and to give certain information on their commodities, geographic locations, and geologic characteristics; the deposits are numbered according to each mineral kinds, and also introduced about general geology, geologic provinces, tectonics and related granites, metallogenic epochs and metallogenic provinces.

This metallogenic map is not resources map; for in their compilation, both existing deposits and those that have been mined out are shown where elements are known to have been concentrated to ores by geologic processes and, by analogy, where as-yet-undiscovered deposits may be expected to exist.

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** This is the predecessor of Geological Survey of Korea: Chosen is Japanese pronunciation of Korea.

GEOLOGY

General Geology

Geology of Korea is relatively well understood except Precambrian stratigraphy in spite of the fact that the research history on Korean geology had not gone beyond 1918 when the erstwhile Geological Survey of Chosen**(Now, Korea Institute of Energy and Resources) was established.

Professor C.H. Cheong(1956) had summarized the geological sequences of South Korea from data available done by many previous geologists. The sequences thus assimilated has been standard and is generally being accepted until very recent

(Table 1).

The distribution of gneisses and schists of Archean to middle Proterozoic age and subsequent granite intrusives are most extensive and diagnostic on the Korean Peninsula. Besides these, other rocks, such as Tertiary sequences mainly along the eastern coastline with random distribution, Cretaceous molasse sediments exposed over a relatively large area of the southeastern margin of the peninsula, Jurassic non-marine sediments developed within fault bounded depressions, varied marine to non-marine Cambro-Triassic sediments in the Pyeongnam and Ogcheon-Taebaegsan Zones, and late Proterozoic marine strata mainly in the Pyeongnam basin, crop out either along tectonic boundaries or within intracratonic basins.

Pre-Gyeongsang (Pre-Cretaceous) sedimentary rocks are intensely folded and mostly metamorphosed due to superposed magmatisms and orogenies and thus it is extremely difficult to correlated the rock sequences and interpret their depositional environments.

Although a number of isotopic dates in the range 2,765 to 1,350 m.y. have been obtained for metamorphic rocks and minerals of Archean to middle Proterozoic age from the Gyeonggi and Ryeongnam Massifs(Fig. 1). A more accurate knowledge of rock sequences forming these extensive basement rocks is required.

Rocks of late Proterozoic Sangweon Group, equivalent to the Sinian system of China, are well known in the Pyeongnam Zone of northern Korea. The Ogcheon Group of Southern Korea, considered of upper late Proterozoic age by Reedman et al. (1975) has long been the subject of debate concerning the relative ages of the rock succession within the group and, also, the relative position of the group with respect to strata of known Cambro-Ordovician age (Joseon Group).

The Joseon Group, which consists mainly of marine sediments and disconformably overlying the Pre-Cambrian basement. Pyeongan Group (Carbo-Triassic) composed of marine to non-marine sediments have been relatively well studied on the basis of stratigraphy and paleontology. The Silurian and Devonian hiatus in Korea up to now have been generally accepted among geologists.

However, Silurian conodonts, which occur in a limited area of the Ogcheon Zone west of Jeongseon, have been examined by C.H. Cheong and H.Y. Lee(1966) and the knowledge thus gained has enabled us to recognize remarkable difference between the inferred sedimentary environments expressed in the Ogcheon and Taebaegsan Zones. Similarly, previously gained paleontological data have enabled us to distinguish between major elements of the Joseon Group [i.e. Yeongweol type(Ogcheon Zone) and Duwibong type(Taebaegsan Zone)] on the basis of trilobites(Kobayashi, 1953). The Pyeongan Group can also be distinguished paleontologically on the basis of Pseudoschwagerina which occurs in the Yeongweol and Eunseong coalfields of the Ogcheon Zone.

At the close of Triassic time, the Pyeongan basis was destroyed due to the "Songrim Disturbance" associated with granitic invasion and active mainly in northern Korea. Shortly thereafter, Jurassic molasse sediments were accumulated within fault-bounded troughs formed during the "Songrim Disturbance". The subsequent "Daebo Orogeny" affected the entire peninsula and deformed all revious rocks. The Daebo granite is remarkably well distributed in a zone along the periphery of the Ogcheon Zone.

Clastic and volcanic-clastic rocks of late Mesozoic age which are distributed along the boundaries of the Ogcheon Zone have been considered to be upper Gyeongsang sediments. But it can be now affirmed that these rocks are more closely related to the late Daebo Orogeny

Table 1 Generalized geological sequence in South Korea(after O.J. Kim, 1975).

Age		C. H. Cheong (1956) System	C. H. Cheong (1956) Series	O. J. Kim (1969) System	O. J. Kim (1969) Series	
Cenozoic		Quarternary		Quarternary	Basalts	
		Tertiary	Yeonil	Tertiary	Yeonil	
			Janggi		Janggi	
Mesozoic	Cretaceous	Gyeongsang	Bulgugsa (granite & porphyry) intrusion		Granites (Bulgugsa granites) Volcanics	
			Silla	Gyeongsang	Silla	
	Jurassic	Daedong	Nagdong		Nagdong	
			Ryugyeong, Seonhyeon } in N. Korea	Daedong	Granites (Daebo granites) Undifferentiated in S. Korea	
	Triassic	Pyeongan	Nogam		Granite?	
Paleozoic	Permian		Gobangsan	Pyeongan	Nogam	
	Carboniferous		Sadong		Gobangsan	
	Devonian		Hongjeom		Sadong	
	Silurian		Cheonseongri?		Hongjeom	
	Ordovician	Joseon	Great Limestone		Granite? Lacking	
	Cambrian		Yangdeog	Joseon	Great Limestone	
Proterozoic		Sangweon	Guhyeon, Sadangwu, Jighyeon } in N. Korea		Yangdeog Granite?	
		Granite gneiss		Sangweon	Undifferentiated in S. Korea	Late Pre-Cambrian
Archeozoic		Yeoncheon			Granite gneiss	
				Ogcheon	Gunjasan	
					Hwanggangri	
					Changri	Middle Pre-Cambrian
					Munjuri	
					Hyangsanri	
					Gemyeongsan	
				Yulri	Goseonri ?	
					Gaghwasa	
				Yeoncheon	Undifferentiated ? ?	
					Weonnam	
				Ryeongnam	Giseong	Early Pre-Cambrian
					Pyeonghae	

Ogcheon metamorphics, T. Kobayashi (1953)
Ogcheon metamorphics, C.M. Son (1968)
C.M. Son (1969)
C.M. Son (1970)

because they are prenetrated by Jurassic granite (163 m.y.) and show significant structural differences.

During the early Cretaceous, terrestrial sediments of fluvial-lacustrine origin were deposited over a relatively large area of south-eastern Korea. No significant deformation can be found affecting these rocks except thermal metamorphism by intrusive and extrusive igneous activity within the basin. Such magmatism continued during the late Cretaceous and Paleogene until Neogene sedimets, formed of marine volcanoclastic and clastic rocks of Oligocene(?)-early Miocene age(Janggi Group) and shallow marine sediments of the Miocene Yeonil Group, were deposited. A right-lateral fault with north-northeast trend developed within the Gyeongsang basin along the Cretaceous- early Tertiary boundary.

During the Pliocene, volcanism took place on Jeju-do(Island) and Ulleungdo(Island) and in the inland Tertiary sub-basin. Pliocene and Pleistocene thin marine sediments were also accumulated on Jeju-do(Island).

For the general review and comparison purpose, the geological sequence of South Korea which was summarized by Prof. C.H. Cheong and that revised by Prof. O.J. Kim are tablated in Table 1. The most controversial problem among geological sequences of South Korea has been concentrated in Ogcheon System since middle 1950s. The system was originally thought to be Precambrian(Nakamura, 1923), but later was considered to be metamorphosed Paleozoic and/or Mesozoic formations, by many workers, so that Prof. Cheong did not even mentioned the system in Table. Prof. T. Kobayashi(1953) states the the system was metamorphosed late Paleozoic to early Mesozoic formations, and Prof. C.M. Son has revised his idea few times.

Geologic Provinces of South Korea

On the basis of tectonics and distribution of geology Prof. O.J. Kim attempts to divide South Korea into four main geological provinces and their major geological features are summarized as follows(Fig. 1).

A. Gyeonggi-Ryeongnam province;(Precambrian system and Jurassic granites)
B. Ogcheon Geosynclinal province;
  a. Ogcheon Neogeosynclinal zone;(Paleozoic to Mesozoic formations & younger granites)
  b. Ogcheon Paleogeosynclinal zone;(Precambrian Ogcheon system & younger granites)
C. Gyeongsang basin province;
  a. Gyeongsang basin proper area;(Cretaceous formations & Cretaceous granites)
  b. Yeongyang basin area;(Cretaceous formation & Cretaceous granites)
  c. Mesozoic area;(Cretaceous volcanics)
D. Tertiary province;(Tertiary formations & volcanics)

A. Gyeonggi-Ryeongnam province

Gyeonggi Massif: Gyeonggi Massif is located in the north-west of Ogcheon geosynclinal province. According to the isochron age determinations and studies on metamorphism in the area, three rock groups, namely Gwangju Group, Goyang Group and Gapyeong Group, can be recognized. The Archean Gwangju Group consists of mica schist, granitic and migmatitic gneiss, banded gneiss, quartz-feldspathic gneiss, garnet-porphyroblastic gneiss, quartzite, limesilicate and peridotite. They are distributed in Hongcheon, Yangsuri-Cheongpyeong, north of Gapyeong, and the western part of the Gyeonggi Massif. In this metamorphic zone garnet-sillimanite-K-feldspar assemblages or garnet-cordierite-sillimanite-K-feldspar assemblages are most prominent and shows granulite facies and partly amphibolite facies.

The early Proterozoic "Goyang Group" crops out more widely than the Archean Gwangju

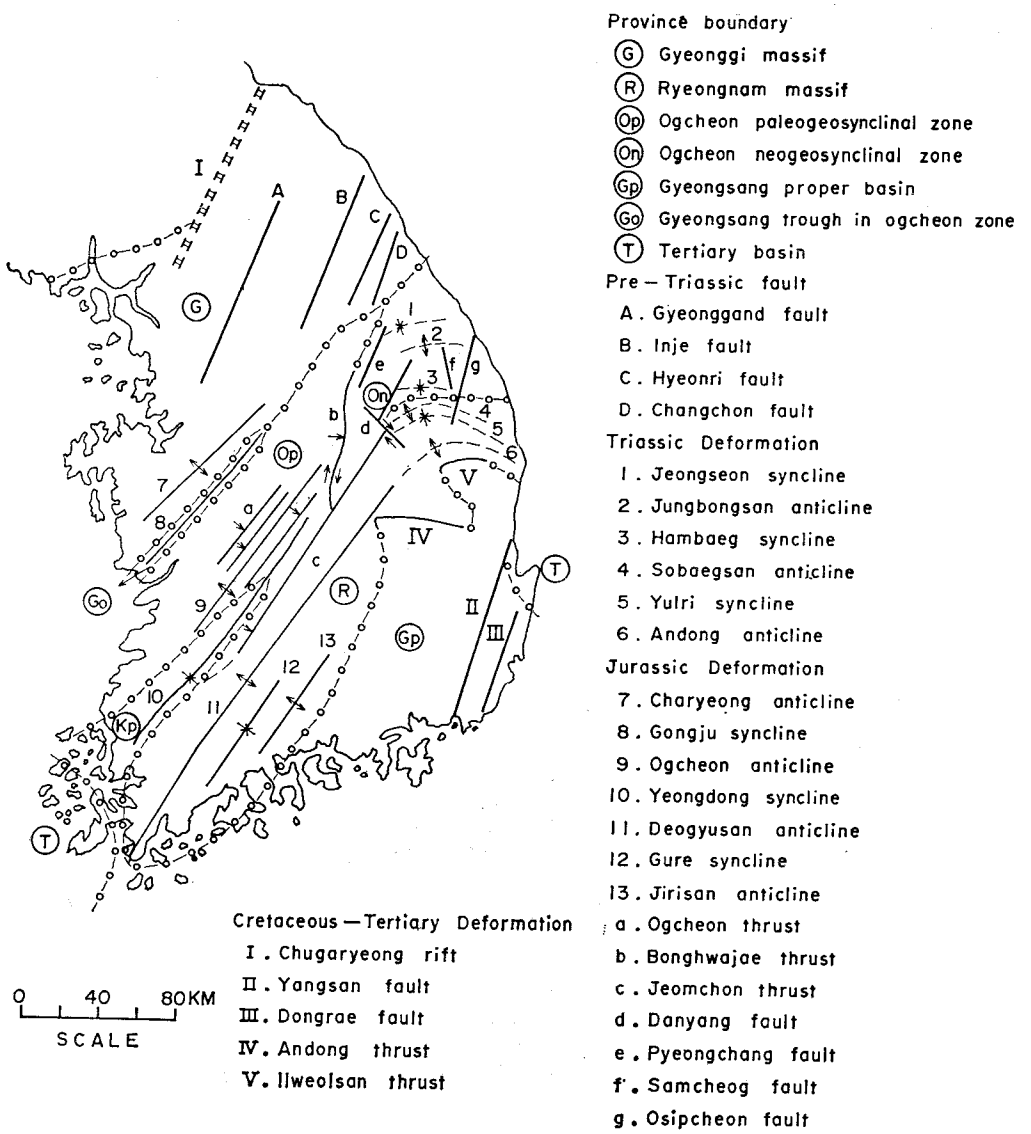


Fig. 1 Geological provinces and structure map of South Korea(after O.J. Kim et al., 1977).

Group. It consists mainly of granitic gneiss, banded gneiss, garnet porphyroblastic gneiss, porphyroblastic gneiss, biotite-muscovite-chlorite schist, quartzite, amphibolite limesilicate, graphite and magnetite. This metamorphic zone shows amphibolite facies transitional between greenschist and amphibolite. They are distributed in the vicinity of Chuncheon, Youngduri, south of Yangsuri, west of Cheongpyeong, Goyang, Anyang, Asan and Seosan area in the Gyeonggi Massif. The uraniferous horizon, closely associated with quartzite beds, has been recognized in this group near Gapyeong; it resembles the Lianshanguan uraniferous deposit of northeast China(Qin Fei and Hu Shaokang, 1979) The magnetite-bearing Seosan Group(C.M. Son, 1971) probably belongs to the Goyang Group and is correlative with in Wutai Group of China.

The middle Proterozoic "Gapyeong Group" is composed mainly of schists such as sillimanite schist, biotite-chlorite schist, phyllite, slate with graphite, quartzite and limesilicate. They are distributed south of Gapyeong, west of Anyang and west of Yeoncheon. These metamorphic zones display greenschist and amphibolite facies. Metasomatic migmatites such as porphyroblastic gneiss and quartz feldsparthic gneiss are predominent in the Youngduri, Yangsuri and Anyang areas. These rocks grade into schist.

Ryeongnam Massif: The main rock groups of the Ryeongnam Massif are composed of gneiss and schist similar to those of the Gyeonggi Massif, the most common rock types being quartzo-feldspathic and migmatitic gneisses. Interspersed, the gneisses are groups of schist, the most extensive of which, the Yulri Group, rests on the gneissic basement. During metamorphism or later, intrusions of anorthosite, gabbro and diorite took place in the southern part of the massif, and pegmatite or felsite intrusions appear in the northern part where rock types are relatively well differentiated.

Three main rock groups have been distinguished; Pyeonghae, Weonnam and Yulri Groups and these may be correlative with the Gwangju Group(Archean), Goyang Group(early Proterozoic) and Gapyeong Group(middle Proterozoic) of Gyeonggi Massif, respectively. The major part of the granitic gneiss forming the Pyeonghae Group, previously thought an orthogneiss and referred to as the Kokurian Granite, is now confirmed as paragneiss(O.J. Kim et al., 1963). The Pyeonghae is believed to be the oldest of the groups in the Ryeongnam Massif and it consists, apparently, of a sequence of formerly pelitic and psammitic sedimentary rocks which have been metamorphosed to augen gneiss, banded gneiss, mica schist, mica-sillimanite schist, quartz-feldspar-biotite gniess, and quartz-sericite schist. This units of crystalline limestone, quartzite and amphibolite are included in this group. The Giseong Formation, which is composed of agglomerate, meta-tuff and meta-rhyolite, adjoins and is structurally intermediate between the Pyeonghae(older) and Weonnam (younger) Groups. The Pyeonghae Group crops out conspicuously in Onjeongmyeon.

The early Proterozoic Weonnam Group which adjoins the older Giseong Formation is composed of augen gneiss, banded gneiss, quartz-feldspar-biolite gneiss, mica schist, mica-sillimanite schist, graphite schist, quartz-sericite schist, crystalline limestone and amphibolite. The distribution of the group is more extensive than that of the Pyeonghae Group.

The middle Proterozoic Yulri Group adjoins gneisses of the Weonnam Group on the Uljin and Samgeunri quadrangle. The Yulri Group comprises pelitic and psammitic sedimentary rocks which have been altered to micaceous quartzite, chlorite schist, phyllite and limesilicate rock. They apparently were formerly a thinly interbedded, predominantly clastic, shallow-water sequence in which crossbedding is well preserved. The Buncheon granite gneiss intrudes the Yulri Group while the Hongjesa granite, which is dated as 1,714±28 m.y. (D.H. Kim et al., 1978) by Rb/Sr, intrudes both the Yulri Group and Buncheon granite gneiss. The Yulri Group rests unconformably (?) upon gneisses believed to be about 2,000 m.y. old.

Recently a very interesting isochron age based upon felsite samples from the Buncheon granite gneiss of the Buku area yielded K/Ar ages of 1,029±35 and 1,625±77 m.y. (KIGAM and D'Appolonia, 1979). These results will be very helpful in further geological mapping in Korea, because most of the acidic and basic dikes on the peninsula have been hitherto considered to be of Cretaceous age. The oldest felsite of the Buku area is approximately equivalent in age to the Hongjesa granite of the Ryeongnam

Massif.

B. Ogcheon Geosynclinal Province

Kobayashi(1953) divided Ogcheon geosynclinal zone into metamorphosed and non-metamorphosed zones, and stated that these two zones were originally consisted of same sedimentary formations having metamorphosed in southwestern part and remained unmetamorphosed in northeastern part, so that the boundary between them must be gradational. Prof. O.J. Kim has clearly demonstrated that the boundary between them was upthrust and shear fault, the metamorphosed part being thrusted over the non-metamorphosed part. The metamorphosed part is geologically consisted of Ogcheon system of Precambrian age and the non-metamorphosed part of sedimentary formations of Paleozoic to Cretaceous in age. The difference of geology and tectonics in both areas are due to the fact that Ogcheon geosyncline was shifted or migrated and effected by different orogenies from time to time so as to show different sediments and tectonics. Thus O.J. Kim designated the metamorphosed part "Paleogeosynclinal zone" and non-metamorphosed part "Neogeosynclinal zone."

Ogcheon Neogeosynclinal Zone: Neogeosynclinal zone comprised northeastern parts of Ogcheon geosynclinal zone and is mostly composed of Joseon system(Cambro-Ordovician age), and Pyeongan system(late Carboniferous to Triassic age), but in few narrow strips are there also Daedong system(Jurassic age) and Gyeongsang system(Cretaceous age). Stocks of granties and granodiorites of Jurassic and Cretaceous age are scattered in few places. Sedimentary formations in the area are not metamorphosed. It must be mentioned that entire limestone for cement manufacture and other uses, and over 80 percent of anthracite coal in South Korea are produced from this area.

The structure of the area is rather complicated. Two broad synclines and an anticline are major structural features in central to northeastern parts of the area, whereas these feature diminish toward southwest to show prominent thrusts and upthrusts. In an anticlinal zone just mentioned numerous thrusts trending NNE direction are conspicuous so as to reveal imbricated structure. It is believed that the folds were originated by Songrim Disturbance at the end of Triassic period, and the faults by Daebo Orogeny.

Ogcheon Paleogeosynclinal Zone: Paleogeosylinal zone is mainly composed of Ogcheon system of various schists of Precambrian age accompanied with Permian Pyeongan System and Cretaceous Gyeongsang System in few separated localities. The first two formations are intruded by Jurassic granites and associated plutons which are aligned paralleling to the trend of Ogcheon geosyncline axis. The Cretaceous granites also intruded in border areas.

Ogcheon system is composed of (1) Gemyeongsan, (2) Hyangsanri, (3) Munjuri, (4) Changri, (5) Hwanggangri, and (6) Gunjasan series in ascending order. Two unconformities were recognized between Changri and Hwanggangri series and between Hwanggangri and Gunjasan series. Rocks of the system are schists and gneisses, quartzite, limestone and dolomite, phyllite, sericite-chlorite schists, black slate and amphibolite. It is worthwhile to describe very briefly Hwanggangri and Gunjasan series because of their unusual characteristics. Hwanggangri series is composed of pebble-bearing phyllite to slaty rock interstratified with few thin layers of limestone in few places. The pebbles are of many varieties of rock fragments mainly granite-gneiss, quartzite and phyllite, and in rare occasions limestone and granite. Scattering various size of pebbles in fine matrix is suggestive of its origin. O.J. Kim postulates that Hwanggangri series might be tillite deposits. Gunjasan series, newerly designated by O.J. Kim in 1969, is composed of pebble-bearing silicic and slightly

calcic rocks. Some of limestone nodules are not metamorphosed whereas others are entirely altered to amphiboles leaving reaction-rim like features around borders.

Ogcheon system in Ogcheon Paleogeosynclinal zone trends northeastly in parallel to general trend of the geosyncline and is isoclinally folded and thrusted many times so as to repeat the same formations several times. These structural features were developed by Daebo Orogeny during Jurassic period.

C. Gyeongsang basin province.

Gyeongsang basin province is located in southeastern part of Korean Peninsula. The geology of the province is composed of Nagdong and Silla series, both of which are of Cretaceous in age and believed to be continental sediments by all previous investigators. Both series are consisted of sandstones, shales, conglomerates and red beds. Very thin lenticular limestones and calcareous shale beds are intercalated in very few localities. Basalt and rhyolite flows are also observed in many places. Volcanic rocks of basalt, andesite and rhyolite are predominant at the upper horizones of Silla series and these volcanics together with Cretaceous granites are formerly designated as Bulgugsa series. Thin cherty layers are intercalated in black shale bed at the upper part of Silla series. Granites and Masanites of Cretaceous age are scattered as stocks in many places in the basin without disturbing adjacent sedimentary formations except induration.

a. Gyeongsang basin proper area and,
b. Yeongyang basin area(northeastern part of Gyeongsang basin) are separated by narrow belt of schists and gneisses but sedimentary formations are connected each other in an area having width of only few kilometers.
c. Mesozoic volcanic area is located in wide belt in the middle of the basin and southwestern part of Ogcheon geosynclinal zone.

D. Tertiary Province

Tertiary sediments are distributed in two places in South Korea; one in central coast(Samcheog) and the other in southeastern coastal area(Ulsan-Pohang area). Both of them are very small in areal distribution.

The lower Janggi series is generally terrestrial deposit and composed of conglomerate, shale, mudstone and sandstone intercalated by few thin lignite coal seams, and basalt and rhyolite flows. The upper Yeonil series is marine deposit and composed of shale, mudstone, sandstone and conglomerate. Both series are believed to be Neogene in age.

Structure is rather simple and characterized by gentle dip. However, in few localities in lower formation tight folds are observed in many places. This led to the idea that folding took place after the deposition of lower parts of Janggi series and prior to deposition of mid-Janggi series. The structural relationship between Janggi and Yeonil series is believed to be unconformable. It is believed by the O.J. Kim that archipelagos in southwestern part of Korea are composed of Tertiary formations.

TECTONICS AND RELATED GRANITES

In the Gyeonggi Massif area two great unconformities were recognized(O.J. Kim, 1973) and three unconformities were also identified in the Ryeongnam Massif area(O.J. Kim et al., 1963). The metamorphic rocks separated by these unconformities show a different attitude of deformation. Thus, the periods in which the metamorphism and deformation took place in these areas can be categorized into three periods (O.J. Kim 1972). Nevertheless, it is uncertain as to their exact ages of episodes and whether or not they could exactly be correlated each other in both Precambrian terrains. This is the

reason why the geologic structure of both Precambrian terrains is grouped as pre-Triassic in age, because the structural breaks in Korea are definitely known to have occurred in the end of Triassic(Songrim Disturbance) and mid-Tertiary(Yeonil Disturbance). The generalized structural pattern is shown in the Fig. 1 where the Tertiary structure is not shown because of insignificance.

Pre-Triassic deformation

In the Gyeonggi Massif the foliation of the metamorphic complex even within the same system as well as in the different system bounded by unconformities is so diverse that generalization can not be drawn. However, the prevailing ones trend NNW-SSE direction in the western parts and NNE-SSW direction in the central to eastern parts of the massif. Four major faults trend to NNE-SSW direction but cut by the Daebo granite at the southwestern ends. There is no evidence that the foliation of the complex had been effected by the intrusion of the Daebo granite. In the Ryeongnam Massif the foliation is also very diverse, but changes to nearly NE-SW direction toward the southwestern parts and cut slight-obliquely by the Jeomchon thrust.

Triassic deformation
(Songrim Disturbance)

In the Ogcheon Neogeosynclinal zone at east central region of South Korea, Paleozoic and Triassic sedimentary formations are folded and the axis of folds trend west-northwesterly. This deformation is thought to be caused by the Songrim Disturbance at the end of Triassic period, since the Jurassic sediments in the area have not been affected by this deformational movement.

The western end of those folds are bent to the Sinian direction of Jurassic age. In the northeastern portion of the Ryeongnam Massif the trend of the Sobaegsan anticline, Yulri syncline and Andong anticline is WNW in general, but it is guessed that they were modified by the Triassic deformation although they might be originally Precambrian structures.

Jurassic deformation(Daebo Orogeny)

The Jurassic deformation caused by the Daebo Orogeny had taken place and continued from early Jurassic to early Cretaceous. (This was known from the age dating of the Daebo granites) This orogeny is the biggest one in Korea and some of the preceding formations were severely folded and faulted. The nature of the Daebo Orogeny is manifested by the distribution of the Jurassic Daedong sedimentary formations and the alignment of the Daebo granites which are well cropped out along Sinian direction in the Ogcheon geosynclinal zone and its adjacent Precambrian terrains.

There are four anticlinoriums and three synclinoriums which run alternately from the southern border of the Gyeonggi Massif to the Ryeongnam Massif through the Ogcheon zone. The Ogcheon thrusts are in the Ogcheon zone, the Bonghwajae thrust bounds the Ogcheon Paleogeosynclinal zone and Neogeosynclinal zone, and the Jeomchon thrust joined by the Bonghwajae thrust bounds the Ogcheon zone and the Ryeongnam Massif toward the southwest. These anticlinoriums constitute major mountain ranges and the younger sediments of Jurassic and Cretaceous periods scatter in the few isolated locations in the synclinorium areas.

Late Cretaceous to Tertiary deformation

Only minor folds are observed in Cretaceous Gyeongsang sedimentary basin altough the sedimentary formations in the basin show homoclinal structure to the southeast in general. The fragmentation of the basin caused by the post-Bulgugsa Disturbance resulted in forming of the upthrust at Andong and Ilweolsan, which bound the Precambrian basement and the Cretaceous sediments. Along the Chugaryeong rift valley extruded the Cenozoic basalt flows which

cover the old river beds. High heat flows are checked along the Yangsan and Dongrae faults

Mid-Tertiary deformation (Yeonil Distrubance)

The great unconformity has been known to exist between the lower and upper Miocene formations. The lower formations are wildly folded whereas the upper ones exhibit no sign of deformation. The disturbance of mid-Miocene is known as the Yeonil Disturbance.

Associated granites

Granites of various geologic time are closely associated with the orogenies in Korea. The age and occurrence of the Precambrian granites are not certain although they are relatively estimated as shown in the Table 1. The Jurassic Daebo granites, syntectonic plutons of the Daebo Orogeny, intruded along the Sinian direction in the cores of the Ogcheon folded belts and in the Gyeonggi-Ryeongnam Precambrian land mass.

At the end of Cretaceous and probably extended into early Tertiary, the Bulgugsa granites and the associated acidic intrusives intruded in the Gyeongsang basin area and the adjacent Ogcheon zone as small stocks without any pronouncing deformation.

The granites of the post-Joseon (mid-Paleozoic) and the Songrim Disturbance (late Triassic) are expected to exist. In fact the granites of these periods were reported in North Korea recently but not discovered in South Korea thus far. The granites of the Yeonil Disturbance (mid-Tertiary) are also expected to exist but no age dating has been done enough to find them. The relation of the plutons to various orogenies in South Korea is summarized in the Table 2.

METALLOGENIC EPOCHS

Metallogenesis of mineral deposits in Korea can be treated in two folds; those related with igneous rocks and those of sedimentary and secondary origin. Metallogenesis of mineral deposits associated with igneous rocks is naturally related with igneous activities accompanied with orogenies and disturbances in Korea (Table 2).

Metallogenic epochs might coincide with the periods of syntectonic or subsequent igneous rock intrusions accompanied with orogenies and disturbances. Thus, metallogenic epochs that are certain in Korea so far are;

A. Precambrian periods
B. Paleozoic periods
C. Jurassic to early Cretaceous periods
D. Late Cretaceous to early Tertiary periods
E. Quaternary periods
F. Age unknown periods

Majority of hydrothermal deposits are embedded in Precambrian schists and gneisses as well as younger sedimentary formations up to Gyeongsang formation. Nearly entire contact replacement deposits are in lenticular limestone layers in Precambrian formations as well as in Great Limestone series of Cambro-Ordovician periods. Besides of these wide ranges of occurrence, no detail study on these mineral deposits are so well accomplished as to differentiate their metallogenic epochs that it is impossible so far in Korea to discriminate Precambrian epoch from Jurassic one. Thus, spatial distribution of mineral deposits belonging to Jurassic to early Cretaceous is widespread all over Korea except Geyeongsang basin.

Mineral deposits belonged to Precambrian metallogenic epochs are hematite-magnetite, graphite, talc, asbestos, scheelite, titaniferous magnetite, nickel, tin and uranium. Asbestos and talc are associated with Precambrian serpentines, and scheelite with Precambrian amphibolite, both of which are uncertain as to their metallogenic epochs although they are grouped into Precambrian epoch. Graphite occurs in graphite schist formations and hematite and magnetite in

Table 2 Orogenies and associated igneous rocks in South Korea(after O.J. Kim, 1975).

Orogeny	Periods	Granite	Associated Volcanics
Yeonil disturbance	Mid-Tertiary	Unknown	Basalt, rhyolite
Bulgugsa disturbance	Late Cretaceous to early Tertiary	Bulgugsa granites	Rhyolite, andesite, basalt
Daebo orogeny	Jurassic to Early Cretaceous	Daebo granites	Hornblendite, andesite
Songrim disturbance	Late Triassic	Unknown	Unknown
Post-Joseon disturbance	Late Ordo. to early Carb.	Unknown	Unknown
Post-Sangweon disturbance	End of Precambrian	Unknown	Unknown
Taebaeg disturbance	Early late-Precambrian(?)	Granite gneisses, unclassified	Amphibolite(?)
Ryeongnam orogeny	Early mid-Precambrian(?)	Ryeongnam Granite gneisses	Serpentinite(?)

quartzite bed of Precambrian age.

Mineral deposits belonged to Paleozoic metallogenic epochs are hematite-magnetite, limonite and manganese. Hematite and magnetite are associated with sedimentary rocks of miogeosynclinal type. Manganese is associated with Paleozoic sedimentary rocks, and whose ore deposits are sedimentary origin in Geumhwa province.

Major mineral commodities that are accompanied with Jurassic to early Cretaceous metallogenic epochs are gold, silver, lead, zinc, molybdenum, tungsten, magnetite, fluorite, manganese and nickel-cobalt, of which metallogenic epochs of some fluorite and magnetite deposits are uncertain.

Mineral deposits belonged to late Cretaceous to early Tertiary is rather of mesothermal to epithermal fissure filling vein types widely distributed in Gyeongsang basin in South Korea and nearly all parts of North Korea. And in minor portions in Ogcheon geosynclinal zone where some of Bulgugsa granites are cropped out. Major mineral commodities that are accompanied with late Cretaceous to early Tertiary metallogenic epochs are gold, silver, copper, lead-zinc, tungsten-molybdenum, manganese, magnetite, fluorite-asbestos and pyrophyllite.

Major mineral commodities that are accompanied with quaternary epoch are placer gold and thorium.

Age unknown mineral commodities are kaoline. Precambrian iron deposits of sedimentary origin is known in few places and is made up mainly with hematite occasionally accompanied by magnetite. Hematite beds are known to occur in Dongjeom quartzite of early Ordovician age, and at the base of Hongjeom series of late Carboniferous, and limonite beds are known to occur in Sadong formation of Permian age. These are combined together as Paleozoic metallogenic epoch.

Abundance of gold, silver, molybdenum, tungsten and fluorite is resulted by predominance of granitic rocks and gneisses. Scarcity of chromite, nickel and cobalt is due to lack of basic to ultrabasic intrusives. Epithermal deposits of mercury, antimony and sulphur are entirely lacking because of lack of recent volcanic rocks.

Metallogenic epochs and accompanied mineral commodities are tabulated as follows;

Metallogenic epochs	Mineral commodities
Precambrian epoch	1. Iron(Hematite-magnetite) 2. Graphite 3. Talc, asbestos 4. Tungsten(Scheelite) 5. Titaniferous magnetite

	6. Nickel 7. Tin 8. Uranium
Paleozoic epoch	1. Hematite-magnetite 2. Limonite 3. Manganese
Jurassic to early Cretaceous epoch	1. Gold-silver 2. Lead-zinc 3. Tungsten-molybdenum 4. Magnetite 5. Fluorite 6. Manganese 7. Cobalt-nickel
Late Cretaceous to early Tertiary epoch	1. Gold-silver 2. Copper 3. Lead-zinc 4. Manganese 6. Magnetite 7. Fluorite-asbestos 8. Pyrophyllite
Quaternary epoch	1. Placer gold 2. Thorium
Unknown epoch	1. Kaoline

METALLOGENIC PROVINCES

Mineral commodities chosen

All mines and large outcrops plotted were picked up from various publications, reliable reports and personal investigations by the KIER members(Korea Institute of Energy and Resources) and especially the references of North Korea were picked up from the publications by Government General of Chosen(Korea), Japanes time 1910~1945.

Metallogenic Provinces

Precambrian Metallogenic Provinces;

1. Iron(Hematite-Magnetite)

Sedimentary origin hematite-magnetite deposits are distributed in Chungju, Seosan, Hongcheon, Yangyang, in South Korea and also in Musan, Unsan and Jangjaedong provinces in North Korea.

The iron deposits are associated with quartzite, gneiss and slate, and originated from the ferruginous sedimentary beds by metamorphism and metasomatism.

2. Crystalline Graphite

Korea is one of the well known graphite producing countries. The graphite is in graphite schist of Precambrian age and distributed in many schist areas. The prominent areas are Gyeonggi, Gongju, Gure in South Korea, and Byeogdong, Seongjin provinces in North Korea, but only a couple of mines in Gyeonggi province are under operation.

3. Talc and Asbestos

Talc is associated either with Precambrian dolomite beds or serpentines. Famous Chungju and Jeonju belts are in dolomite bed trending NE direction in Ogcheon Paleogeosynclinal zone, and Yugu belt(northeastern portion of Gwangcheon province) in serpentine zone that extend NE-SW direction. Metallogenic epoch has been tentatively grouped into Precambrian provinces because of the fact that they are imbedded in Precambrian formation although their metallogenic epoch is uncertain.

Asbestos deposits are associated with Precambrian serpentine in Gapyeong and Gwangcheon provinces, both of which extend NE-SW direction in general.

4. Tungsten

Tungsten deposits are associated with Precambrian amphibolite belt which extends NEE direction in Ryeongnam Precambrian area, in which Ogbang-Ssangjeon tungsten mines are the representative one. Metallogenic epoch of the deposit is thought to be Precambrian and it is named Ogbang belt becuase of the fact that the deposit is segregation type in amphibolite of probably Precambrian age.

5. Titaniferous magnetite

Several magmatic magnetite-ilmenite deposits are emplaced in hornblende schist of the Archean crystalline schist complex at the north of Seoul (Gonamsan deposits) and Soyeonpyeong, Boleum island, as fine exsolution intergrowth of magnetite and ilmenite.

6. Nickel

Nickel deposits in Korea are of pentlandite-bearing pyrrhotite deposits associated with Precambrian basic intrusives. Nickel deposits are distributed in Goseong, Gapyeong, Eumseong, Gimcheon and Jirisan(Sannae) areas.

7. Tin

Low grade, cassiterite-bearing pegmatite deposits are distributed in southern part of Sangdong mine(Sungyeong) and east coastal area(Uljin).

Paleozoic Metallogenic Provinces;

1. Hematite-Magnetite

There are two formations of Paleozoic age which contain sedimentary hematite beds, one in Dongjeom quartzite bed of Ordovician and the other in base of Hongjeom series of upper Carboniferous. Hematite-magnetite beds in Dongjeom are widely scattered in the east of Taebaeg mountain range, E-W divide, which is named Samcheog zone, and small scale mining is underway in places. Only one location is known in the west of the divide.

Hematite beds in the base of Hongjeom series crop out in Oggye area, east of the divide and Yeongweol area, west of the divide.

2. Limonite

Sedimentary limonite beds are embedded in the upper horizon of Sadong series of Permian age, the main anthracite coal measure in Korea. It is also known to occur in both west(Ogdong area) and east(Yeongdong area) of the divide and one mine in the eastern coastal area is under production.

3. Manganese

Manganese oxide bed is embedded in late Paleozoic sedimentary rocks as sedimentary origin ore deposits. The prominant area is Geumhwa province in North Korea.

Jurassic to early Cretaceous Metallogenic Provinces;

Various kinds of mineral deposits in Korea are, mainly, associated with Daebo granites of Jurassic to early Cretaceous age. The deposits are emplaced in the granites as well as in the surrounding Precambrian schists and paragneisses, and are aligned parallel to NE-SW Sinian direction.

1. Gold-Silver

Majority of gold-silver deposits in Korea are belong to Jurassic to early Cretaceous epoch. With few exceptions they are embedded in Jurassic granite or surrounding schists and paragneisses, and aligned parallel to NE-SW Sinian direction. The gold-silver provinces are delineated into 6 provinces in North Korea and 10 provinces in South Korea. They are, in order from north to south, Buyeong, Changseon, Suncheon-Seongcheon, Anbyeon, Suan and Geumhwa provinces in North Korea, and Pocheon, Hongcheon, Haemi, Cheonan, Hwaam, Chunyang, Seolcheon, Hapcheon, Suncheon and Gwangyang provinces in South Korea. Among them Hongcheon, Cheonan and Seolcheon are the most producing and prominant provinces and trend in Sinian direction in South Korea. In North Korea Suncheon-Seongcheon, Suan and Anbyeon provinces are big producing and prominant provinces.

These deposits are mostly of hypothermal to mesothermal veins in granites or Precambrian schists and para-gneisses except Hwaam province where most of the deposits are emplaced in limestones of Cambro-Ordovician age as vein type deposits.

2. Lead-Zinc

Lead-zinc provinces of this epoch are relatively small and show no definite trend but irregular. Deposits emplaced in Precambrian schists are

mostly vein type and those in limestones of Precambrian or Cambro-Ordovician age are contact replacement type. Belonged to the former type are Shiheung, Gapyeong and Muju provinces in South Korea. Changseong province in North Korea, and to the latter type being Hwanggangri, Taebaegsan and Geumsan provinces in South Korea, Suncheon-Seongcheon, Seoheung and Taeryeong provinces in North Korea.

3. Tungsten-Molybdenum

Korea is one of the main tungsten producers in the free world. Main production comes from the Sangdong deposits of contact metasomatic type. Generally tungsten in closely associated with molybdenum, and the deposits are classified into several types such as contact metasomatic scheelite deposits, wolframite-scheelite-molybdenite-quartz veins and breccia pipe.

High temperature veins of quartz-tungsten-molybdenum or quartz-molybdenum association in Precambrian gneiss and Mesozoic granite are common type of deposits.

Tungsten deposits in South Korea are mainly of wolframite-quartz vein in granites(Daehwa province), and in sediments(Danyang province), contact replacement deposits in limestone or special type of replacement deposits in Cambrian slate(Sangdong province) which is represented by famous Sangdong scheelite mine. In North Korea, the tungsten deposits are also of wolframitequartz vein in schists(Ganggye and Shanheung provinces).

Molybdenite deposits are mostly emplaced in Jurassic granites and diorites as quartz veins or pegmatite veins. Representative are Jucheon, Daehwa, Pyeonghae and Gochang provinces in South Korea, and Ganggye and Suan provinces in North Korea.

4. Magnetite

A few magnetite deposits are known to occur emplacing in metamorphic rocks, metasediments and miogeosynclinal sedimentary rocks of various age. In North Korea Gaecheon, Jaeryeong and Geumcheon provinces belong to this epoch. However, metallogenic epoch of these deposits are not sure by lack of age dating of the relative igneous rocks.

5. Fluorite

There are three fluorite districts in South Korea which are Chuncheon, Hwanggangri and Geumsan provinces, and three districts in North Korea which are Jeongyeong, Daejeong and Jaeryeong provinces. Deposits in Chuncheon, Jeongyeong and Daejeong provinces are emplaced in Precambrian schists and their general trend is of roughly NE-NS directon. Deposits in Hwanggangri, Geumsan and Jaeryeong provinces are emplaced in limestones of Precambrian or Cambro-Ordovician age, and also generally show NE-NS trend. Metallogenic epoch of latter three provinces is uncertain about whether they belong to Jurassic to early Cretaceous or late Cretaceous to early Tertiary. It is, however, tentatively decided to be Jurassic to early Cretaceous age as other provinces.

6. Manganese

Manganese deposits are not so many in Korea. They are irregular massive replacement body in Precambrian limestones, and in Cretaceous slate. Janggun province in South Korea and Hweyang province in North Korea are the prominant places.

7. Cobalt-Nickel

Cobatl-nickel deposits in Korea are of pentlandite bearing pyrrhotite deposits associated with basic intrusives. Weongdong province and few deposits of this type are known to occur in scattered places.

Late Cretaceous to early Tertiary Metallogenic Provinces;

Late Cretaceous to early Tertiary Metallogenic provinces are distributed in nearly all parts of North Korea and in some part of South Korea. The distribution is restricted to Gyeongsang basin

which is situated in southeast of Korea and Jeonnam area which is southwest of Korea, the geology of these areas are consisted of Cretaceous sediments, volcanics and plutons.

Mineral deposits in this epoch have no definite trend but rather irregular, and are more or less mesothermal to epithermal vein types. Occurrences of deposits are also limited to fissures and cracks in either andesitic rocks or black and indurated slate of upper member of Silla series, both of which are of late Cretaceous in age.

1. Gold-Silver

Deposits of this epoch are rather scare and distributed mainly in North Korea. The mineral deposits are embedded in Precambrian gneisses and schists as vein type of NW direction, and the prominent areas are Myeongcheon, Seongjin, Yeongheung, Sagju, Seongcheon, Yeonbaeg and Anpung provinces.

In South Korea the deposits are exclusively of fissure filling veins in andesitic rocks and hard Haman beds of upper Silla series, to which is of province is named. Tongyeong gold mine slated typical epithermal deposit and representative of this province.

2. Copper

Copper deposits of this epoch in North Korea are associated with various rocks, namely limestone, gabbro, gneiss and granitic rocks as fissure filling vein types and replacement types. The prominent areas are Gapsan, Euiju, Yeongweon, Jangyeon and Cheolweon provinces.

In South Korea, Gyeongnam and Ilgwang provinces in southern portion of Gyeongsang basin are producing all copper, practically in Korea. Deposits in the former provinces are emplaced mainly in andesite and related volcanics, or in hard black slate of upper Silla series, and of fissure filling vein types. The latter provinces are emplaced in granite or slate depending on localities. These veins are more or less striking NNW to NNE direction.

Jungweon zone is situated in Precambrian Ogcheon system and generally trends northeastward. The exact age of Jungweon zone is uncertain but is thought to be late Cretaceous age. Chalcopyrite vein, breccia pipe, porphyry and alunite pyrophyllite type deposits are formed in sedimentary formation and volcanic rocks and granite mainly in Gyeongsang basin and along the southern coast. A few contact metasomatic deposits are emplaced in Paleozoic limestone, and native copper occurs in Cretaceous basalt in the northern part of Gyeongsang basin.

Veins are formed by filling two main fissure systems, N-S and E-W, and consist of very simple mineral assemblage of chalcopyrite and minor galena and sphalerite, iron sulfides and arsenopyrite with quartz and calcite gangues.

Two collapse-type breccia pipes (Dalseong, Ilgwang) mineralized with chalcopyrite and tungsten are formed in Cretaceous andesite-porphyry and granodiorite-quartz monzonite stock in Gyeongsang basin.

Several low-grade porphyry copper and/or molybdenum type deposits are known in Gyeongsang basin along southest coast. Closely spaced fractures and veins in granodiorite stocks or andesite covers are mineralized with chalcopyrite, molybdenite and iron sulfides. Argillic, phyllic and propylitic alterations are common.

3. Lead-Zinc

There are eight provinces of lead-zinc deposits, namely, Yeongheung, Yonghyeon, Jangyeon and Geumhwa in North Korea, and Taebaegsan region and Gyeongsang basin (Yeongdeog, Gusan-dong, Daegu and Masan-Milyang) provinces in South Korea.

Lead-zinc deposits of South Korea are divided into two categories. First one is skarn and associated replacement type, and the second is simple fissure filling vein type. The first type deposits are mostly distributed in Taebaegsan mineralized region and the second type of

deposits in Gyeongsang basin. Among them, the skarn replacement type is very important producer in Korea. It's production occupies 94% of total production. Famous ones are Yeonhwa I, Yeonhwa II and Uljin mine etc. Most of fissure-filling type deposits are distributed in Gyeongsang basin.

4. Tungsten-Molybdenum

Wolframite, scheelite and molybdenite deposits are scattered as small size in Changseong, Gogsan and Goseong provinces in North Korea, and Yeonil province in South Korea. These deposits are mainly of quartz veins or network of quartz veinlets.

5. Manganese

Manganese deposits in Dosan province of North Korea are emplaced in limestone as fissure filling vein types and bedded types partially. And the deposits in Gyeongju province are emplaced in black, indurated slate of upper Silla series and in brecciated rhyolite of probable early Tertiary age. Several small fissure filling vein deposits are distributed in formation of various ages. Two economically important replacement type deposits grade into contact-metasomatic lead-zinc deposits in depth (Yeonhwa and Janggun mine).

6. Magnetite

There are three iron deposit provinces in North Korea and also two provinces in South Korea.

In North Korea, the three provinces are Byeogdong, Gyeomipo and Yongcheon iron deposit provinces. In South Korea, the deposits of Yeongpung area are contact-metasomatic magnetite deposits which are probably of late Cretaceous age.

And a few magnetite deposits in Gyeongsang basin area, especially in Gimhae province where Gimhae, Mulgeum and Ulsan mine are well known. These deposits are replacement type deposit in andesite or related volcanic rocks.

7. Fluorite and Asbestos

Fluorite deposits are clustered in three districts, Hwacheon in the northern, and Hwanggangri and Geumsan districts in the central Korea. Quartz-fluorite veins and calcite-fluorite replacement type deposits are formed. In the Hwacheon zone, quartz-fluorite veins formed in Precambrian gneiss and Jurassic granite, in the central zone, both vein and replacement type deposits are emplaced in Cambro-Ordovician limestone and Cretaceous sediments. Some replacement type deposits contain scheelite.

Asbestos deposits are distributed in Euiju and Daegog provinces whose deposits are associated with quartzite, mica schist and slate as fissure filling vein types.

8. Pyrophyllite

Pyrophyllite deposits are distributed in Jeungsan and Gangseo provinces which are located in North Korea, the deposits emplaced in limestone and gneiss complex as fissure filling vein types. And the other pyrophyllite deposits are distributed in Gyeongsang basin area where Jugjang, Milyang, Dongrae and Jeonnam provinces can be well defined in South Korea. These deposits of South Korea are embedded in rhyolitic tuff or other acid volcanic rocks. In tectonic viewpoint, Milyang province is situated along Gimhae-Milyang fault zone, and Dongrae province is along Dongrae-Ulsan graben area, both of which trend generally north-northeastward.

Quaternary Metallogenic Provinces;

Placer deposits are divided into placer gold and thorium deposits, the provinces of placer gold in North Korea are Gyeongweon, Sagju and Sunan area and Asan, Seongnam, Daecheon, Gimje, Ipjang and Damyang provinces in South Korea.

Kaoline Province of Unknown Epoch;

There are many localities of kaoline deposits but among them Hadong district in Gyeongsang basin is well known even in abroad. Hadong

Table 3 Metal/mineral content of deposits is shown by the symbol and shape of the nucleus of spot symbols.

Code	Symbol	a=○	b=□	c=◇	d=◊	e=, <>
1		W	Sn	Be	Nb,Ta	Li
2		Fe	Ti	Fe,Ti(V)	Fe(mgn) Cu	P
3		Cu,Fes	Mo	Cu,Au	Cu,Pb,Zn(Ag)	Cu,Au,Cu,Sn
4		Au	Au,Cu	Au,Ag	Ag,Pb,Zn(Au,Cu)	
5		Cr	Ni	Co	Cu,Ni(Co)	Asbestos
6		Ca	Na	K	Mg	B
7		Pb	Zn	Pb,Zn	Pb,Zn,Ag(Au,Cg)	
8		Hg	Sb	F	Ba	Sr
9		U	V	U.V	Th	U,Th
10		Mn	Al	Kyanite	Pyrophyllite	Talc
11		S	FeS	Mica	Diamond	Graphite

kaoline depositts(Halloysite) are formed by weathering of plagioclase rock which is believed to be differenciated from basic intrusive in Precambrian terrain. The belt extends northward from southern coast to Sancheong area, then intermittently to northeastward to the west of Woegwan on Seoul-Busan rail-road.

METALLOGENIC MAP OF KOREA

The Metallogenic Map of Korea, scaled 1: 1, 000, 000, shows 444 ore deposits of the Korea and adjacent island by symbol on a background adapted from existing geologic, tectonic and metamorphic maps. The deposits(metallic and some non-metallic) are categorized by the commodities they contain, size, geologic environment, age and mineralogic nature. A listing of deposits, keyed by numbers to the map, identifies the deposits by name and gives supplementary information about them.

Geologic and Structural Background

The age of stratified(sedimentary and/or volcanic) rocks and all other rocks is shown by symbol in Metallogenic Map.

The basement rocks are shown by horizontal dash line in Gyeonggi Massif, Ryeongnam Massif and Pyeongbug Massif wich are northwestern part and southeastern part of Korean peninsula respectively.

Folded rocks are shown by vertical, oblique

Table 4 Size limits for deposits, in terms of metric tons of metal or mineral contained unless otherwise specified. Past production and (or) reserves totaled.

Nucleus Size Code	○ Large A	> 	○ Medium B	>. 	○ Small C
Aluminum (bauxite)		100,000,000		1,000,000	
Antimony		50,000		5,000	
Asbestos		10,000,000		100,000	
Barite ($BaSO_4$)		5,000,000		50,000	
Beryllium (BeO)		1,000		10	
Boron (B_2O_3)		10,000,000		100,000	
Chromium (Cr_2O_3)		1,000,000		10,000	
Cobalt		20,000		1,000	
Copper		1,000,000		50,000	
Diamond		10		1	
Fluorite (CaF_2)		5,000,000		50,000	
Gold		500		25	
Graphite		1,000,000		10,000	
Gypsum-anhydrite		100,000,000		5,000,000	
Iron (ore)		100,000,000		5,000,000	
Kyanite group (Al_2SiO_5)		1,000,000		50,000	
Lead		1,000,000		50,000	
Lithium (Li_2O)		100,000		10,000	
Magnesium ($MgCO_3$)		10,000,000		100,000	
Manganese (tons of 40% Mn)		10,000,000		100,000	
Mercury (flasks)		500,000		10,000	
Molybdenum		500,000		5,000	
Nickel		500,000		25,000	
Niobium-Tantalum (R_2O_5)		100,000		1,000	
Phosphate (P_2O_5)		200,000,000		200,000	
Platinum group		500		25	
Potassium (K_2O)		10,000,000		1,000,000	
Pytite (FeS_2)		20,000,000		200,000	
Pyrophyllite		10,000,000		1,000,000	
Rare earths (RE_2O_3)		1,000,000		1,000	
Silver		10,000		500	
Sodium (salts)		10,000,000		1,000,000	
Strontium (salts)		1,000,000		10,000	
Sulfur		10,000,000		100,000	
Talc		10,000,000		1,000,000	
Thorium		10,000		1,000	
Tin		100,000		5,000	
Titanium (TiO_2)		10,000,000		1,000,000	
Tungsten		10,000		500	
Uranium		10,000		100	
Vanadium		10,000		500	
Zinc		1,000,000		50,000	

Table 5 Geologic environment of deposits, shown by ticks on nucleus. Odd numbered codes referred to depositional environment of host rocks(A), even numbered codes to intrusive igneous rocks (B), if any, believed to be related to the mineralization.

(A) Depositional environment

1		Eugeosynclinal type
2		Volcano-sedimentary sequence of Archean age
3		Sedimentary rocks of miogeosynclinal type
4		Sequence of intermediate and felsic volcanic rocks with terrestrial and marine sedimentary rocks
5		Thick metamorphosed sequence
6		Cover rocks in successor basins
7		Undeformed continental volcanic rocks
8		Platform cover rocks, including coastal plains

(B) Igneous environment

1		Alkaline rocks
2		Felsic rocks - granite to quartz diorite
3		Gabbroic rocks, including diabase
4		Ultramafic rocks
5		Diorite
6		Anorthosite
7		Alkalic-mafic rocks

and horizontal lines in northeastern part o Taebaegsan Ogcheon zone, age of Carboniferous Triassic(Pyeongan Group) and Cambro--Ordovician sediments(Joseon Group).

Migmatites and granite gneisses that are presumably of mixed sedimentary and igneous derivation are shown by vertical lines, oblique lines and crossed lines.

Mesozoic sediments which are located mainly in southeastern part of Korean peninsula are shown by horizontal dotted line, which are consisted of mainly shale and sandstone.

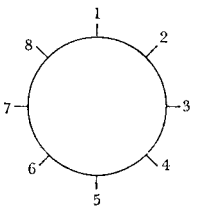
Intrusive rocks of Jurassic and Cretaceous ages are shown by small cross symbols, and volcanics are shown by "V" letter symbols.

Faults and tectonic boundaries are shown by a simple line(faults) and dotted line combined (tectonic boundary).

Table 6 Geologic class of deposit, shown by symbol around nucleus.

Code	Symbol	Class
1		Pegmatite deposits
2		Strata-bound chemical sediments
3		Skarn or greisen deposits and replacement deposits
4		Placer deposits
5		Stockworks, pipes and deposits of irregular type
6		Evaporites
7		Vein and shear zones
8		Concordant deposits in igneous rocks
9		Laterites
10		Mainly disseminated deposits
11		Massive sulfide deposits

Table 7 Geologic age of mineralization shown by ticks on the ring for the major areas in South Korea.



1 Precambrian (undivided)
2 Late Paleozoic
3 Latest Paleozoic to Triassic
4 Jurassic
5 Cretaceous
6 Latest Mesozoic to Paleogene
7 Neogene
8 Quaternary

or younger: code 3
or older : code 7
from to : code 4 - 6

Mineral Deposits

Spot Symbols; There are two parts of spot symbols, namely a nucleus and a ring, to each of which ticks may be appended. The metal/mineral content of deposits is shown by the symbol and shape of the nucleus(Table 3). Eleven symbols(including black) and three shapes, which by orientation of the square and lozenge become five, provide for 55 possible combinations(one has not been used). The shapes were chosen as the simplest forms to which ticks in one or more of eight positions can be appended. In so far as possible, the commodities are placed in natural groups and symbols assigned that will facilitate their recognition.

The simplest and/or most common metals are

Table 8 Summary of mineral deposits which is plotted on the metallogenic map of Korea.

Metal and mineral content	Abbreviation	Definite age	Number of deposits
1 Au, Ag and associated metal/mineral	Au	Jurassic, Cretaceous, Quaternary	101
2 Cu and associated metal/mineral	Cu	Jurassic, Cretaceous	34
3 Pb, Zn and associated metal/mineral	Pb	Jurassic, Cretaceous	58
4 Fe, Ti and associated metel/mineral	Fe(Ti)	Precambrian, Latest Paleozoic to Triassic, Jurassic, Cretaceous	65
5 Tungsten	W	Precambrian, Jurassic, Cretaceous	28
6 Molybdenum	Mo	Jurassic, Cretaceous	17
7 Ni, Co and associated metal/mineal	Ni(Co)	Precambrian, Cretaceous	14
8 Antimony	Sb	Jurassic, Cretaceous	5
9 Tin	Sn	Precambrian	5
10 Fluorite	F	Jurassic, Cretaceous	14
11 Asbestos	A	Precambrian, Cretaceous	7
12 Graphite	C	Precambrian, Late Paleozoic, Jurassic, Cretaceous	22
13 Manganese	Mn	Late Paleozoic, Jurassic, Cretaceous	7
14 Barite	Ba	Jurassic, Cretaceous	8
15 Kyanite group	Ky	Jurassic, Cretaccous	4
16 Uranium	U	Precambrian, Cretaceous	4
17 Talc	T	Precambrian, Jurassic, Cretaceous	8
18 Thorium	Th	Quaternary	5
19 Pyrophyllite, Clay and Kaoline	Cy	Cretaceous	10
20 Sulphur(Pyrite, Pyrrhotite)	S	Cretaceous	10
21 Magnesite	Mg	Jurassic, Cretaceous	6
22 Mercury	Hg	Cretaceous	3
23 Phosphate	P	Cretaceous	2
24 Beryl	Be	Jurassic	2
25 Mica	M	Cretaceous	5
			444

represented by circles and squares; for example, lead and zinc, copper and molybdenum, and combinations of these by a diamond. The lozenge is used for more complex ores such as lead--zinc--silver.

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韓國의 鑛床生成圖

金 善 億·黃 德 煥

要約：筆者는 1981年 파리, 1983年 마닐라에서 개최되었던 CGMW會議에 參席함을 계기로 世界共通의 製作規約을 遵守해 가면서 大韓地質圖 및 한국의 地體構造圖를 基本圖로 하여 그간의 鑛床調査研究資料中 444個 主要對象鑛床을 選定, 이들 資料를 整理綜合 分類하여 1983年에 한국의 鑛床生成圖를 發刊(韓國動力資源研究所)한 바 있다.

처음 試圖된 일이었을 뿐 아니라 對象個個 鑛床의 精密調査資料가 不足하여 恰足하지 못하였음에 次後 보다 補完된 充實한 內容의 鑛床生成圖를 期待하여 마지 않는다.

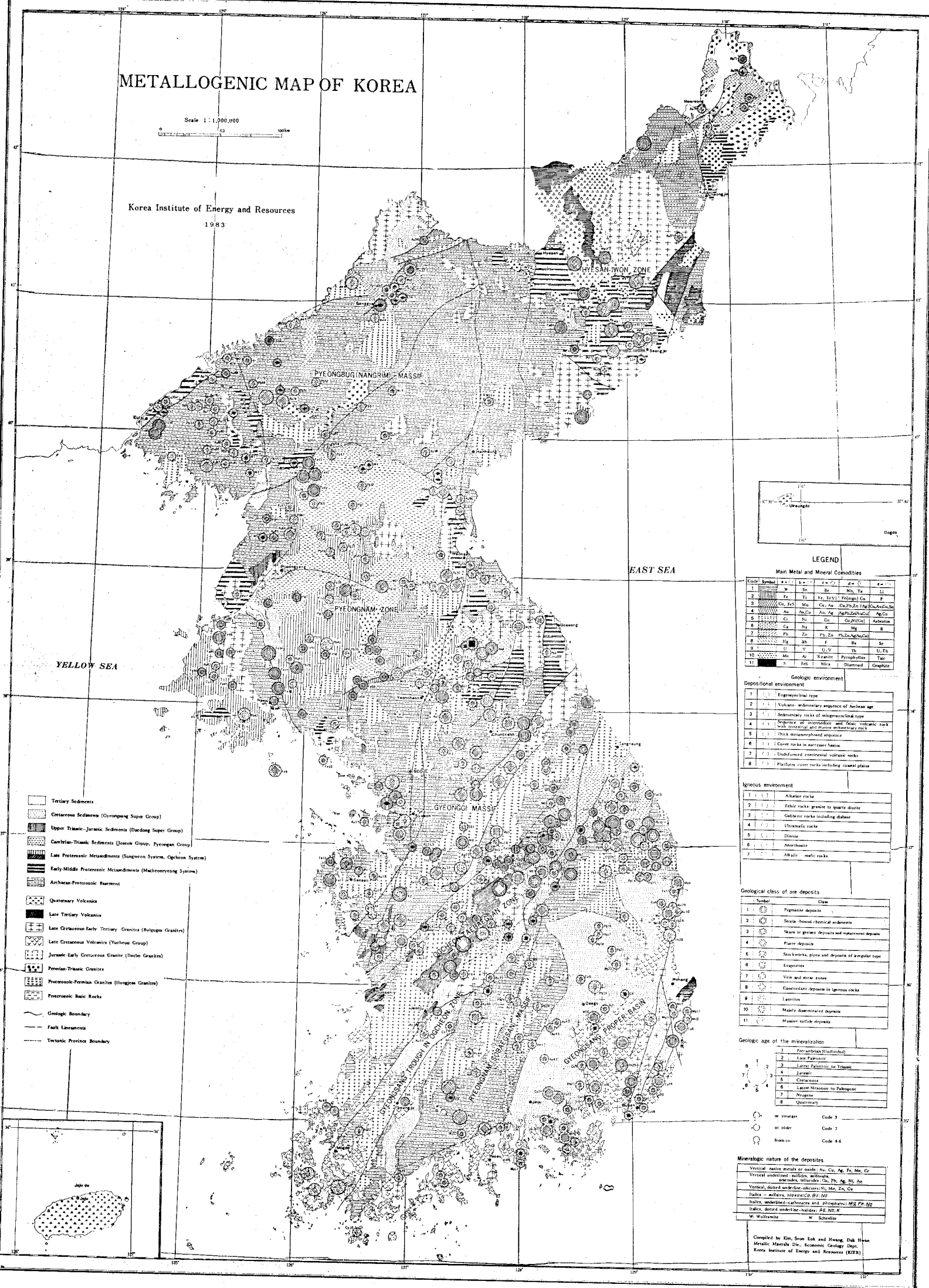
METALLOGENIC MAP OF KOREA

Scale 1 : 1,000,000

0 50 100km

Korea Institute of Energy and Resources

1983



Tertiary Sediments

Cretaceous Sediments (Gyeongsang Super Group)

Upper Triassic–Jurassic Sediments (Daedong Super Group)

Cambrian-Triassic Sediments (Joseon Group, Pyeongan Group)

Late Proterozoic Metasediments (Songwoon System, Ogcheon System)

Early-Middle Proterozoic Metasediments (Macheonryeong System)

Archaean-Proterozoic Basement

Quaternary Volcanics

Late Tertiary Volcanics

Late Cretaceous-Early Tertiary Granites (Bulguga Granites)

Late Cretaceous Volcanics (Yucheon Group)

Jurassic-Early Cretaceous Granite (Daebo Granites)

Permian-Triassic Granites

Proterozoic-Permian Granites (Hongjesa Granites)

Proterozoic Basic Rocks

Geologic Boundary

Fault Lineaments

Tectonic Province Boundary

LEGEND

Main Metal and Mineral Comodities

Code	Symbol	a ○	b ○	c ○ △	d ○ △	e ○
1		W	Sn	Be	Nb, Ta	Li
2		Fe	Ti	Fe, Ti(V)	Fe(mgn) Co	P
3		Cu, ZnS	Mo	Cu, Au	Cu,Pb,Zn /Ag|Cu,Au,Co,Se	
4		Au	Au,Co	Au, Ag	Ag,Pb,Zn/Au,Cu	Ag,Co
5		Co	Ni	Co	Cu,Ni|Co|	Asbestos
6		Ca	Na	K	Mg	B
7		Pb	Zn	Pb, Zn	Pb,Zn/Ag|Au,Cu|	
8		Hg	Sb	F	Ba	Sr
9		U	V	U,V	Th	U,Th
10		Mo	Al	Kyanite	Pyrophyllite	Talc
11		S	FeS	Mica	Diamond	Graphite

Geologic environment

Depositional environment

1		Eugeosynclinal type
2		Volcano- sedimentary sequence of Archean age
3		Sedimentary rocks of miogeosynclinal type
4		Sequence of intermediate and felsic volcanic rock with terrestrial and marine sedimentary rock
5		Thick metamorphosed sequence
6		Cover rocks in successor basins
7		Undeformed continental volcanic rocks
8		Platform cover rocks including coastal plains

Igneous environment

1		Alkaline rocks
2		Felsic rocks- granite to quartz diorite
3		Gabbroic rocks including diabase
4		Ultramafic rocks
5		Diorite
6		Anorthosite
7		Alkalic – mafic rocks

Geological class of ore deposits

	Symbol	Class
1		Pegmatite deposits
2		Strata-bound chemical sediments
3		Skarn or greisen deposits and replacement deposits
4		Placer deposits
5		Stockworks, pipes and deposits of irregular type
6		Evaporites
7		Vein and shear zones
8		Concordant deposits in igneous rocks
9		Laterites
10		Mainly disseminated deposits
11		Massive sulfide deposits

Geologic age of the mineralization

1	Precambrian(Undivided)
2	Late Paleozoic
3	Latest Paleozoic to Triassic
4	Jurassic
5	Cretaceous
6	Latest Mesozoic to Paleogene
7	Neogene
8	Quaternary

or younger Code 3

or older Code 7

from to Code 4-6

Mineralogic nature of the deposites

Vertical native metals or oxide; Au, Cu, Ag, Fe, Mn, Cr
Vertical underlined - sulfides, selenoshs, arsenides, tellurides ; Cu, Pb, Ag, Ni, Au
Vertical, dotted underline -silicates; Ni, Mn, Zn, Cu
Italics – sulfates, nigrate; *Ca, Ba, Ni*
Italics, underlined–carbonates and phosphates; *Mg, Fe, Na*
Italics, dotted underline–halides; *Ag, NO, K*
W: Wolframite W Scheelite

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