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The stratigraphy of the Pyeongan Supergroup of South Korea: A review

Chang Zin Lee*

Department of Earth Science Education, Chungbuk National University, Chungbuk 361-763, Korea

Abstract: The Pyeongan Supergroup can be divided into seven lithostratigraphic units (Moscovian to Early Triassic?) in the Samcheok coalfield and four lithostratigraphic units (Bashkirian to Artinskian) in the Yeongwol coalfield of South Korea. On the basis of fusulinid biostratigrapic data in the Yeongwol coalfield, the boundary between the Carboniferous and Permian strata of the Pyeongan Supergroup has been considered as unconformity since the Kasimovian and Gzhelian strata are missing. *Protriticites* and *Triticites,* which are the cosmopolitan index fusulinids indicating the Kasimovian and Gzhelian age, are not found from the uppermost part of the Geumcheon and Pangyo Formations. Recently some fusulinids such as *Xenostaffella koreaensis, Hanostaffella magna,* and *Fusulina danyangensis* found from the uppermost part of the Geumcheon and Pangyo Formations are recognized as the early Kasimovian-type fusulinids, although the upper Kasimovian- to Gzhelian-type fusulinids are still missing.

Keywords: Pyeongan Supergroup, Late Paleozoic, biostratigraphy, fusulinid, unconformity

Introduction

The Pyeongan Supergroup, the Late Carboniferous to Early Triassic? in Korea, is distributed within many coalfields of the Okcheon Belt and Taebaeksan Basin in South Korea (Fig. 1) and overlie disconformably the Cambro-Ordovician Chosun Supergroup. The Samcheok and Yeongwol coalfields are the type area of the Pyeongan Supergroup in South Korea.

The Phyongan System in North Korea, which is equivalent to the Pyeongan Supergroup in South Korea, is irregularly distributed. The type section of the Phyongan System is located in the Southern Phyongnam coalfield in the vicinity of Pyongyang City, North Korea. The study of the Phyongan System in Korean peninsula started from the Southern Phyongnam coalfield of North Korea. The stratigraphic terms (the Hongjom, Sadong, Gobangsan, and Thaejawon series) were given in the course of dividing the strata distributed in the Southern Phyongnam coalfield (Nakamura et al., 1957) and then applied to the Late Carboniferous to Early Triassic? strata in Korean peninsula. However Cheong (1969, 1973) suggested that the stratigraphy of the Phyongan System was not useful to apply to the Pyeongan Supergroup in South Korea and pointed out the following problems: (1) Inaccessibility to the type locality and stratotype in the Southern Phyongnam coalfield and (2) lithologic and chronostratigraphic differences between the Pyeongan Supergroup and the Phyongan System. Thus, he proposed a new scheme on the lithostratigraphic division of the Pyeongan Supergroup in South Korea. The new division is used as the standard stratigraphic units (Lee, 1987; Geological Society of Korea, 1999; Korea Institute of Geology and Mineral Resources, 1995), although some investigators are still applying the stratigraphic terms of the Phyongan System to the Pyeongan Supergroup in South Korea.

The purpose of this study is to summarize and review the previous stratigraphy of the upper Carboniferous to lower Triassic strata in Korea and to review the fusulinid biostratigraphy of the Pyeongan Supergroup as well as to discuss the boundary between the Carbonifeous and Permian strata of South Korea.

*Corresponding author: leecz@chungbuk.ac.kr
Tel: 82-43-261-2737
Fax: 82-43-267-2737

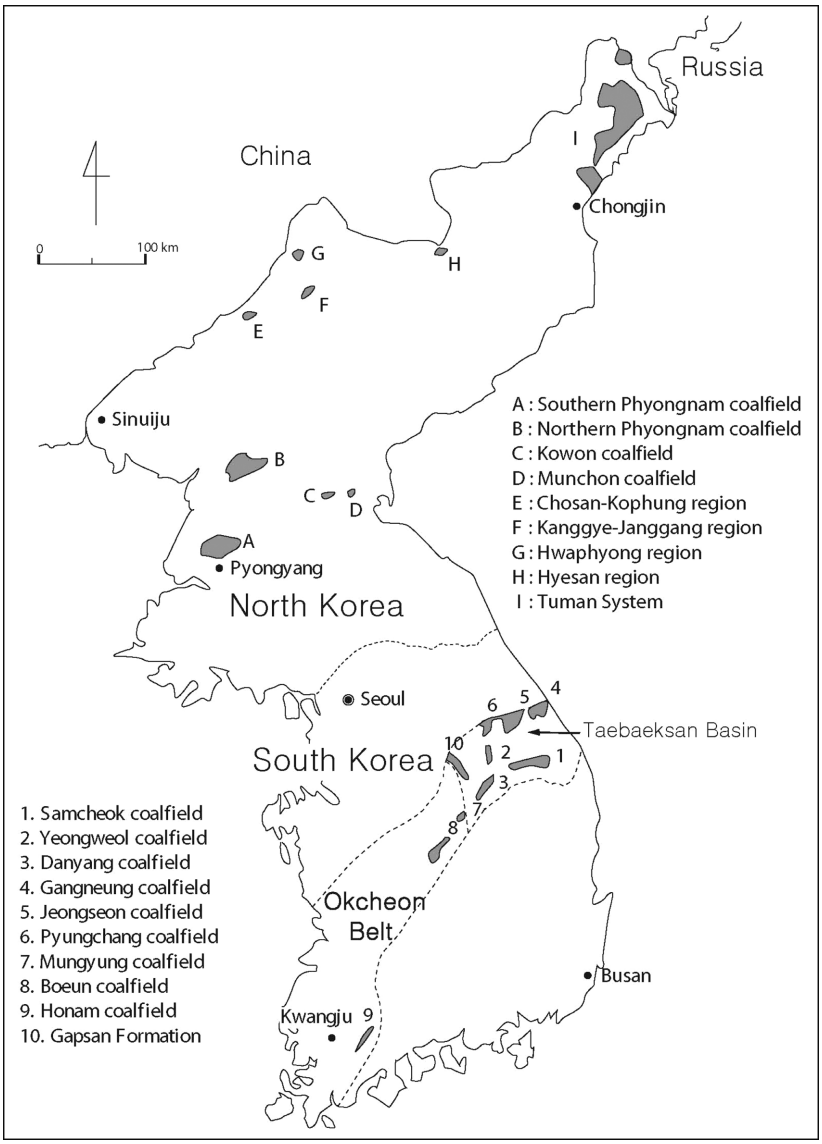

Fig. 1. Distribution of the Late Carbonferous to Early Triassic strata in Korea (modified from Cheong, 1987).

Brief history of the stratigraphic classification of the Late Carboniferous to Early Triassic stratigraphy in Korea

Yabe (1906) found the Carboniferous strata near Pyongyang City based on the occurrence of *Fusulina*. Yabe (1919), Konno (1928), Shiraki (1930, 1940), Kobadake (1930, 1942), Kodaira (1930, 1931), and Matsushita (1938) mapped anthracite-bearing strata and classified the Late Paleozoic strata in the Phyongnam coalfield. Kawasaki (1927) subdivided the Late Paleozoic strata into four units; the Hongjom Group, Sadong Group, Gobangsan Series, and Green Rock Formation. Kobayashi (1953) applyed these four chronostratigraphic units in the subdivision of the Late Paleozoic strata in the Yeongwol, Samcheok, and Jeongseon coalfields of the Taebaeksan Basin. They are the Hongjom, Sadong, Gobangsan, and Greenstone series. He pointed out that no Uralian (Kasimovian

Table 1. Brief history of the stratigraphic classification of the Late Carboniferous to Early Triassic strata in the Korean peninsula

Investigator	Late CARBONIFEROUS			PERMIAN			Early TRIASSIC	
Yabe (1906)	Carboniferous strata			-			-	
Yabe (1919)	Hongjom Group			Sadong Group		Jangpyongsan plant fossil strata	-	
Kawasaki (1927)	Pyongan System							
	Hongjom Group	Sadong Group				Gobangsan Series	Green Rock Formation	
Konno (1928)	Hongjom Series	Sadong Series				Gobangsan Series	Thaejawon Red Rock Formation	
Nakamura et al. (1957)	Hongjom Series			Lower Sadong Series	Upper Sadong Series	Gobangsan Series	Thaejawon Series	
GICTR (1962)	Hongjom Series			Sadong Series			Gobangsan Series	Nogam Series
Tateiwa (1976)	Hogjom Series	Lower Sadong Series	?	Upper Sadong Series		Gobangsan Series	Nogam Series	

-; no strata reported. GICTR; Geological Investigation Corps of Taebaeksan Region.

and Gzhelian) fossils were found from the Hongjom and Sadong Series. Nakamura et al. (1957) studied on the stratigraphy and structure of the Southern Phyongnam coalfield and divided the Phyongan System into four chronostratigraphic units: the Hongjom, Sadong, Gobangsan, and Thaejawon series. Tateiwa (1976) proposed the following five chronostratigraphic units in the Samcheok and Yeongwol coalfields; the Hongjom, Lower Sadong, Upper Sadong, Gobangsan, and Nogam series. The brief history of the stratigraphic classification of the Carboniferous to Triassic strata in the Korean peninsula is summerized in Table 1.

In fact, the Hongjom and Sadong series in the Southern Phyongnam coalfield were assigned to the Late Carboniferous and Early Permian respectively, whereas the Hongjom, Lower Sadong, and Upper Sadong series in the Samcheok coalfield were refered to the middle Late Carboniferous, upper Late Carboniferous, and Early Permian respectively on the basis of the lithology and foraminiferal fauna. In spite of the chronostratigraphic differences on the Hongjom and Sadong series between the Southern Phyongnam coalfield and the Samcheok coalfield, the stratigraphic units of the Phyongan System in the Southern Phyongnam coalfield of North Korea have been roughly adapted to those of late Paleozoic strata in South Korea and had been used by many investigators (Hatae, 1939; Kawasaki, 1927, 1931, 1934, 1938; Shiraki, 1940; Kobayashi, 1953; Baldwin, 1957; Brill, 1957; Reinemund, 1957; Geological Investigation Corps of Taebaeksan Region, 1962).

To overcome the chronostratigraphic differences and inaccessibility to the type locality, Cheong (1969, 1987) proposed new stratigraphic units to the Pyeongan Supergroup in the Samcheok coalfield; the Late Carboniferous Manhang and Geumcheon Formations, the Permian Jangseong, Hambaeksan, Dosagok, and Gohan Formations, and the Early Triassic Donggo Formation. In the Yeongwol coalfield, he also proposed a new stratigraphic division; the Carboniferous Yobong and Pangyo Formations and the Permian Bamchi and Mitan Formations (Table 2).

North Korean geologists (Om et al., 1996) would also recognize the problem of the Sadong Series ranging the Late Carboniferous to Early Permian and then changed the Lower Sadong Series into the Ripsok Series on the basis of fusulinid study. They subdivided the Phyongan System of North Korea into the Late Carboniferous Hongjom and Ripsok series,

Table 2. Stratigraphic division and correlation of the Pyeongan Supergroup in the Samcheok and Yeongwol coalfields and the Phyongan System in the Phyongnm coalfield

Locality / Geologic age			Samcheok coalfield Cheong (1969, 1987)	Yeongwol coalfield Cheong (1969, 1987)	Phyongnam coalfield Om et al. (1996)	Samcheok & Yeongwol coalfields Tateiwa (1976)
Early TRIASSIC			Donggo Formation		Thaejawon Series	Nogam Series
PERMIAN		Lopngian	Gohan Formation			
		Guadalupian				
	Cisuralian	Kungarian	Dosagok Formation Hambaeksan Formation		Gobangsan Series	Gobangsan Series
		Artinskian	Jangseong Formation	Mitan Formation	Sadong Series	Upper Sadong Series
		Sakmarian Asselian		Bamchi Formation		
Late CARBONIFEROUS		Gzhelian Kasimovian			Ripsok Series	
		Moscovian	Geumcheon Formation	Pangyo Formation	Hongjom Series	Lower Sadong Series
			Manhang Formation	Yobong Formation		Hongjom Series
		Bashkirian				

the Permian Sadong and Gobangsan series, and the latest Permian to Early Triassic Thaejawon Series (Table 2).

Stratigraphy of the Pyeongan Supergroup

Samcheok coalfield

The Pyeongan Supergroup of Samcheok coalfield can be divided into seven lithostratigraphic units; the Manhang, Geumcheon, Jangseong, Hambaeksan, Dosagok, Gohan, and Donggo Formations in ascending order (Cheong, 1969).

The Manhang Formation equivalent to the Hongjom Series of Tateiwa (1976) disconformably overlies the Late Ordovician Duwibong Formation of the Chosun Supergroup (Cambro-Ordovician). The Manhang Formation, 180-300 m thick, consists of coarse or pebbly coarse sandstone at the basal part, alternation of purple-green shale and sandstone in the lower part, and alternation of reddish or greenish gray sandstone and shale with interbeds of light-gray limestone in the upper part.

Cheong (1973, 1974) described some fusulinids and established three fusulinids subzones in the lower Moscovian. Park (1989) and Park and Sun (2001) also established one conodont zone of the Moscovian. Chun (1985) reported the late Carboniferous plant fossils.

The Geumcheon Formation is equivalent to the Lower Sadong Series of Tateiwa. The gray coarse-grained sandstone of the lowermost part of the Geumcheon Formation conformably overlies the dark gray shale of the uppermost part of the Manhang Formation. The Geumcheon Formation, 70-120 m thick, consists mainly of alternation of dark gray sandstone and shale with some interbeds of gray limestone lenses and thin coal seams. Cheong (1973, 1974) established three fusulinid subzones and refered them to the late Moscovian and Park (1989) and Park and Sun (2001) described upper Moscovian conodonts.

The Jangseong Formation is equivalent to the Upper Sadong Series of Tateiwa (1976). The formation unconformably overlies the Geumcheon Formation, but the unconformity between the two formations is invisible. The formation, 40-150 m thick, comprises

alternation of dark-gray sandstone and shale containing two or three coal beds, among which one bed is of workable quality and thickness (Cheong, 1987). Kawasaki (1927, 1931, 1934, 1938) and Chun (1985, 1987) described many Artinskian plant fossils.

The Gobangsan Series of Tateiwa (1976) in the Samcheok coalfield is characterized by three lithofacies types; light grey sandstone with intercalations of gray shale in the lower part, yellow, red, and green sandstone and shale in the middle part, and gray sandstone and siltstone in the upper part. Cheong (1969) subdivided the Gobangsan Series into the Hambaeksan, Dosagok, and Gohan Formations in ascending order by the lithofacies.

The Hambaeksan Formation conformably overlies the Jangseong Formation. The Hambaeksan Formation, about 250 m thick, comprises alternation of milky white coarse-grained sandstone and thin gray shale. Chun (1985, 1987) described the middle Permian plant fossils.

The Dosagok Formation conformably overlies the Hambaeksan Formation. The Dosagok Formation, 200-300 m thick, is characterized with red and green coarse-grained sandstone or pebbly sandstone and greenish gray or purple shale. Shiraki (1940) and Chun (1985, 1987) described many middle Permian plant fossils.

The Gohan Formation conformably overlies the Dosagok Formation. The Gohan Formation, 200-300 m thick, comprises alternation of gray or greenish gray medium-grained sandstone and greenish gray siltstone in ascending order. Shiraki (1940) and Chun (1985, 1987) described many late Permian plant fossils.

The Donggo Formation equivalent to the Nogam Series in the Samcheok coalfield (Tateiwa, 1976) and to the Thaejawon Series of the Southern Phyongnam coalfield (Om et al., 1996), about 400 m thick, unconformably overlies the Gohan Formation and is unconformably overlain by the Late Mesozoic strata in the Samcheok coalfield. The Donggo Formation consists of basal conglomerate, alternation of arkosic fine-grained sandstone and siltstone in ascending order. The boundary between the Permian and Triassic is uncertain because of the lack of index fossils and other geochronological data.

Yeongwol coalfield

The Pyeongan Supergroup of Yeongwol coalfield can be divided into four units: The Yobong, Pangyo, Bamchi, and Mitan Formations in ascending order (Cheong, 1969).

The Yobong Formation disconformably overlies the Yeongheung Formation of Chosun Supergroup in the Yeongwol coalfield. The Yobong Formation, about 110 m thick, comprises alternation of coarse-grained purple sandstone and conglomerate, green sandstone, 30 m thick light gray limestone bed, alternation of purple or green sandstone, shale, and light gray limestone in ascending order (Lee, 1984). Cross and graded beddings are well-developed in the coarse-grained sandstone. Lee (1985) established two fusulinid zones of the Bashkirian age and lower Moscovian age, and Lee et al. (1988) confirmed the same age by the conodont study.

The Pangyo Formation conformably overlies the Yobong Formation. The Pangyo Formation, about 130 m thick, comprises alternation of light gray-gray sandstone, shale and limestone and alternation of gray sandstone, shale and limestone in ascending order. Lee (1985) recognized two fusulinid zones of the upper Moscovian age and Lee et al. (1988) confirmed the same age by conodont study.

The Bamchi Formation paraconformably overlies the Pangyo Formation (Lee, 1985, 1992). The Bamchi Formation, about 85 m thick, comprises dark gray limestone with a thin shale bed, alternation of dark-colored fine-grained sandstone and shale, a dark-colored limestone bed, and alternation of dark-colored shale and sandstone in ascending order. Many fusulinids, foraminifers, and conodonts have been reported from the Bamchi Formation (Cheong et al., 1983; Park, 1993; Lee, 1984, 1990). Lee (1984) recognized one fusulinid zone of Asselian-Sakmarian age and Lee et al. (1988) confirmed the same age by conodont study. Lee (1990) reported some Permian

foraminiferids from the limestones of the Bamchi Formation: *Bradyina, Cribrogenerina, Diplospaerina, Globivavulina, Mediocris, Paleotextularia, Planoendothyra, Tetrataxis,* and *Tuberitina.* The uppermost bed of the Bamchi Formation is the dark gray shale which is overlain by the dark gray medium grained thick sandstone of the Mitan Formation.

The Mitan Formation conformably overlies the Bamchi Formation. This formation, about 200 m thick, comprises alternation of gray sandstone and dark gray shale with anthracite beds. Kawasaki (1934) reported many Permian plant fossils from this formation.

Fusulinid biostratigraphy

The Pyeongan Supergroup comprises marine carbonates, coastal clastics, and non-marine clastics with coal seams. Such sequences are widely distributed in the Late Paleozoic coal-bearing strata and are well-developed in Penchi, Taiyuan, and the lower part of the Shansi Formations of China (Liu et al., 1998). The lithology and fusulinid assemblage of the Late Carboniferous to Early Permian strata of Korea are very similar to those of North China. So Nakamura et al. (1957), Kobayashi (1953), and Tateiwa (1976) correlated the Hongjom and Sadong Series to Penchi Series (Moscovian) and Taiyuan Series (Sakmarian) respectively and thought the Uralian (Kazimovian and Gzhelian) Stage was missing between the Hongjom Series (Moscovian) and Sadong Series (Sakmarian) in the Southern Phyongnam coalfield based on the foraminiferal fauna by Hatae (1939).

Cheong (1969, 1973) described many Moscovian-type fusulinids from the Manhang and Geumcheon Formations of Samcheok coalfield and recognized three fusulinid zones which are correlated with those of Penchi Formation. Cheong and Park (1977) reported some Moscovian and Sakmarian fusulinids from the Yobong, Pangyo, and Bamchi Formations of the Yeongwol coalfield without any Uralian-type fusulinids.

Lee (1985, 1992) recognized five fusulinid zones: *Eostaffella-Pseudostaffella* Zone, *Profusulinella* Zone, *Beedeina* Zone, *Neostaffella-Fusulinella* Zone, *and Pseudoschwagerina-Pseudofusulina* Zone in ascending order. The fusulinids are the typical genera from the Late Paleozoic strata of Korea and China.

Abundant of *Eostaffella* and primitive species of *Pseudostaffella* from the *Eostaffella-Pseudostaffella* Zone are occurred in a limestone lens and the lower and middle part of 30 m thick limestone bed (the Yobong limestone bed) of the lower part of the Yobong Formation in the Yeongwol coalfield. The fusulinid zone and the Yobong limestone bed are not detected from the Manhang Formation of Samcheok coalfield, the Hongjom Series of Southern Phyongan coalfield, and the Penchi Formation in North China. The generic association of *Eostaffella, Pseudostaffella*, and *Millerella* of this zone is reported from the upper part of the Luosuan Stage and the Huashibanian Stage (Bashkirian Stage) of China (Wang and Jin, 2003), the lower part of the Shindongsi Formation (Bashkirian Stage) in West Yunnan of Southwest China (Ueno et al., 2003). Therefore the lower part of the Yobong Formation can be correlated with the Bashkirian Stage (Table 3).

The generic association of *Profusulinella, Fusiella, Pseudostaffella, Pseudowedekindellina*, and *Verella* is described from the *Profusulinella* Zone of the upper part of the Yobong Formation. Such genera were described from the Manhang Formation (lower Moscovian Stage) of the Samcheok coalfield (Cheong, 1969, 1973), from the *Profusulinella* Zone (lower Moscovian Stage) of the basal part of the Dalaun Stage in Guizhou of South China (Wu et al., 1974; Zhang et al., 2003) and *Eostaffella subsolana* Zone (lower Moscovian Stage) of the Penchi Formation in North China (Sheng, 1958). Therefore the upper part of the Yobong Formation and Manhang Formation can be correlated with the lower Moscovian Stage (Table 3).

The generic association of *Beedeina, Neostaffella, Fusulina,* and *Fusulinella* is found from the *Beedeina* and *Neostaffella-Fusulina* zones of the Pangyo Formation of Yeongwol coalfield. These fusulinids are also reported from the Geumcheon Formation (upper

Table 3. The generic associations of the typical fusulinids from the Late Paleozoic strata of Korea and China

Period	Age	Korea				China
		Samcheok, Yeongwol, and Danyang coalfields Lee (this study)	Samcheok coalfield Cheong (1969, 1973)	Yeongwol coalfield Lee (1992)	Southern Phyongnam coalfield Om et al. (1996)	Wang & Jin (2003) Jin et al. (1999)
Early PERMIAN	Artinskian		-	-	-	*Pamirina* *Davasites*
	Sakmarian Asselian	*Pseudoschwagerina* *Pseudofusulina*	-	*Pseudoschwagerina* *Pseudofusulina*	-	*Robustoschwagerina* *Sphaeroschwagerina* *Pseudoschwagerina*
Late CARBONIFEROUS	Gzhelian		-	-	*Pseudoschwagerina* *Schubertella* *Quasifusulina* *Triticites*	*Triticites* *Montifarus* *Protriticites*
	Kazimovian	*Fusulina (danyangensis)* *Xenostaffella* *Hanostaffella (magna)*				
	Moscovian	*Hanostaffella* *Fusulina* *Fusulinella*	*Hanostaffella* *Fusulina* *Fusulinella*	*Hanostaffella* *Fusulina* *Fusulinella*	*Fusulina* *Fusulinella* *Pseudostaffella*	*Fusulina* *Fusulinella* *Beedeina* *Profusulinella*
		Neostaffella *Beedeina* *Verella*	*Neostaffella Beedeina*	*Neostaffella* *Beedeina* *Verella*		
		Profusulinella *Pseudowedkindellina* *Pseudostaffella*	*Profusulinella* *Pseudowedkindellina* *Pseudostaffella* *Eostaffella* *Millerella*	*Profusulinella* *Pseudowedkindellina* *Pseudostaffella*	*Profusulinella* *Pseudowedekindellina* *Aljutovella* *Eostaffella* *Millerella*	
	Bashkirian	*Eostaffella* *Pseudostaffella* *Millerella*	-	*Eostaffella* *Pseudostaffella* *Millerella*	-	*Pseudostaffella* *Millerella* *Eostaffella*

Moscovian) of Samcheok coalfield (Cheong, 1969, 1973), from the Penchi Formation (Moscovian) in North China (Sheng, 1958), from the upper part of the Shidongsi Formation (upper Moscovian) in West Yunnan (Ueno et al., 2003). Wang and Jin (2003) regarded the those of Penchi Formation as the Moscovian Stage. The genera of *Psudostaffella* and *Fusulina* were reported from the upper part of Hongjeom Series (Moscovian) of Southern Phyongnam coalfield (Om et al., 1996). Therefore the Pangyo and Geumcheon Formations can be correlated with the upper Moscovian Stage (Table 3).

The generic association of *Pseudoschwagerina, Pseudofusulina, Schwagerina, Schubertella,* and *Quasifusulina* were described from the *Pseudoschwagerina-Pseudofusulina* Zone of the Bamchi Formation generic association of *Pseudoschwagerina, Pseudofusulina, Schwagerina, Schubertella*, and *Quasifusulina* in Yeongwol coalfield and dated as Asselian and Sakmarian (Lee, 1984, 1992). Jin et al. (1999) assigned the fusulinid zone containing *Pseudoschwagerina* and *Robustoschwagerina* to the Asselian and Sakmarian stages and *Triticites* Zone to the Gzhelian Stage in the Carboniferous stratigraphy of China (Table 3).

Discussion on the boundary between the Carboniferous and Permian

In the Samcheok coalfield the boundary between the Carboniferous and Permian of the Pyeongan Supergroup is coincide with the boundary of the Geumcheon and Jangseong Formations (Table 2). Although no visible unconformity is found between the two formations, the boundary can be found easily at the place where

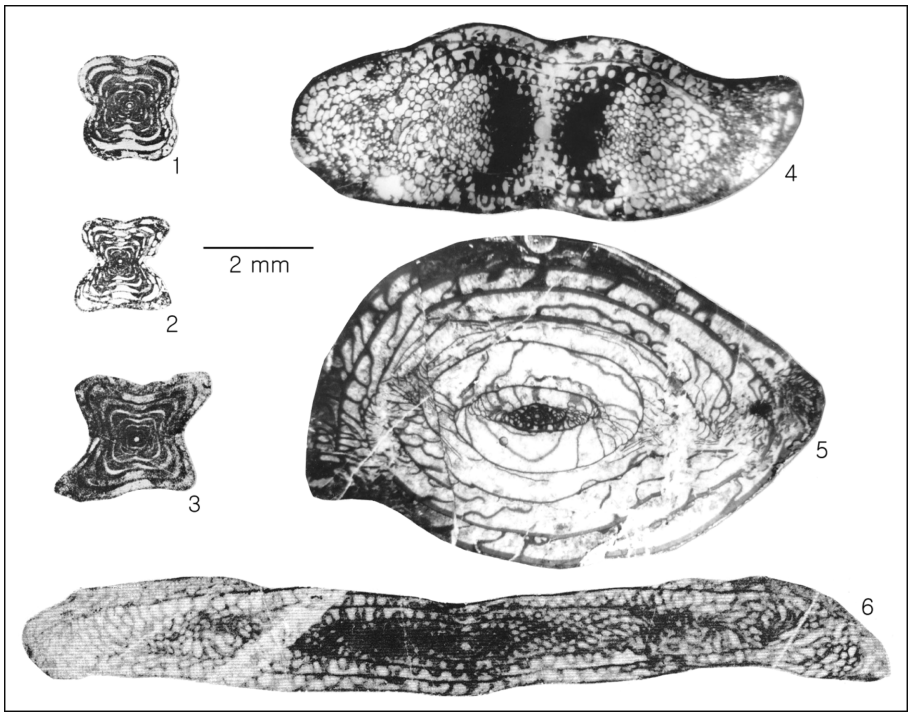

Fig. 2. Typical fusulinids from the boundary between the Carboniferous and Permian of South Korea. 1; *Hanostaffella hanensis* Cheong from the Geumcheon Formation in Samcheok coalfield. 2; *Xenostaffella koreaensis* Cheong from the uppermost part of the Geumcheon Formation in Danyang coalfield. 3; *Hanostaffella magna* Cheong from the uppermost part of the Geumchon Formation in Danyang coalfield. 4; *Quasifusulina inusitata magna* Cheong from the upper part of the Bamchi Fotmation in the Yeongwol coalfield. 5; *Pseudoschwagerina paraborealis* Han from the lower part of the Bamchi Formation in Yeongwol coalfield. 6; *Fusulina danyangensis* Cheong, from the uppermost part of the Geumcheon Formation in Danyang coalfield.

Geumcheon Formation is overlain by the sandstone bed of the lowest cyclothem of the Jangseong Formation. *Protriticites* sp. has ever been reported from Samcheok coalfield by Cheong (1987), but the specimens and any descriptions are not preserved. The *Pseudoschwagerina-Pseudofusulina* Zone of the Bamchi Formation in the Yeongwol coalfield is missing in the Samcheok coalfield. Cheong (1987) interpreted the boundary embraces a long time gap encompassing the Kazimovian, Gzhelian, Asselian, and Sakmarian stages in the Samcheok coalfield from the evidences of the Moscovian fusulinids from the Geumcheon Formation and the Artinskian plant assemblage from the Jangseong Formation.

The boundary between the Carboniferous and Permian of the Pyeongan Supergroup in Yeongwol coalfield is also undetected by any physical evidences except fusulinid study and is assigned at the 1.7 m horizon from the lowermost part of the 9 m thick limestone bed in Yeongwol coalfield (Lee, 1992). The lower part of the limestone bed which is the uppermost part of the Pangyo Formation yields the Moscovian fusulinids, however the upper part of the limestone bed which is the lowermost Bamchi Formation, the Asselian and Sakamrian fusulinids. The boundary is observed at the horizone between the *Fusulinella-Neostaffella* Zone of the Pangyo Formation and the *Pseudoschwagelina-Pseudofusulina* Zone of the Bamchi Formation. The Kasimovian- and Gzhelian-type fusulinids such as *Protriticites* and *Triticites* are not found between the two zones. So Lee (1985, 1992, 1998) reported that the boundary

between between the Carboniferous and Permian of the Pyeongan Supergroup would be unconformity (Table 3).

Fusulinids such as *Xenostaffella koreaensis* (2 in Fig. 2), *Hanostaffella magna* (3 in Fig. 2), and *Fusulina danyangensis* (6 in Fig. 2) described from the uppermost horizon of the Danyang coalfields (Cheong, 1973, 1974) have the most developed forms of the Carboniferous fusulinids in South Korea. *Xenostaffella koreaensis* and *Hanostaffella magna* have never reported from other coalfields in Korea and other countries. Although it's very difficult to correlate the international biostratigraphy, these fusulinids should be later ones than *Hanostaffella hanensis* (1 in Fig. 2).

Fusulina danyangensis (6 in Fig. 2) was also reported from the Yeongwol and Samcheok coalfields (Cheong, 1969, 1973; Lee, 1985). The kinds of *Fusulina cylindrica, Quasifusulina*, and *Fusulina* (*Quasifusulinoides*) have the extremely elongated forms like the *Fusulina danyangensis* and were reported from the Moscovian to Sakmarian stage of Eurasia and North America (Loeblich and Tappen, 1988). Generally *Fusulina* and *Quasifusulina* are known as the index fossils of late Moscovian and Asselian age respectively (Chen, 1934; Loeblich and Tappen, 1988). The morphological differentiation of *Fusulina to Quasifusulina* is gradually changing toward more elongation, tightly coiling, and heavy axial fillings. *Fusulina danyangensis* is thought to be the middle stage of the morphological differentiation. Therefore the fusulinid species of *Fusulina danyangensis, Xenostaffella magna,* and *Hanostaffella magna* might be the early Kasimovian-type fusulinids that may substitute for *Protriticites*, however the late Kasimovian- to Gzhelian fusulinids are still missing. Lee (1984, 1992) reported the *Pseudoschwagerina paraborealis* Han (5 in Fig. 2) from the lower part and the *Quasifusulina inusitata magna* Cheong (4 in Fig. 2) from the upper part of the Bamchi Formation in Yeongweol coalfield and assigned two fusulinids to the Asselian and Sakmarian age respectively.

Conclusion

The Pyeongan Supergroup of Samcheok coalfield can be divided into seven lithostratigraphic units; the Moscovian Manhang and Geumcheon Formations, the Artinskian Jangseong, the middle Permian Hambaeksan and Dosagok Formations, the upper Permian Gohan Formation, and the Lower Triassic? Donggo Formation in ascending order, while that of Yeongwol coalfield can be divided into four units: The Bashkirian to Moscovian Yobong Formation, the Moscovian Pangyo Formation, the Asselian and Sakmarian Bamchi Formation, and the Artinskian Mitan Formation in ascending order.

The lower part of the Yobong Formation including the generic association of *Eostaffella, Pseudostaffella*, and

Millerella can be correlated with the Bashkirian, the upper part of the Yobong Formation and Manhang Formation including the generic association of *Profusulinella, Fusiella, Pseudostaffella, Pseudowedekindellina*, and *Verella* with the early Moscovian, the Pangyo and Geumcheon Formations including the generic association of *Beedeina, Neostaffella, Fusulina,* and *Fusulinella* with the late Moscovian, the uppermost part of the Geumcheon and Pangyo Formations including *Fusulina danyangensis, Xenostaffella koreaensis,* and *Hanostaffella magna* with the early Kasimovian, and the Bamchi Formation including the generic association of *Pseudoschwagerina, Pseudofusulina, Schwagerina,* and *Quasifusulina* with the Asselian and Sakmarian.

The fusulinid species of *Fusulina danyangensis, Xenostaffella koreaensis,* and *Hanostaffella magna* might be the early Kasimovian-type fusulinids that may substitute for *Protriticites*, however the late Kasimovian- to Gzhelian fusulinids are not found yet. Therefore the boundary between the Carboniferous and Permian of the Pyeongan Supergroup would be still unconformity missing the upper Kasimovian and Gzhelian.

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