Jour. Petrol. Soc. Korea
Vol. 2, No. 1, p. 9~18, 1993

High-P metamorphic belt in central China and its possible eastward extension to Korea

Liu Xiaochun

Department of Geology, Changchun University of Earth Sciences, Changchun, China

ABSTRACT : The high-P metamorphic belt in central China, between the Sino-Korean and the Yangtze continental plates, is composed of the low-T and high-P metamorphic belt on the south and the high-T and high-P metamorphic belt on the north. The low-T and high-P metamorphic belt consists predominantly of bimodal metamorphic volcano-sedimentary sequences of Middle to Upper Proterozoic, characterized by the occurrences of blueschists, which have undergone a progressive metamorphism from blueschist through greenschist to epidote amphibolite facies with metamorphic conditions of 7~14 kb and 350~560℃. The high-T and high-P metamorphic belt mainly consists of the Upper Archean to Lower Proterozoic crystalline basement characterized by the aboundant occurrences of eclogites formed at 12~28 kb and 620~840℃. The formation of high-P metamorphic belt is related to the collison between the Sino-Korean and the Yangtze continental plates during Indosinian orogeny. The two belts may extend to central Korean Peninsula correlating respectively to the Okchon belt and the Kyonggi massif based on comparative studies of geography, tectonics and petrology. Therefore, much attention should be paid to search for such high-P metamorphic rocks as blueschists or eclogites in those two areas, which can play a key role for understanding the tectonic evolution of the Korean Peninsula.

Key Words : High-P metamorphic belt, blueschist, eclogite, East Asian tectonics, continental collision

INTRODUCTION

One of the most significant progresses in metamorphic geology in China is the discovery of a large-scale high-P metamorphic belt between the Sino-Korean and the Yangtze continental plates in 1980's. Recently many geologists have conducted researches on this high-P metamorphic belt. Zhang *et al.* (1989) considered this belt to be a high-P metamorphic belt composed of blueschist-whiteschist-eclogite. Liu *et al.* (1989) suggested that it was a large tectonic melange belt. I proposed the concept of paired high-P metamorphic belts consisting of the low-T and high-P belt on the south and the high-T and high-P belt on the north (Liu, 1991). Though different views still exist concerning the problems of the constituent, age and mechanism of the high-P metamorphic belt, most geologists considered that its formation was closely related to the subduction and collision between the Sino-Korean and the Yangtze continental plates.

The discovery of the high-P metamorphic belt in central China further confirms the conclusion that the Dabie Mountains are geologically the eastern extension of the Qinling orogenic belt (Ren *et al.*, 1980). More significant is its reappearance to the east of Tanlu Fault in North Jiangsu and the Jiaodong Peninsula. Hence, the Su-Lu massif is not a part of the Sino-Korean continental plate, but is the further eastward extension of the Qinling orogenic belt. This convincing petrological evidence provides the explanation of the great left-lateral displacement of Tanlu Fault. The orogenic belt extends to the east and emerges under Yellow

Present address: Laboratory of Ore Deposits Geochemistry, Institute of Geochemistry Academia Sinica, Guiyang, PRC.

Sea and Bohai Sea. Based on the information on geography and tectonics, it should reappear in the Korean Peninsula if there is no large tectonic movement between the Mainland China and the Korean Peninsula. However, no high-P metamorphic complexes have been found in the Korean Peninsula up to now. According to recent studies on the belt and comparative analysis of geological conditions in the Mainland China and the Korean Peninsula, the present paper discusses the eastward extension of the belt and the possibility of finding high-P metamorjphic rocks such as blueschists and eclogites in the Korean Peninsula.

REGIONAL GEOLOGICAL SETTING

The high-P metamorphic belt in central China (as an important part of the Qinling orogenic belt) occurs between the Sino-Korean and the Yangtze continental plates. It spreads over more than 1500 km from the border area of Shanxi, Henan and Hubei Province to the west, through north of Hubei, central Anhiu, north of Jiangsu Province to the Jiaodong Peninsula in the east (Fig. 1). The occurrences of blueschists in Bikou group in Sichuan, Gansu and Shanxi Province indicates that this group may represent the westward extension of the high-P metamorphic belt. This belt is cut by Tanlu Fault into two parts: the western part between Shangdan-Tongcheng Fault and Xiangfan-Guangji Fault; the eastern part within the region bounded by Wulian-Jime-Muping Fault and Jiashan-Xiangshui Fault. The width of the belt is about 50~100 km, with a maximum of 150 km.

The belt consists of low-T and high-P metamorphic complexes on the south and high-T and high-P complexes on the north. The former mainly consists of Middle-Upper Proterozoic metamorphic sequences with certain amount of upper Sinian sequences in the west, called Yaolinghe group, Wudang group, Suixian group and Hongan group in Hubei, Susong group and Zhangbaling group in Anhui and Haizhou group in North of Jiansu. The latter consists predominantly of Upper Archean-Lower Proterozoic crystalline basement, including the Dabie massif (Dabie group) around the boundaries of Hubei-Henan-Anhui and the Su-Lu massif (Jiaonan group and part of Jiaodong group) in North Jiansu and the Jiaodong Peninsula. Tectonically, the Dabie massif extends to the west and connects with the Tongbai massif at the boundaries of Hubei-Henan, but there is no report of eclogite in the Tongbai massif. Low-T and high-P metamorphic complexes overlying unconformably on the high-T and high-P metamorphic complexes overlying unconformably on the high-T and high-P complexes have been found in several areas, such as Huangmailing in Hubei, Susong in Anhui and Haizhou in north of Jiansu, but the main tectonic boundary between the two complexes is a deep fault inclining to the north.

On the north side of the belt is the Sino-Korean continental plate consolidated in the late Lower Proterozoic. A suite of low-grade metamorphic volcano-sedimentary rocks called respectively Liuling group in West Henan (as part of Eastern Qinling belt), Xinyang group in East Henan and Fuziling group in Anhui exists in the North Huaiyang fold belt between the high-P belt and the Sino-Korean plate. The age of Liuling group is determined to be Devonian Period by the discovery of Brachiopoda and Stromatopoda fossils, but the age of Xinyang group and Fuziling group is still uncertain: it was previously considered to be Middle-Upper Proterozoic; but recently to be Devonian Period based on the comparative studies of strata and the discovery of terrestrial micro-paleoplant fossils (Gao and Liu, 1988). The counterpart to the east of Tanlu Fault is not found in the Jiaodong Peninsula at present. Tectonically Penglai group may be its counterpart, but there are many differences in lithological characteristics between the two units.

On the south of the belt there exists the Yangtze continental plate consolidated in Upper Proterozoic Jinning Period, which is overlain by South China Sinian System. On the north margin of the Yangtze plate occurs a suite of low-grade metamorphic or unmetamorphosed foreland fold-thrust belt of Sinian (lower Proterozoic)-early Triassic series caused by continent-continent collision, but this belt is overlain by Quaternary System in north

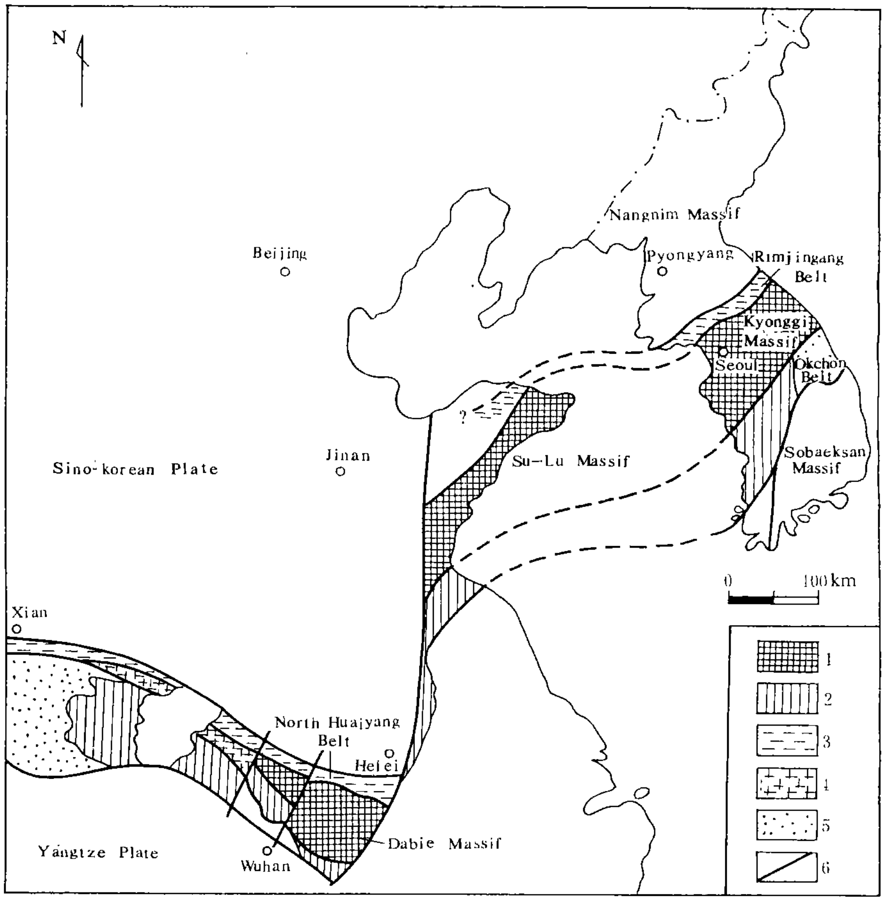

Fig. 1. Simplified map of high-P metamorphic belt in central China and its possible eastward extension to Korea. 1. high-T and high-P metamorphic complexes; 2. low-T and high-P metamorphic complexes; 3. Palaeozoic or Proterozoic low grade metamorphic series; 4. Archean-Lower Proterozoic massif; 5. Palaeozoic; 6. Fault.

of Jiangsu.

GEOLOGICAL CHARACTERISTICS OF HIGH-P METAMORPHIC BELT

Low-T and high-P Metamorphic Complexes

The main component of the complexes is a suite of metamorphic volcano-sedimentary formations composed predominantly of acidic volcanic rocks. The lower part of the formations consists of metamorphic terrigenous sedimentary series of neritic facies characterized by the association of phosphorite-graphite schist-marble-kyanite schist and overlies unconformably on the crystalline basement. The upper part in the west is a series of metamorphic neritic deposits (Sinian System) represented by interbedded metapelites and marbles. The acidic volcanic rocks mainly consist of tuffs with a large amount of crystalloclastic albites. In acidic volcanic rocks, the SiO_2 content is greater than 70 wt precent, and the Na_2O content ranges from 4 to 7 wt percent. The basic volcanic rocks are also composed mainly of tuffs, together with minor amount of lavas and volcanic breccias. Their SiO_2 content ranges from 45 to 55 wt percent and Na_2O is mostly greater than 3 wt percent. It is obvious that these volcanic rocks are a bimodal spilitic-quartz keratophyric series. Evidences from petrochemistry and geochemistry indicate that the formations were formed in continental rift salic crystalline basement. Some components of the rift may have developed into oceanic crust.

Low-T and high-P metamorphic complexes have been subject to progressive metamorphism. Blueschist, greenschist and epidote amphibolite facies can be divided from the south to the north in Hongan group in Hubei. Similar facies were recognized in Haizhou group, north of Jiangsu, but blueschist facies was found only in drill holes becaused it was overlain by the Quaternary system. The outcrops of metamorphic rocks are poorly exposed in other areas. Typical mineral assemblages of blueschist facies rocks are crossite + chlorite + epidote + albite + stilpnomelane in metabasites, crossite + spessartine granet + epidote + phengite + albite + quartz + piemontite in acidic metavolcanics, and magnesioriebeckite + chlorite + sericite + quartz in metapelites. Up to now, lawsonite and jadeite have not been found in blueschists. The assemblages of greenschist facies rocks are similar to those of blueschist facies except that crossite was replaced by actinolite or barroisite. Epidote amphibolite facies is characterized by the appearance of almandine garnet and hornblende in metabasites, and kyanite, chloritoid and topaz in metapelites. Glaucophane eclogites usually occur in Hongan group and Suixian group, North of Hubei.

The metamorphic P-T conditions of blueschist facies are estimated to be 7 kb and 350～450℃ based on assemblages, mineral compositions and geothermobarometry. Jadeite-content of omphacite and garnet-clinopyroxene geothermometer (Ellis and Green, 1979) indicate that eclogites in epidote amphobolite facies are formed at 11～14 kb and 540～560℃. Thus, the progressive metamorphism in low-T and high-P metamorphic complexes occurs over the P-T field of 7～14 kb and 350～560 ℃. Temperatures and pressures are synchronously increase from the south to the north. The main high-P minerals of blueschist, such as sodic amphibole, garnet, piemontite and epidote, have obvious chemical zonations. The rim of crossite was replaced by actinolite or barroisite, and piemontite by epidote. They grow during the decompression heating process resulting relatively high-T and low-P greenschist facies. Most eclogites also experience intensive retrograde metamorphism of epidote amphibolite facies.

High-T and high-P Metamorphic Complexes

The complexes are characterized by the common occurrences of eclogites in gneiss complexes. The gneiss complexes consist of a variety of gneisses, including plagioclase gneiss, two-feldspar gneiss and granitic gneiss, together with minor schists, amphibolites, granulites, quartzites, marbles and eclogites. Recent study suggests that they may be a suite of tonalite-trondhjemite-granodioritic gneisses and supracrustal rock series (Liu *et al.*, 1988). Three different occurrences of eclogites can be divided: (a) eclogites occurring as pseudobeds, bands or pods in ultra-basites (mostly garnet peridotites); (b) eclogites occurring as interbeds or blocks in gneisses and schists; (c) eclogites occurring as small irregular blocks within marbles. The petrochemistry and REE and Sr isotope geochemistry indicate that the protolith of eclogites are either gabbros formed during continental extension or bedded continental tholeiites corresponding to Upper Archean-Lower Proterozoic supracrustal rocks, but eclogites coexisting with marbles may be derived from calcareous mudstones. The peculiar massive structure of eclogites in outcrops is believed to be due to intensive ductile deformation during the uplift from deep level.

The critical feature of eclogite is that it contains coesite, an indicater of ultra high-P metamorphism. The typical mineral assembleges of coesite eclogites are garnet + omphacite + coesite ± kyanite ± zoisite. Coesite only occurs as inclusions in both garnet and omphacite and is mostly transformed into polycrystalline quartz aggregate. The expansion fracuture textures develop in host crystal (garnet or omphacite) because of the 10% volume increase in the process of transformation from coesite to quartz (Liu and Hu, 1991). Recently, diamond and aragonite are found in some eclogites (Xu *et al.*, 1991; Liu *et al.*, 1992). The existence of coesite and garnet-clinopyroxene geothermometer indicate that coesite eclogites are formed at pressures greater than 28 kb and temperatures ranging from about 650～750℃ in the Dabie massif to 700～840℃ in the Su-Lu massif. Petorgraphical studies show that not all eclogites in the area contain coesite, and P-T conditions for the formation of eclogites are also not uniform. In the Dabie massif, four eclogite types have been recognized from the southeast to the northwest, and their metamorphic conditions are shown in Table 1. The PTt paths of eclogites are either cooling or isothermal processes during decompression.

There is a controversy about the relationship of metamorphism between eclogites and their country rocks. The following high-P metamorphic rocks have been found in the Dabie massif in a recent study: (a) garnet-jadeite quartzite: occurs as thin layers within gneiss and mainly consists of garnet (Py_{14} A_{168} Sp_1 Gr_{15} An_2), jadeite (Jd_{84} Ac_2 Di_5 Hd_8 Ts_1) and quartz. Quartz pseudomorphs after coesite composed of polycrystalline quartz aggregate are common in both garnet and jadeite. (b) garnet-phengite schist and gneiss: typical mineral assemblage is garnet ($Py_{18\text{-}21}$ $Al_{51\text{-}53}$ $Sp_{1\text{-}1.5}$ $Gr_{24\text{-}27}$ $An_{0.5\text{-}2}$)+3T-type phengite+quartz+rutile. The marginal rims of phengite are often replaced by aggregates of biotite, plagioclase and quartz. (c) omphacite marble: occurs as layer within gneiss and mainly composed of calcite, omphacite (Jd_{39} Ac_4 Di_{53} Hd_2 Ts_2) and minor phengite. The occurrence of these high-P metamorphic rocks suggests that the eclogites together with regional country rocks underwent in situ high-P metamorphism (Liu *et al*., 1992). The differences in fabric and mineral compositions between eclogites and gnesses lead to the variation in retrograde metamorphic reaction rate during uplift process, which may explain the apparent discrepancy in metamorphic conditions of eclogites and their country rocks. In the Dabie massif, the synchronous variation of retrograde metamorphic mineral assembleges and P-T conditions both in eclogites and their country rocks (gneiss complexes) from epidote amphibolite through amphibolite to granulite facies from the southeast to the northwest

Table 1. The P-T conditions for different evolutional stages of eclogites

Type	Pre-eclogite stage	Eclogite stage	Post-eclogite stage
Amphibole eclogite	epidote amphibolite	620～698℃, >20 kb	Epidote amphibolite
Coesite eclogite	>500℃, 8～10 kb	674～755℃, 28～35 kb	facies 450～550℃, 5～7 kb
Quartz eclogite		775～783℃, >16 kb	Amphibolite facies 520～610℃, 5～7.5 kb
Garnet pyroxenite		684～829℃, >12 kb	Granulite facies 660～850℃, 4～10 kb

indicates that the "progrssive" metamorphic zone of the Dabie complexes results from retrograde metamorphism of eclogite facies. This conclusion has negated the traditional opinion that the age of progressive metamorphism in the Dabie massif is Upper Archean-Lower Proterozoic.

Age of high-P metamorphism

A great disputation exists on the age of high-P metamorphism. There are two main opinions: Upper Proterozoic (Zhang *et al*., 1987; Dong, 1989) and Mesozoic Indosinian (Li *et al*., 1989). The former is based on the fact that high-P rocks occur only in Precambrian metamorphic strata and no high-P minerals are found in Phanerozoic strata. Rb-Sr whole rock isochron ages of 725 Ma from Hongan group and 730 Ma from Zhangbaling group support the former conclusion. The latter is mainly from isotope geochronology of eclogites and blueschists. Up to now, four Sm-Nd mineral and whole rock isochron ages ranging from 211 to 244 Ma have been obtained from the Dabie massif, and similar Sm-Nd ages (211～232 Ma) from the Su-Lu massif. We have reported three $^{40}Ar\text{-}^{39}Ar$ ages for phengite and six K-Ar ages for phengite and sodic amphibole ranging from 204～254 Ma in blueschists. These results are consistent with the ^{40}Ar-^{39}Ar ages of 232 Ma (phengite) and 217 Ma (riebeckite) obitained from Eastern Qinling (Mattauer *et al.*, 1985). Recently, U-Pb ages of 212 Ma of zircon from biotite gneiss in the Dabie massif have been obtained by L. Aimes as reported by Wang *et al.* (1992).

It is obvious that the age of high-P metamorphism is still an important question to be solved in the future. I support the latter, because Sm-Nd mineral and whole rock isochron ages are useful for determing the timing of eclogite formation (Vidal and Hunziker, 1985), and ^{40}Ar-^{39}Ar phengite and glaucophane ages of blueschist formation. The fact that the high-P rocks occur only in Precambrian strata can not prove that they surely formed in Precambrian, and Rb-Sr whole rock isochron age may represent the age of protolith. Therefore, isotope geochronology has provided a convincing evidence that the high-P metamorphism occurred during Indosinian and the "progressive" metamorphism in the Dabie massif and the amphibolite facies metamorphism in the Su-Lu massif also formed at the same stage. Dabie and Su-Lu massifs are the crystalline basements of Upper Archean-Lower Proterozoic strongly superimposed by high-P metamorphism and its retrograde metamorphism during Indosinian. This conclusion is important to elaborate the tectonic evolution history of the areas.

EASTWARD EXTENSION OF HIGH-P METAMORPHIC BELT

The Korean peninsula is primarily divided into three Archean-Lower Proterozoic massifs: the Nangnim massif in the North, the Kyonggi massif in the Centre and the Sobaeksan (Ryongnam) massif in the South (Lee, 1987). They are separated by two narrow Phanerozoic fold belts, the Rimjingan belt and the Okchon belt. The three massifs are chiefly composed of various crystalline schists and gneisses, with a small amount of amphibolite, quartzite and marble. The complexes underwent metamorphism from amphibolite to upper amphibolite facies with local epidote amphibolite facies. Extensive granitization and migmatization occur in high-grade metamorphic areas. The major ages of granitic gneisses are 1700~2100 Ma, with the oldest age of 2765 Ma (Lee, 1987). The Rimjingang fold belt, separating the Nangnim massif and the Kyonggi massif, is located near the military demarcation line of South and North Korea and mainly consists of low-grade metamorphic Devonian System called Rimjingang group (Lee, 1987). The protoliths of the group belong to marine facies intercalated with terrestrial facies composed of shale, sandstone and quartz sandstone with intercalated limestone. Keratophyre exists in the upper part of the group. A lot of fossils of Brachiopoda, Cephalopoda and Gastropoda, etc. are found in the eastern part of the belt (Lee, 1987). The Rimjingang belt, striking NEE to nearly EW with its width about 30~40 km, probably thrusts over the Kyonggi massif (Filatova, 1990) to the south.

The Okchon fold belt, separating the Kyonggi massif and the Sobaeksan massif, is mainly composed of Okchon group, which consists of terrigenous clastic rock, limestone, lava and tuff. Cluzel *et al.* (1990) considered that the protoliths of this group were a rift series. The timing of Okchon group is still controversial: it was previously believed to be Precambrian, but recently to be Paleozoic. The Okchon metamorphic complexes are characterized by a series of progressive metamorphism from greenschist facies through transitional greenschist-amphibolite facies to amphibolite facies (Lee, 1987). The northeastern part of the Okchon belt consists of Early Paleozoic to Triassic sediments. This belt, 50~60 km in width, thrusts southward over the Sobaeksan massif, and is thrust by the Kyonggi massif (Filatova, 1990).

The Nangnim massif is generally believed to be the eastern part of the Sino-Korean continental plate because it is connected directly with the Mainland China. Stratigraphy of its overlying Cambrian-Ordovician System and the related fossils belong to the North China type. The Rimjingang belt consisting of Devonian System apparently can not be included in the Sino-Korean plate. The lithological characteristics of the belt may be compared with those of the north

Huaiyang belt in China, especially near the west shore, containing few types of fossils but more intercalated keratophyre, similar to Fuziling group. Rimjingang group previously considered to be Precambrian metamorphic rocks, but is determined to be Devonian System by the occurrence of index fossils. There also exists a controversy about the age of Xingyang group and Fuziling group. In the Jiaodong Peninsula, Yang (1992) considered that the Penglai group within Qixia county might compare with Rimjingang after recent discovery of Gastropoda fossils of middle Devonian-early Carboniferous Epoch. This leads to the disintegration of Penglai group. Thus, a complete Late Paleozoic fold belt transecting the Mainland China and the Korean Peninsula can be connected. Hence, the Su-Lu massif and the Kyonggi massif are located in the same toctonic environment, and not included in the Sino-Korean continental plate as considered by some geologists. Yang and Chen (1985) proposed that Okchon group is similar to Zhangbaling group and its overlying Sinian System in central Anhiu, both in tectonic location and in lithologic characters. Therefore, I infer that the Okchon belt may belong to low-T and high-P metamorphic complexes and Phanerozoic strata in the northeastern part of the belt may correspond to the foreland fold-thrust belt on the northern margin of the Yangtze plate. Hence, the Sobaeksan massif should be the eastern extension of the Yangtze continental plate, not belonging to the Huaxia massif.

As discussed above, the tectonic units in the Mainland China and the Korean Peninsula are schematically shown in Fig. 1. The location and direction of the tectonic lines are not identical. The reasons for this may be as follows: (a) the extension of the high-P metamorphic belt in central China is irregular, for example, the main tectonic lines strike NWW to nearly EW to the west of Tanlu Fault, but NE to the east of the Fault; (b) in the direction of transversing the high-P metamorphic belt, there exist a series of vertical faults of NE strike often showing a little strike-slip displacement (generally dextral except Tanlu Fault). This kind of fault also probably exists between the Mainland China and the Korean Peninsula; (c) after Mesozoic, the Korean Peninsula might have experienced the complicated tectonism caused by the activities of Pacific plate. Some geologists believe the NNE striking fault system in the southwest part of the Okchon belt to be a large dextral strike-slip fault formed during Indosinian (Cluzel *et al.*, 1991). Therefore, the tectonic correspondence between the Mainland China and the Korean Peninsula is clear. The southward thrusting of various tectonic units in the Korean Peninsula (Filatova, 1990) is similar to that of the Dabie Mountains in central China.

If the tectonic connection mentioned above is correct, the Kyonggi massif may contain eclogites, and Okchon group may belong to low-T and high-P metamorphic complexes. Park and So (1972) considered that Okchon belt is a high-P metamorphic belt, forming a paired metamorphic belt with low-P type Kyonggi metamorphic belt. This opinion is not accepted because there is no high-P mineral assemblages in the belt. However, it has been reported that stilpnomelane coexists with cholrite, muscovite, albite and biotite in greenschist facies pelitic and psammitic rocks in the Okchon metamorphic belt (Lee, 1987). Though stilpnomelane is a common low-T mineral, it mostly occurs in high-P metamorphic rocks (Miyashiro, 1973). Stilpnomelane is a major mineral phase both in blueschist facies and in greenschist facies rocks in high-P metamorphic belt in central China. Of course, high-P metamorphic conditions could be determined only when stilpnomelane coexists with other high-P minerals, such as phengite, spessartine garnet and piemontite, etc. Biotite-rich massive mafic melanosome and garnet porphyroblast with diameter up 2~10 cm are common in the Kyonggi massif (Lee, 1987), I speculate that they are possibly eclogites, because massive eclogites rich in garnet and poor in omphacite appear to be the same as a garnet megacryst in the field. Of course, this supposition needs to be verified by field, geological and petrographic studies.

DISCUSSION AND CONCLUSIONS

The features and dynamic evolutions of the margins between the Sino-Korean continental plate and the Yangtze plate were in controversy for a long time. The discovery and verification of high-P metamorphic belt in central China provided important petrological evidence for solving these problems. Although there exist different origins of blueschists, they occur only in appropriate environments such as subduction zones and related convergent plate settings, as demonstrated by thermal modeling (Ernst, 1988). The origin of eclogite-gneiss complexes seems to be a complicated issue. According to their occurrence, the formation of eclogite-gneiss complexes is mainly related to the collision between two continental plates. Therefore, I conclude that the high-P metamorphic belt in central China is produced by subduction and collision between Sino-Korean and Yangtze continental plates and that the Qinling belt is a typical collision orogenic belt.

Based on lithology and age of metamorphism, the origin, development and formation of the high-P metamorphic belt in central China spread over a long period of time. Most geologists considered that the Sino-Korean and the Yangtze plates were a connected craton before Middle Proterozoic (Dong, 1986), and a rift was formed between the two plates during Middle-Upper Proterozoic, in which a huge bimodal volcano-sedimentary sequence was formed. The phosphorous-bearing series at the bottom of this sequence represents the early product of the rift. A narrow ocean basin existed in the rift during Early Palaeozoic and the extension environment transformed to convergent one by Late Mesozoic. Final collision and connection of the two plates occurred during Indosinian. In the process of continent-continent collision, the basement and the overlying rift series of Yangtze plate were involved in intracontinental subductions. The former was converted into high-T and high-P metamorphic complexes and the latter into low-T and high-P complexes. The process continued to Middle Triassic, and a foreland fold-thrust belt of Sinian-Early Triassic was formed on the north margin of the Yangtze plate. Therefore, the formation history of the high-P metamorphic belt in central China represents the evolution history on the margin of the Sino-Korean and the Yangtze plates.

At present, it is an urgent task to search for high-P metamorphic complexes in the Korean Peninsula. The blueschists on the upper part of Haizhou group have been eroded because of large scale uplift in this region, so does Okchon group. Under such conditions, much attention should be paid to finding such minerals as phengite, spessartine garnet and piemontite that are extensively present in greenschist facies rocks of Haizhou group during the searching work. The field characteristics of eclogite are comparatively easy to identify, but its massive occurrence and rare distribution seldom attract the attentions of geologists. The eclogites in the Dabei massif were not found until early 1980's. If the tectonic lines and the correlations between the tectonic units proposed in this paper are true, I predict that there is the possibility of finding eclogite in the Kyonggi massif. If the work of searching for high-P metamorphic belt is successful, a set of tectonic units and evolutionary relations among the units similar to those in Mainland China will be established, which undoubtedly will push and improve the geological studies in the Korean Peninsula.

ACKOWLEDGEMENTS

I am grateful to my Graduate Advisor Prof. Zhang Yixia for his critical comments and suggestions and Prof. Cao Xi for his fruitful discussions on an earlier draft of the manuscript. Thanks are also given to Dr. Moonsup Cho for his constructive suggestions and improvements of the English version of this paper.

REFERENCES

Cluzel, D., Cadet, J.P. and Lapierre, H., 1990. Geodynamics of the Ogcheon belt (South Korea). Tectonophysics, 183, 41-56.

Cluzel, D., Lee, B.J. and Cadet, J.P. 1991. Indosinian dextral ductile fault system and synkinematic plutonism in the Southwest of the Ogcheon belt (South Korea). Tectonophysics, 194, 131-151.

Dong, S., 1989, The general features and distributions of the glaucophane schist belts of China. Acta Geol. Sinica, 3, 273-284 (in Chinese with English abstract).

Dong, S. et al., 1986, Metamorphism in China and its relation with the crustal evolution. Geological Publishing House, Beijing.

Ellis, D.J. and Green, D.H., 1979, An experimental study of the effect of Ca upon garnet-clinopyroxene Fe-Mg exchange equilibria. Contrib. Mineral. Petrol., **71**, 13-22.

Ernst, W.G., 1988. Tectonic history of subduction zones inferred from retrograde blueschist P-T paths. Geology, 16, 1081-1084.

Filatova, N.I., 1990, Mesozoic evolutionary of the Korea-Japan region. Geotectonics (USSR), 5, 112-124.

Gao, L. and Liu, Z., 1988, New discovery of microfossils from the Nanwan Formation of the Xinyang Group, Henan, and its geological significance. Geol. Review, 5, 421 (in Chinese).

Lee, D. S. (ed.), 1987, Geology of Korea. The Kyohak-Sa Publishing Co., Seoul, 514 p.

Li, S., Hart, S.R., Zheng, S., Guo, A., Liu, D. and Zhang, G., 1989, Sm-Nd age for the collison between the Sino-Korean and Yangtze cratons. Acad. Sinica, 3, 312-319 (in Chinese).

Liu, R., Ma, B., Zhang, Z., Yang, H. and Hu, L., 1989, Geological features of the tectonic melange in Northern Jiangsu-Southern Shandong region and lithologic column. Seismol. Geol., 1, 47-54 (in Chinese with English abstract).

Liu, W., Zhu, B., Jiang, M. and Liu, H., 1988, Basic geological characteristics of a Quartz-mica diorite mass in Liyuzhai, Dabie Mountains area, Hubei Province. Regional Geol. China, 3, 281-284 (in Chinese with English abstract).

Liu, X., 1991, The paired high-pressure metamorphic belts in eastern-central China. Geol. Review, 4, 300-309 (in Chinese with English abstract).

Liu, X. and Hu, K., 1991, Ultra-high-pressure metamorphism. Geol. Sci. Technol. Inform., 1, 17-23 (in Chinese with English abstract).

Liu, X. and Hu, K., 1991, Metamorphic correlation between eclogites and their country rocks and formation of regional "progressive" metamorphic zones in Dabie massif. J. Changchun Univ. Earth Sci., 4, 366-372 (in Chinese with English abstract).

Mattauer, M., Matte, D., Malavieille, J., Tapponnier, P., Maluski, H., Xu, Z., Lun, L. and Tang, Y., 1985, Tectonics of the Qinling belt: build-up and evolution of the eastern Asia. Nature, 317, 496-500.

Miyashiro, A., 1973, Metamorphism and metamorphic belts. George Allen Unwin, London, 492 p.

Park, B.K. and So, C.S., 1972, The Okcheon System in the central part of Southern Korean Peninsula as an Ancient Island Arc. J. Geol. Soc. Korea, 8, 198-210.

Ren, J., Jiang, C., Zhang, Z. and Qin, D., 1980, The geotectonic evolution of China. The Scientific Publishing House, Beijing (in Chinese).

Wang, X., Liou, J.G. and Maruyama, S., 1992, Coesite-bearing eclogites from the Dabie Mountains, Central China: petrogenesis, P-T paths and implications for regional tectonics. J. Geol., 100, 231-250.

Xu, S., Su, W., Liu, Y., Ji, S., Okay, A.I. and Sengor, A.M.C., 1991, Diamond from high-pressure metamorphic rocks in the eastern part of the Dabie Mountains. Bull. Sci., 17, 1318-1321 (in Chinese).

Yang, Z., 1992. New progress in the study of the Jiaodong Block. Regional Geol. China, 1, 43-50 (in Chinese with English abstract).

Yang, Z. and Chen, Y., 1985, Tectonic conjunction of eastern China and Korea Peninsula across Huanghai and Bohai Seas. J. Oceanography Huanghai Bohai Seas, 1, 50-62 (in Chinese with English abstract).

Zhang, S., Zhou, G. and Jing, Y., 1987, The characteristics of blueschist belt on the north margin of Yangtze platform. J. Changchun Univ. Earth Sci., Spec. Issue: 53-70 (in Chinese with English abstract).

Zhang, S., Hu, K., Liu, X. and Qiao, L., 1989, The characteristics of Proterozoic blueschist-whiteschist-eclogite in Central China: a trinity of ancient intercontinental collapsion-collision zone. J. Changchun Univ. Earth Sci., Spec. issue: 152-157 (in Chinese with English abstract).

(책임편집 : 권성택)

중국 중앙부의 고압 변성대와 한반도로의 동쪽 연장 가능성

리우 샤오춘

Department of Geology, Changchun University of Earth Sciences
Changchun, China

요 약 : 사이노-코리안(Sino-Korean)과 양쯔(Yangtze) 대륙판 사이에 있는 중국 중앙부의 고압 변성대는 남쪽의 저온-고압 변성대 그리고 북쪽의 고온-고압 변성대로 각각 구분된다. 저온-고압 변성대는 청색편암의 산출에 의해 특징지워지는데 중부-상부 원생대의 쌍모형 변성 화산-퇴적층으로 주로 구성되어 있는데, 이들은 녹색 편암상, 녹염석 각섬암상을 거쳐 변성 조건 7～14 kb, 350～560℃의 청색편암상에 이르는 점진 변성작용을 받았다. 고온-고압 변성대는 주로 12～28 kb, 620～840℃의 조건에서 형성된 에클로자이트(eclogite)가 많이 산출되는 것이 특징이며 상부 시생대-하부 원생대 결정질 기반암으로 구성되어 있다. 이러한 고압 변성대의 형성은 인도시니안(Indosinian) 조산운동 동안 사이노-코리안과 양쯔 대륙판의 충돌과 관련되어 있다. 이들 두 변성대는 지형학적, 지구조적 그리고 암석학적인 비교 연구에 의하면 한반도 중앙부의 옥천대와 경기 육괴로 각각 연장될지도 모른다. 그러므로, 이 두 지역에서 한반도의 지구조적인 진화를 이해하는데 핵심적인 역할을 할 수 있는 청색편암 혹은 에클로자이트와 같은 고압 변성암을 찾는데 많은 관심을 두어야 할 것이다.

핵심어 : 고압변성대, 청색편암, 에클로자이트, 동아시아 지구조, 대륙충돌

현주소 : Laboratory of Ore Deposits Geochemistry, Institute of Geochemistry Academia Sinica, Guiyang, PRC.