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Fusulinids from the Carboniferous strata in the Gangdong area of Samcheok coalfield, Korea

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Abstract: The goal of this study is to elucidate the fusulinid biostratigraphy of the Carboniferous limestones distributed in the Gangdong area of Samcheok coalfield, Korea. The Carboniferous strata of the study area mainly comprise alternaton of dark gray shale, dark gray and reddish sandstone, and gray limestone. The limestones consist mainly of wackestone-packstone containing various fossil fragments such as crinoid, coral, brachiopod, foraminifera, fusulinid, and bryozoa; this observation thus suggests that the study site was the shallow marine environments. A tital of 12 species belonging to 5 genera of fusulinids are identified from the limestones of the Gangdong geologic section: *Ozawainella turgida* Sheng, *Ozawainella* sp. A, *Ozawainella magna* Sheng, *Pseudostaffella antiqua* (Dutkevich), *Pseudostaffella paracompressa* Safonova, *Pseudostaffella kimi* Cheong, *Pseudostaffella* sp., *Beedeina lanceolata* (Lee and Chen), *Beedeina samarica* (Rauser-Chernoussova), *Beedeina* sp. A, *Neostaffella sphaeroidea cuboides* Rauser-Chernoussova, and *Hanostaffella hanensis* Cheong. Such fusulinids species were reported from the lower part of the Geumcheon Formation in Samcheok coalfield and the middle Moscovian stage in Eurasia. On the basis of the fusulinid biostratigraphic correlation of the Gangdong geologic sections (A) to (C), the limestone should be overlapped by faults and folds. Moreover the stratigraphic thickness of the limestone is thinner than the thickness of the limestone outcrop of the Gangdong geologic section. Therefore, the stratigraphic sequence of the Gangdong geologic section is represented as the Gangdong geologic section (A).

Keywords: Fusulinid, Geumcheon Formation, Moscovian, Samcheok coalfield

Introduction

The Samcheok coalfield, well-known for the coal production before 1980s, is important for the type section of the Late Paleozoic strata of South Korea. Previous paleontological studies on the Carboniferous strata can be summerized as follows. Hatae (1939) listed some Moscovian fusulinids from the Geumcheon Formation. Cheong (1969, 1973) recognized the sum of 6 fusulinid subzones from the Manhang and Geumcheon Formations and assigned them as the Moscovian age. Yang et al. (1984) reported some marine invertebrates: *Acanthopecten, Annuliconcha, Astartella, Aviculopecten, Spiriferellina*, and *Streblopteria* from the Manhang Formation. Chun (1985, 1987) described some plant fossils from the Manhang and Geumcheon Formations: *Annularia, Cordaites, Calamites, Neuropteris, Pecopteris, Spenophyllum,* and *Tingia*. Choi (1988) described *Paraconularia geumcheonensis*. Park (1989) and Park and Sun (2001) correlated the Manhang and Geumcheon Formations with the Atokan and Demoinesian stages (Moscovian), respectively based on conodont study. Some localities of the Late Paleozoic strata still remain as poorly investigated sites, although many paleontological studies were performed in Samcheok coalfield. Hence, more detailed studies necessary to establish the biostratigraphy of the Late Paleozoic strata in Samcheok coalfield.

The study locality situated at the Gangdong area in the southern part of Samcheok coalfield (Fig. 1) is one of the poorly investigated sites on the Late Paleozoic strata. The limestone outcrop of the study locality is well-exposed beside the disused local road, and the total thickness of the limestone is about 2 times thicker than that of other localities in Samcheok coalfield.

This study focused on the establishment of fusulinid biostratigraphy for determining the geologic age of the

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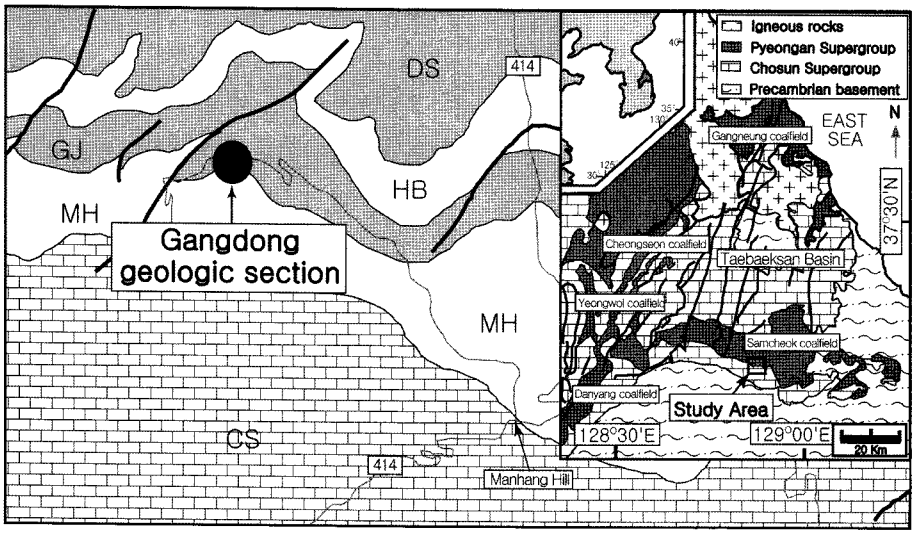

Fig. 1. Geologic map around the Gangdong area of Samcheok coalfield.

limestones and then for the assessment of the mechanism of the thicker limestones distributed in the Gangdong geologic section.

General Geology

The Late Paleozoic Pyeongan Supergroup in Samcheok coalfield unconformably overlies the Early Paleozoic Chosun Supergroup. It is found to consist of alternation of sandstone, shale, and fusulinid bearing limestone in the lower part, and alternation of sandstone and shale with 2 or 3 coal seams in the upper part of the Pyeongan Supergroup.

Cheong (1969, 1973, 1987) suddivided the Pyeongan Supergroup of Samcheok coalfield into 7 formations: The Manhang, Geumcheon, Jangseung, Hambaeksan, Dosagok, Gohan, and Donggo Formations in ascending order.

The study locality is situated in the Gangdong area at the mid-southern part of Samcheok coalfield. The studied geologic section, namely the Gangdong geologic section, seems to be located around the boundary between the Manhang and Geumcheon Formations on the geologic map (Fig. 1).

The Manhang Formation equivalent to the Hongjom Series of Tateiwa's division (1976) disconformably overlies the Chosun Supergroup (Cambro-Ordovician). The Manhang Formation, 180-300 m thick, consists of coarse or pebbly coarse grained 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. Some fusulinids and conodonts were reported from the limestones of the Manhang Formation, and the age of the Manhang Formation is assigned to be the Moscovian (Cheong, 1969, 1973; Park, 1989; Park and Sun, 2001).

The Geumcheon Formation is equivalent to the Lower Sadong Series of Tateiwa's division and conformably overlies the Manhang Formation. 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 fusulinoidean subzones and refered them to the late Moscovian. Park (1989) and Park and Sun (2001) also described upper Moscovian conodonts. Chun (1985, 1987) reported some plant fossils and Choi (1988) described *Paraconularia*

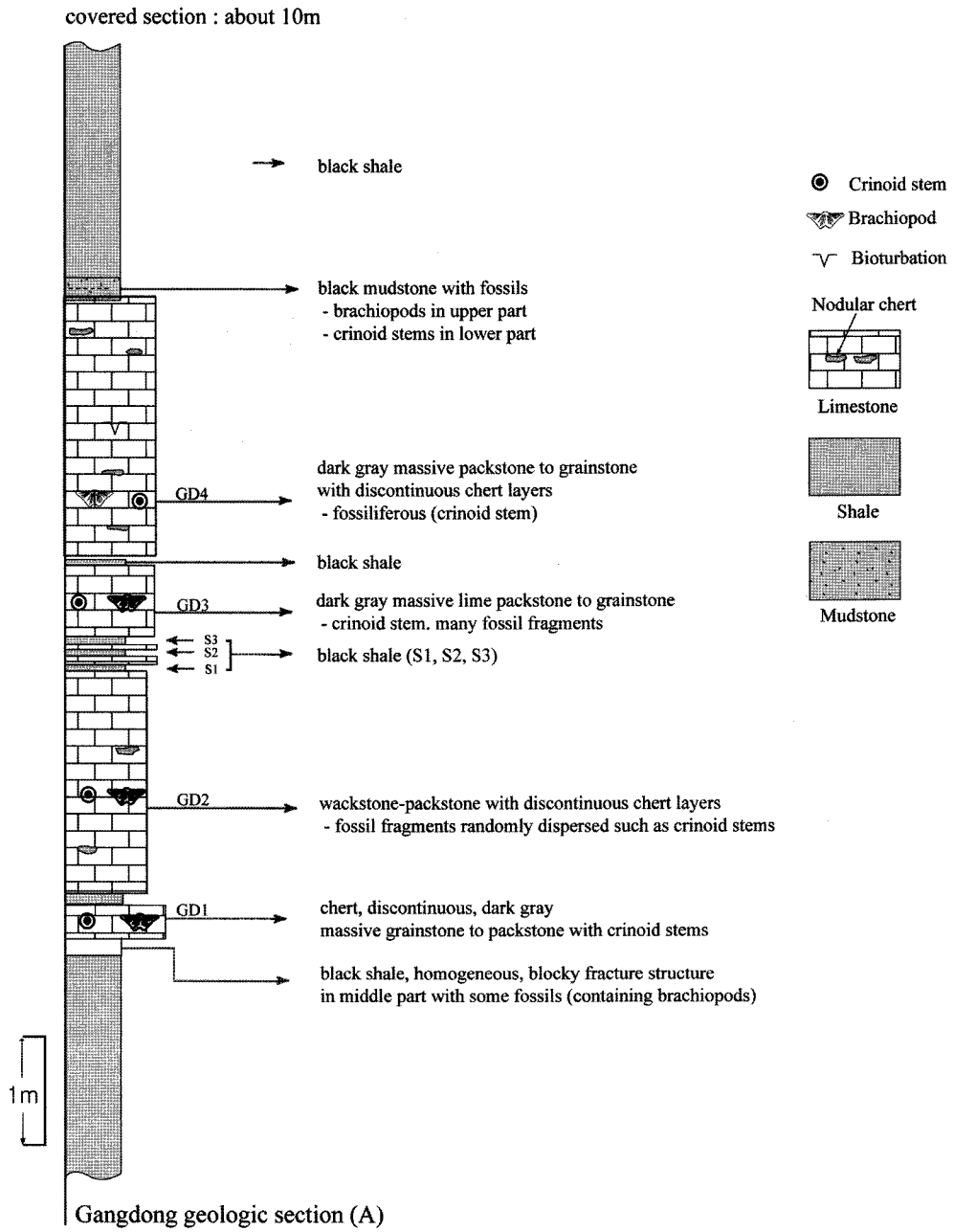

Fig. 2. The charateristics of the limestones around the sampling horizons (GD1 – GD8) in the Gangdong geologic section.

geumcheonensis. Chough et al. (2000) interpreted that the association of marine strata with coal and plant-bearing shale beds of the Manhang and Geumcheon Formations were formed in a marginal marine environment.

The Jangseong Formation is equivalent to the Upper Sadong Series of Tateiwa's division. The formation unconformably overlies the Geumcheon Formation, but the boundary between the two formations is invisible in the field. Hence, the boundary between the Carboniferous and Permian seems to be a para-conformity which is only detected by biostratigaraphic

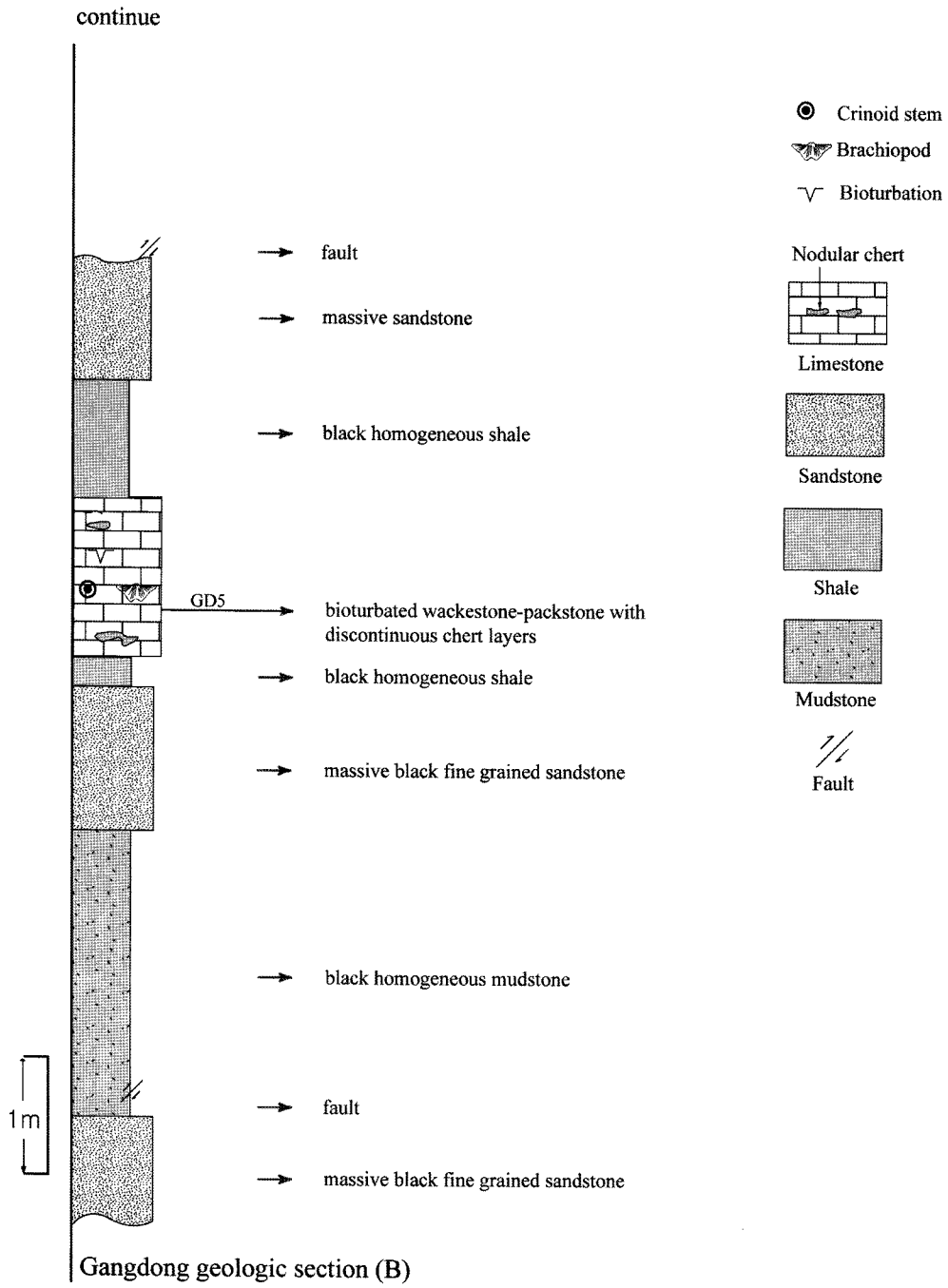

Fig. 2. Continued.

study: Moscovian fusulinids (Geumcheon Formation), Sakmarian plant fossils (Jangseong Formation), and Kasimovian and Gzhelian fauna or flora (missing). 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 plant fossils, and Chun (1985, 1987) reported an Artinskian plant fossil assemblage.

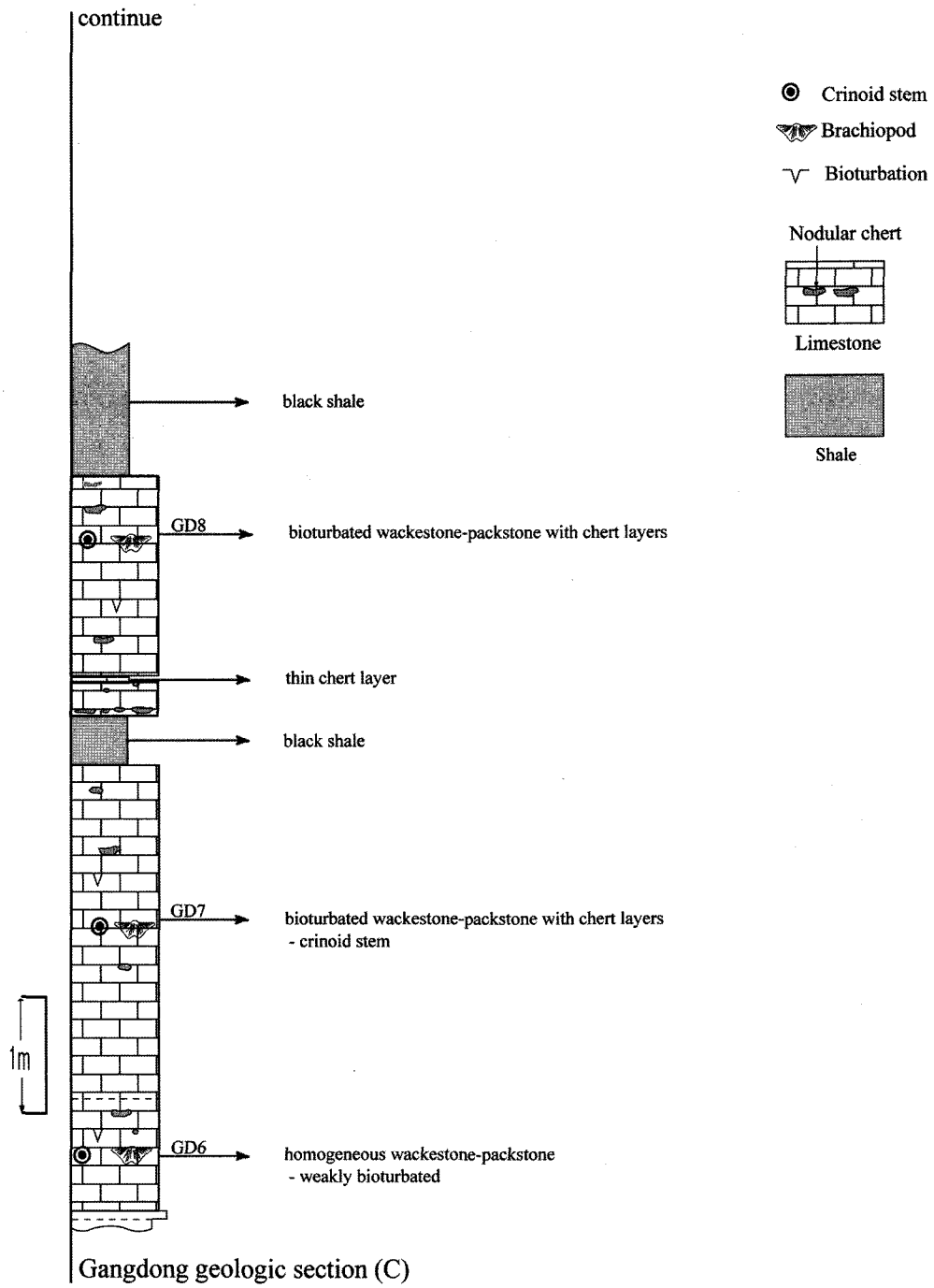

Fig. 2. Continued.

The Gobangsan Series of Tateiwa's division 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.

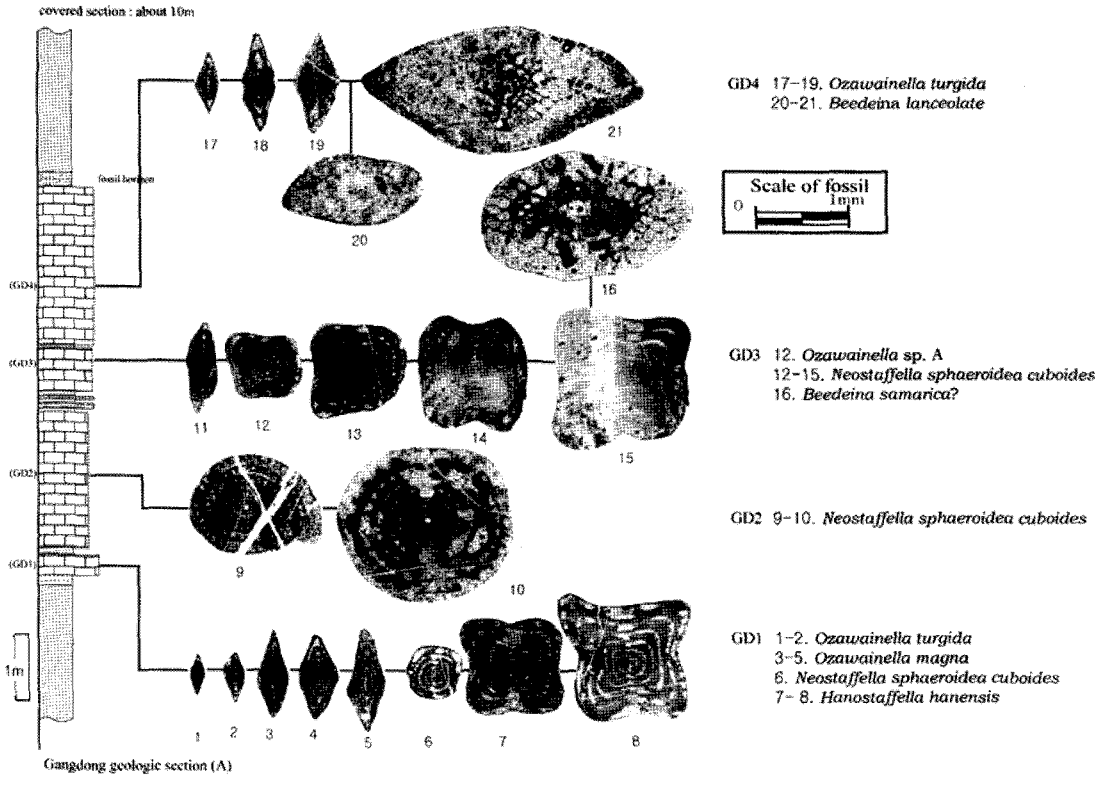

Fig. 3. Fusulinids from the sampling horizons (GD1-GD8) of the Gangdong geologic section.

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, pebbly sandstone, and greenish gray (or purple) shale. Shiraki (1940) and Chun (1985, 1987) described many plant fossils of the Middle Permian.

Sample Locations and the Characteristics of the Limestones

The study locality is situated at the 2.5 km distance along a disused local road branched toward the northwestern direction from the Manhang Hill on the local road 414. There is a well-developed outcrop on the northwestern side of the old road and the outcrop, 42.5 m in thickness, comprises alternaton of sandstone, shale, and limestone. Especially, the thickness of limestone is about 2 times thicker than that of other areas in Samcheok coalfield. The Gangdong geologic section was measured on the outcrop and described the characteristics of the limestone. The description of the limestone is shown beside the Gangdong geologic section in Fig. 2.

Many limestone samples were collected from several horizons, but the description was performed just on the well-preserved limestones (GD1-GD8) as shown in Fig. 2. The limestones are composed of wackestone to grainstone interbedded chert nodules. Many invertebrate fossil fragments such as crinoid,

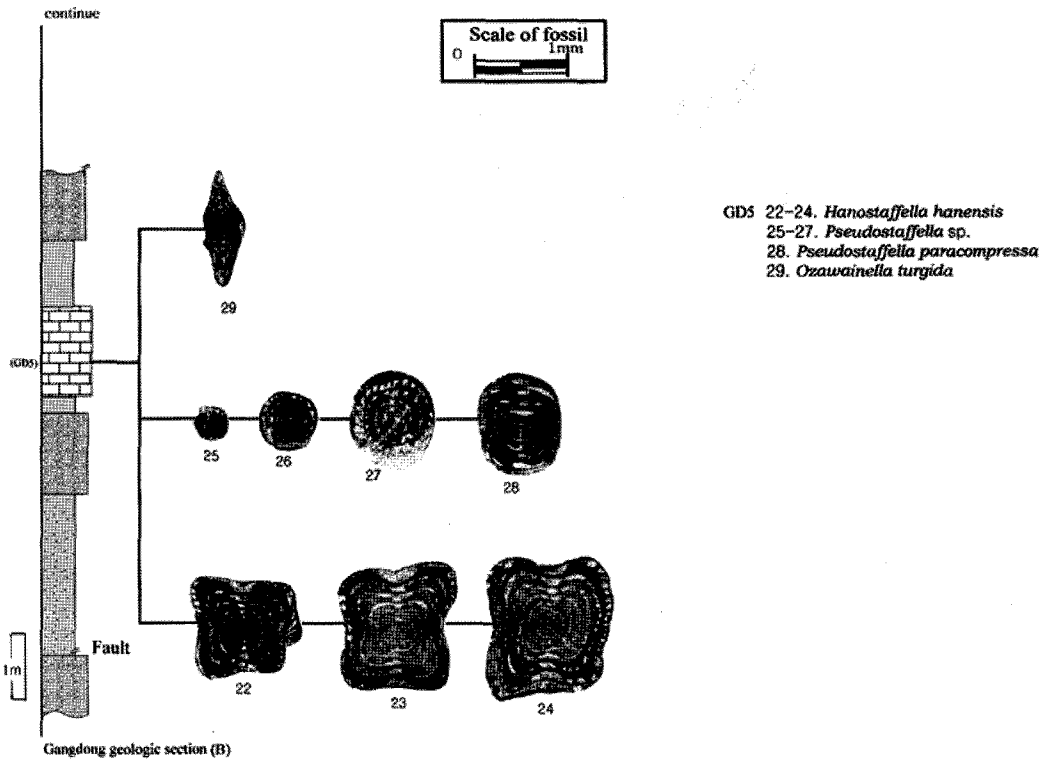

Fig. 3. Continued.

coral, brachiopods, foraminifers, fusulinids, and crinoid stems, and trace fossils are found from the limestone, which indicate the tidal flat to shallow marine environment under the warm climate.

Fusulinid Biostratigraphy

The fusulinid biostratigraphy of the study area is discussed on 8 horizons as shown in Fig. 3. 12 species belonging to 5 genera of fusulinids are identified from 8 horizons on the Gangdong geologic section. The identified fusulinids are illustrated beside each horizon of the Gangdong geologic section.

Some upper Moscovian fusulinids were collected from the limestones of the Gangdong geologic section as follows: *Ozawainella turgida* Sheng, *Ozawainella* sp. A, *Ozawainella magna* Sheng, *Pseudostaffella antiqua* (Dutkevich), *Pseudostaffella paracompressa* Safonova, *Pseudostaffella kimi* Cheong, *Pseudostaffella* sp., *Beedeina lanceolate* (Lee and Chen), *Beedeina samarica* (Rauser-Chernoussova), *Beedeina?*, *Beedeina* sp. A, *Neostaffella sphaeroidea cuboides* Rauser, and *Hanostaffella hanensis* Cheong.

The fusulinid genera *Beedeina, Fusulina, Pseudostaffella, Hanostaffella,* and *Neostaffella* are the typical Moscovian fusulinids reported from Eurasia (Wang and Jin, 2003; Cheong, 1969, 1971, 1973, 1974; Lee, 1985; Vladimir et al., 2000). Cheong (1979) illustrated the phylogenetic diagram on the *Eostaffella-Pseudostaffella-Neostaffella* (*Hanostaffella*)-*Xenostaffella* species succession. On the basis of the Cheong's diagram, *Pseudostaffella* is the middle Moscovian fusulinid, and *Hanostaffella* and *Neostaffella* are the middle to upper Moscovian fusulinids, however *Hanostaffella hanensis* is a little younger than *Neostaffella sphaeroidea cubcides. Pseudostaffella antiqua, Pseudostaffella paracompressa, Pseudostaffella kimi, Beedeina lanceolate*, and *Beedeina samarica* were reported from the middle Moscovian stage.

The above fusulinids were reported from the

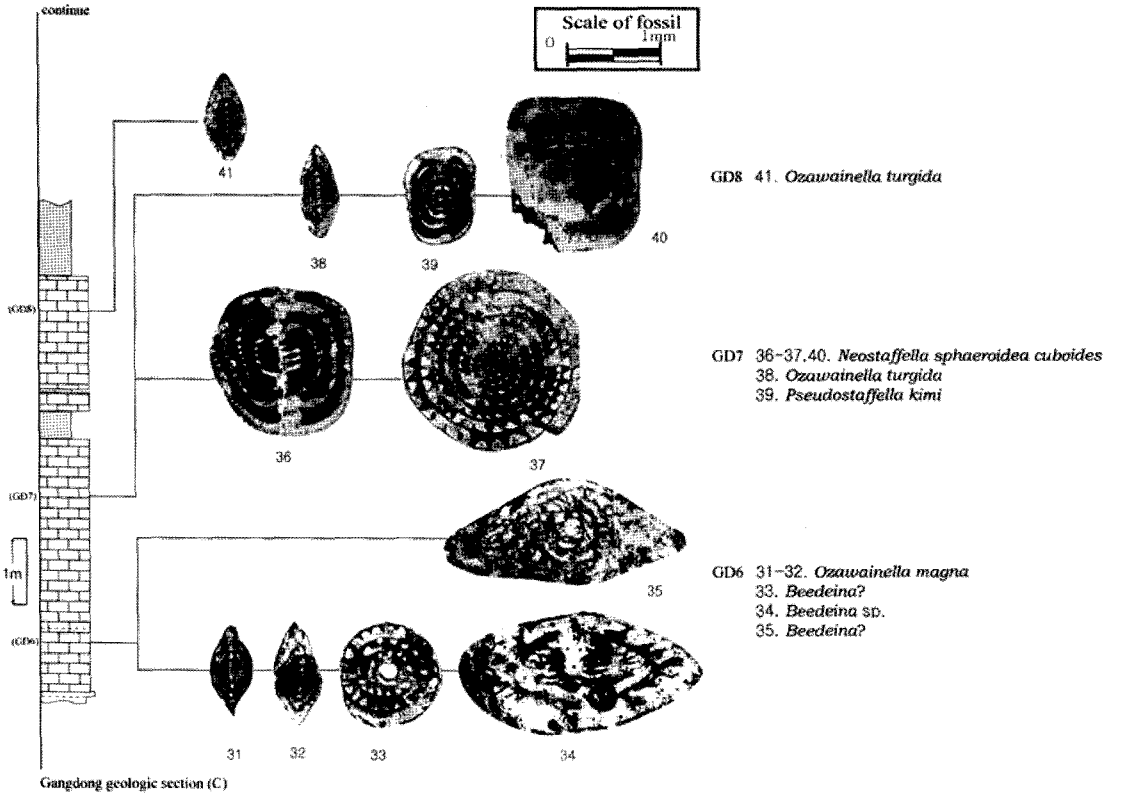

Fig. 3. Continued.

Pangyo Formation of Yeongweol coalfield and the Geumcheon Formation of Samcheok coalfield (Cheong, 1969, 1971, 1973, 1974; Lee, 1985; Lee et al., 1988) in Gangwondo, South Korea, and also from the middle to upper Dalaum stage in China (Wang and Jin, 2003) and from the *Fusulinella bocki-Pseudofusulinella pulchura* Zone (upper Moscovian) in Amdrup Land, North Greenland (Vladimir et al., 2000). Therefore the strata of the study area should be biostratigraphically correlated with the Geumcheon Formation in Samcheok coalfield and with the middle to upper Moscovian stage of the Eurasian straigraphic division.

On the Gangdong geologic section in Fig. 3, *Hanostaffella hanensis* Cheong and *Neostaffella sphaeroidea cuboides* Rauser-Chernoussova were collected from GD1, while *Neostaffella sphaeroidea cuboides* Rauser-Chernoussova from GD2, *Beedeina samarica* (Rauser-Chernoussova) and *Neostaffella sphaeroidea cuboides* Rauser-Chernoussova from GD3, and *Beedeina lanceolate* (Lee and Chen) from GD4. It means that the stratigraphic sequence of GD1-GD4 horizons should be set as GD4, GD3, GD2, and GD1 in ascending order. The stratigraphic sequence of GD1-GD4 should be overturned although the horizons of GD1-GD4 seem to be GD1, GD2, GD3, and GD4 in ascending order on the outcrop (Figs. 3 and 4).

Hanostaffella hanensis Cheong was collected from GD1 and GD5, while *Neostaffella sphaeroidea cuboides* Rauser-Chernoussova from GD2 and from GD7 with *Pseudostaffella kimi*. *Ozawainella magna* Sheng was collected from GD1 and GD8. *Beedeina samarica* (Rauser-Chernoussova) and *Neostaffella sphaeroidea cuboides* Rauser-Chernoussova were collected from GD3, and *Beedeina lanceolate* (Lee and Chen) from GD4, while some *Beedeina* species

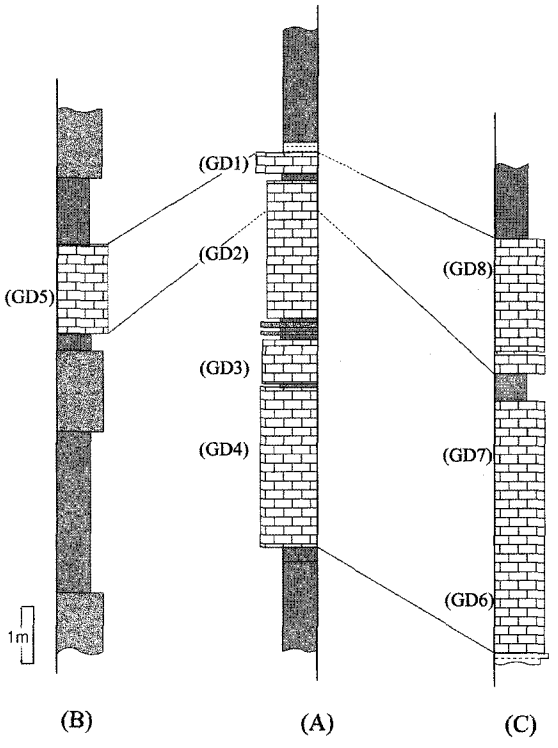

Fig. 4. Correlation chart of the Gangdong geologic sections (A), (B), and (C).

from GD6 in Fig. 3. Based on the fusulinid biostratigraphic occurrence, the horizons of GD1 can be correlated with the horizon of GD5, while the horizons of GD2 to GD4 can be correlated with the horizon of GD6 and GD7. The horizon of GD1 can be roughly correlated with the horizon of GD8 although *Ozawainella magna* Sheng is not a good index fossil because of the long time exsistence. Such fusulinid biostratigrapic correlation is summarized and illustrated in Fig. 4.

The stratigraphic sequence of the limestone in the study area is represented as the Gangdong geologic section (A) in Fig. 4. Therefore, the limestone should be overlapped by faults and folds and the stratigraphic thickness of the limestone is represented as the Gangdong geologic section (A), which is about a half thinner than the thickness of the limestone outcrop of the Gangdong geologic section.

Conclusion

The following results were obtained from the fusulinid study on the Moscovian Geumcheon Formation of the Gangdong area of Samcheok coalfield.

The limestones of the Moscovian Geumcheon Formation of the Gangdong area consist mainly of wackestone-packstone and contain many bio-skeletons of crinoid, coral, brachiopod, foraminifers, fusulinids, and many trace fossils, which indicate the tidal flat to shallow marine environment under the warm climate.

12 species belonging to 5 genera of fusulinids are identified from the limestone of the Gangdong geologic section: *Ozawainella turgida* Sheng, *Ozawainella* sp. A, *Ozawainella magna* Sheng, *Pseudostaffella antiqua* (Dutkevich), *Pseudostaffella paracompressa* Safonova, *Pseudostaffella kimi* Cheong, *Pseudostaffella* sp., *Beedeina lanceolata* (Lee and Chen), *Beedeina samarica* (Rauser-Chernoussova), *Beedeina* sp. A, *Neostaffella sphaeroidea cuboides* Rauser-Chernoussova, *Hanostaffella hanensis* Cheong. The limestone of the Gangdong geologic section belongs to the lower part of the Geumcheon Formation and is correlated with the upper Moscovian stage (Podolsky) on the basis of the fusulinid fauna (*Neostaffella sphaeroidea cuboides* Rauser-Chernoussova and *Hanostaffella hanensis* Cheong) identified from the limestone.

On the basis of the evolutionary step of fusulinid species in the limestone of the Gangdong geologic section, the stratigraphic sequence of GD1-GD4 should be overturned and the ascending order is GD4-GD3-GD2-GD1. GD5 would be correlated with GD1 and GD6 to GD8 would be correlated with GD4 to GD1. The limestone should be overlapped by faults and folds and the stratigraphic thickness of the limestone is thinner than the thickness of the limestone outcrop of the Gangdong geologic section Therefore, the stratigraphic sequence of the Gangdong geologic section is represented as the Gangdong geologic section (A).

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