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CONODONT BIOSTRATIGRAPHY OF THE UPPER CHOSEON SUPERGROUP IN JANGSEONG-DONGJEOM AREA, GANGWEON-DO

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ABSTRACT

This work is a biostratigraphic study on the upper part of the Lower Paleozoic Choseon Supergroup (Maggol Limestone, Jigunsan Shale and Duwibong Limestone) exposed in the Jangseong-Dongjeom area, the Taebaeg City, Gangweondo, by means of conodont study.

The condonts from the Maggol Limestone, the Jigunsan Shale and the Duwibong Limestone are classified systematically. Two new species *Aurilobodus* n. sp. and *Drepanodus* n. sp. are proposed in open nomenclature. Conodont biozones are also established in three formations of the study area.

Biostratigraphyically the fauna of upper part of the Maggol Limestone is correlated with upper Liangjiashan Formation – First Member of the Upper Machiakou Formation in North China, with late Arenigian to earliest Llanvirnian in Europe, and with the fauna 2, 3 to some lower four of the North American Midcontinent conodont fauna. The fauna of the Jigunsan Shale is correlated with middle part of the Upper Machiakou Formation in North China, with Middle Llanvirnian in Europe and the fauna 4 of the North American Midcontinent. The fauna of the Duwibong Limestone corresponds to upper part of the Upper Machiakou Formation in North China, to late Llanvirnian to early Llandeilian in Europe and to the fauna 5 to 6 of the North American Midcontinent.

Bioprovincially the Maggol and Duwibong conodont fauna are closely related to those of North China and the North American Midcontinent, while the Jigunsan Shale has a mixed nature of the North Atlantic and the North American Midcontinent.

Finally, it is also confirmed that the lithostratigraphic tripartite division, namely the Maggol Limestone, the Jigunsan Shale and the Duwibong Limestone is reasonable.

INTRODUCTION

The study area is located in the southern part of the Taebaeg-city, Gangweon-do, where the Early Paleozoic Choseon Supergroup of so-called "Duwibong type" is well exposed. The Choseon Supergroup in the study area has been known as one of the stratotypes of Choseon Supergroup of the Duwibong Type because of its clearity of the lithostratigraphic division and its abundant occurrence of the macrofossils. Therefore, many authors have carried out stratigraphical, paleontological, sedimentological and tectonical studies.

In this study we try to solve the four following problems; Firstly the Geological Investigation Corps of the Taebaegsan Region(1962) combined the Maggol Limestone, Jigunsan Shale and Duwibong Limestone into Magdong Limestone, which caused many arguments on this stratigraphic unit. Hence we traced vertical and lateral continuities of the three pre-established formations in study area in order to examine possibility of subdivision of the Magdong Limestone. Secondly we try to establish the biostratigraphical zones of condonts and thirdly we intended to correlate this zones with the conodont biozones of North China, Europe and North America as well as the data established by Lee, Y.N. & Lee, H.Y. (1986), and we try to determine the geological age of the three formations mentioned above. Finally, we investigated the bioprovincial affinity of conodonts in the study strata.

LITHOSTRATIGRAPHY

The Choseon Supergroup of Duwibong Type is well exposed in the southern wing of the

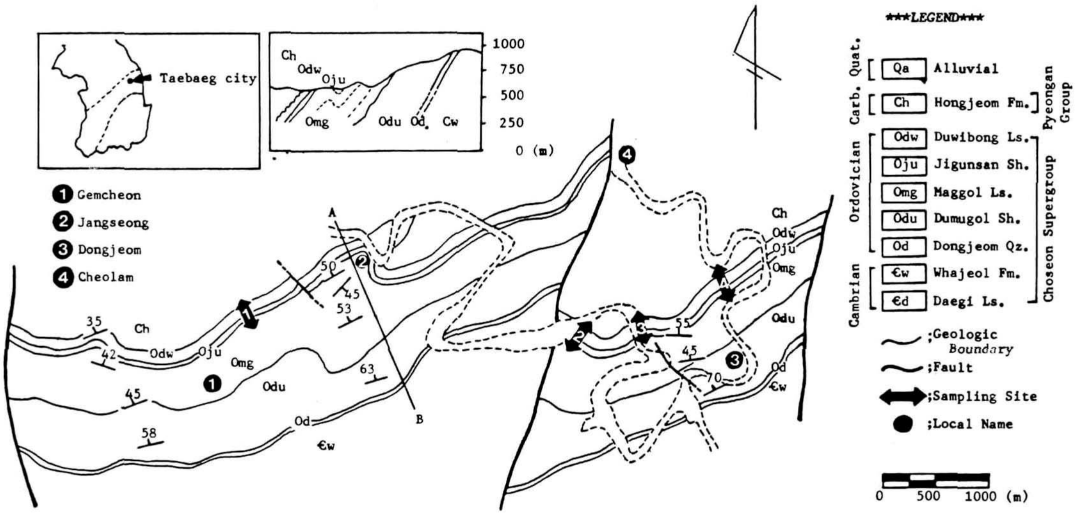

Fig. 1. Geologic map of the Jangseong-Dongjeom Area, Taebaeg-City, Gangwon-Do with sampling localities.

Baegunsan Syncline. It was divided into 10 lithostratigraphic units by Kobayashi (1934a, 35a); namely the Jangsan Ouartzite, Myobong Slate, Daegi Formation, Sesong Slate, Whajeol Formation, Dongjeom Quartzite, Dumugol Shale, Maggol Limestone, Jigunsan Shale and Duwibong Limestone in ascending order. The Choseon Supergroup overlies uncomformably the Precambrian Metasedimentary rocks and it is overlain by the Permo-Triassic Pyeongan Group unconformably. The geologic map of the study area is presented in Figure 1.

Since Kobayashi (1934, 1935) studied this supergroup, many studies have been done by a number of workers; the stratigraphical and sedimentological studies were carried out by Son et al. (1965), Kobayashi (1966), Cheong(1964, 1969, 1973), Kim et al.(1973), Son(1973), Yun(1978), Cheong et al. (1979), Kim(1980), Park et al.(1985) and paleontological studies were carried out by Kobayashi(1930, 1934, 1935, 1953, 1966), Müller(1964), Kim(1969), Lee(1970, 1975a, b, 1976, 1977, 1979, 1980), Lee & Lee(1971, 1986) and Lee & Lee(1988). The Upper part of the Supergroup, including the Maggol Limestone, Jigunsan Shale and Duwibong Limestone, is main object of our study, so that a brief explanation of former three formations is here only summerized.

Maggol Limestone: The formation, named by Kobayashi(1928), overlies the Dumugol Shale and is overlain by the Jigunsan Shale conformably. The formation consists chiefly of bluish to dark gray well-bedded limestones and rarely intercalated dolomitic limestones and calcareous shales; The thickness of the formation is measured about 250-300 meters. Especially in order to define the boundary between Maggol Limestone and Jigunsan Shale, the upper part of the formation(about 80 meters interval below the upper limit) was thoroughly investigated in this study.

Jigunsan Shale: The formation, named by Yamanari(1926), covers the Maggol Limestone and is covered with the Duwibong Limestone conformably. Since the formation is not only well traced laterally but also lithologically well distinguished from the upper and lower formations in the study area, it is confirmed that the Jigunsan Shale can be established as an independent lithostratigraphic unit, and the so-called Magdong Limestone by the GICTR in 1962 must be divided into the Maggol Limestone, Jigunsan Shale and Duwibong Limestone in ascending order. The formation is subdivided roughly into two parts; namely, the lower part which consists mainly of dark gray to black shale and the upper part, which is composed chiefly of bluish gray vermicular limestone with thinly intercalated dark gray shale. Its thickness is estimated to be about 30-40 meters.

Duwibong Limestone: The formation, named by Kobayashi(1928), overlies the Jigunsan Shale conformably and is overlain by the Carbo-Triassic Pyeongan Group unconformably. The formation consists mainly of gray to dark gray massive limestones. The thickness of the formation is about 60-80 meters. Figure 2 shows the vertical lithologic change of the three formations in the sample-collected sections of the study area:

SAMPLE COLLECTING LOCALITIES AND CONODONT FAUNA

A total of 67 samples from four selected sections, i.e., Geumcheondong, Memiltle, Hyeolnaechon and Napalgogae, were collected from the Maggol Limestone(25 samples), Jigunsan Shale(15 samples) and Duwibong Limestone(27 samples). The location and stratigraphical position of each sample are presented in Figures 1 and 2 and also number of collected samples and condont-yielding samples are presented in Figure 2. All of the samples were processed by the normal preparation method for conodont sepearation, which include crushing, washing, dissolving with solution of 15% CH_3COOH, sieving and drying.

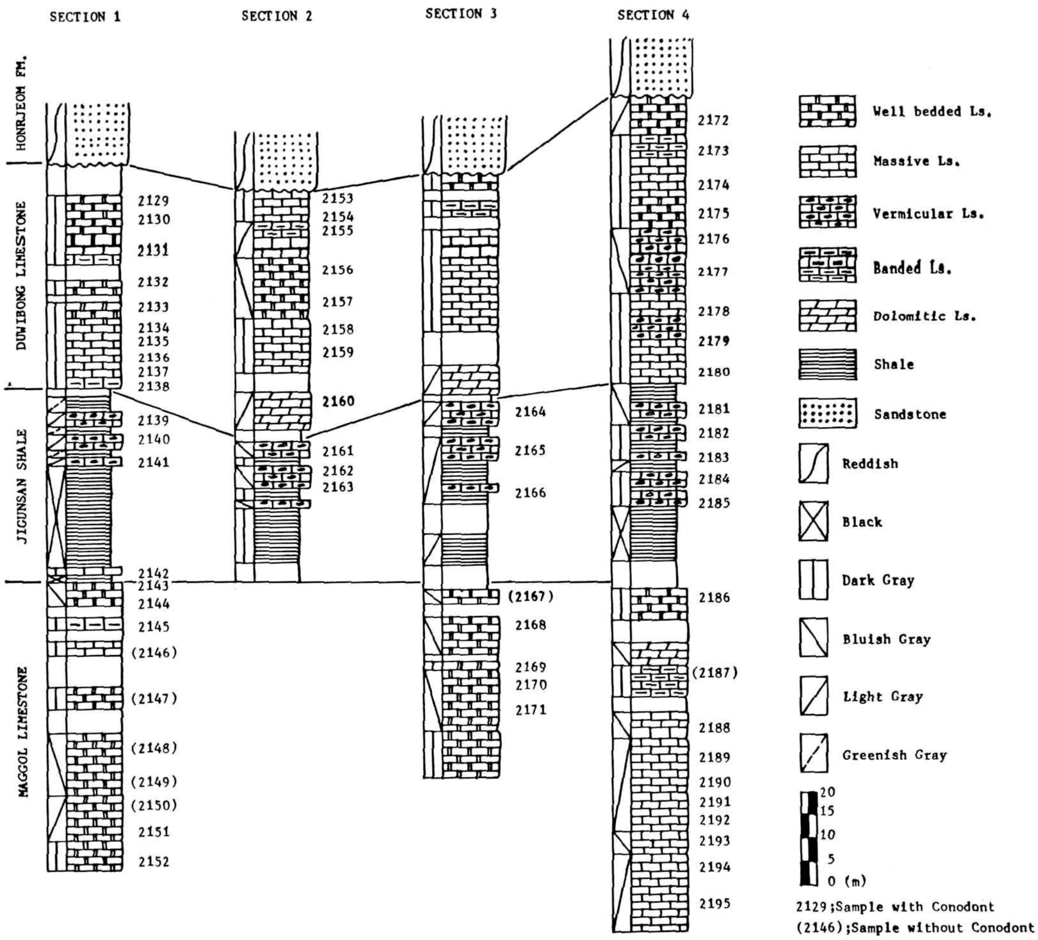

Fig. 2. Columnar sections of the Duwibong Limestone, Jigunsan Shale and Maggol Limestone.

All the recovered condonts amount to 1849 individuals. Among them 332 were obtained from the Maggol Limestone, 542 from the Jigunsan Shale and 985 from the Duwibong Limestone, respectively. In general the recovered conodonts are well preserved though some specimens from the uppermost part of the Maggol Limestone are poorly preserved. Conodont color alteration index value(Epstein et al., 1977) of conodonts in the study ranges from 5 to 7 showing dark gray to milky white in color.

In the systematic description of conodont species, we adopted the multielement classification, but disjunct element classification method was also incidently used in case of deficiency of material. In that case, the generic names are put in quotation marks.

The conodonts from the upper part of the Maggol Limestone are classified into 8 species of 7 genera by multielement classification and 20 species of 11 genera by form taxonomy. The species described below are limited only from this formation; *Aurilobodus leptosomatus, A.* n. sp., *"Drepanodus" altipes, "Histoidella" serratus, "Oistodus" inclinatus, "Paltodus" inconstans, Rhipidognathus maggolensis, Scolopodus cornutiformis, S. giganteus* and *"Ulricho-*

dina" aff. *wisconsinensis.* Among them two faunal zones are established, namely the lower *Aurilobodus leptosomatus* Zone and the upper unnamed Zone. The lower *A. leptosomatus* Zone includes taxa such as *Histoidella serratus, Paltodus inconstans, Rhipidognathus maggolensis, Scolopodus cornutiformis, S. giganteus* and *Ulrichodina wisconsinensis* with the zonal fossil. *A. leptosomatus* which is limited only in this biozone. The *A. leptosomatus* Zone begins with the mixed occurrence of the species such as *Histoidella serratus, Paltodus inconstans, Scolopodus giganteus* and ends at the disappearance of *Paltodus inconstans, Rhipidognathus maggolensis* and *Ulrichodina wisconsinensis.*

The Unnamed zone consists mainly of the long range taxa such as *Tangshanodus tangshanensis, Acontiodus viriosus, Belodella rigida, Scolopodus euspinus* and *S. nogamii,* so that a definite zonal fossil cannot be selected. However, *Scolopodus eburnus* and *S. flexilis* are disappeared in the uppermost limit of the Unnamed zone.

The conodonts from the Jigunsan Shale are classified into 14 species of 10 genera by multielement classification, and 12 species of 10 genera by form taxonomy. In the Jigunsan Shale, *Dapsilodus compressus, Erraticodon tangshanensis, "Oneotodus" mitratus, Panderodus gracilis* and *Tangshanodus tangshanensis* are superior taxa, and *Aurilobodus* cf. sp. A, "*Belodina*" n. sp., *Eoplacognathus suecicus, E. jigunsanensis* and "*Triangulodus*" n. sp are

Table 1. Numbers of conodont specimens recovered from each sample of Maggol Ls.

FORMATION	MAGGOL LIMESTONE																		
LOCALITY	Section 1				Section 3							Section 4							Total
SPECIES / SAMPLE NUMBER	2143	2144	2145	2151	2152	2168	2169	2170	2171	2186	2188	2189	2190	2191	2192	2193	2194	2195	
Acodus sp.									1									1	1
Acontiodus viriosus	1									2	1	2			3				9
*Aurilobodus leptosomatus																1		1	2
A. n sp.															2				2
*Belodella rigida oistodontiform el.																		1	1
adenticulated biconvex el.															1			1	2
denticulated triangular el.																	1		1
denticulated plano-biconvex el.																			0
Distacodus sp.									1										1
Drepanodus altipes															1		1	1	3
D. homocurvatus																	1	1	2
D. sp.		2								1	3	1		5	12	3		1	28
Histoidella serratus																1		1	2
Oistodus contractus																		1	1
Paltodus inconstans															2				2
*Rhipidognathus laiwuensis prioniodiniform el.									2						1			1	4
bryantodiniform el.																		2	2
trichonodelliform el.																		3	3
ozarkodiniform el.																		2	2
*R. maggolensis bryantodiniform el.														1	3	3	1	1	9
trichonodelliform el.																		1	1
Scandodus sp.	2								3	1		1			1	1	1	4	14
Scolopodus asperus																	1		1
S. cornutiformis																		1	1
S. eburnus			1						2			1							4
S. euspinus															1	9	2	3	15
*S. flexilis erectiform el.															2				2
arcuatiform el.			1						1		1				3	1	3	2	12
S. giganteus					1													1	2
S. nogamii																2	2	1	5
*Tangshanodus tangshanensis cordylodontiform el.				1				1	13			2	1		1	1	2	4	26
gothodontiform el.									2		2		1		1	5	3	2	16
oepicodontiform el.									5		1	2						1	9
trichonodelliform el.							1		13		2		1		6	3	2	5	33
dichognathiform el.								1	3							1			5
prioniodiniform el.								1	1		3	1			5	3		5	19
oistodontiform el.									8			2			6	3		5	24
*Triangulodus changshanensis drepanodontiform el.																			0
oistodontiform el.																		3	3
distacodontiform el.																		3	3
trichonodelliform el.																		1	1
Ulrichodina aff. wisconsinensis															1	1		1	3
Indet	1		3			2		1	1	2	3	1		1	9	6	6	8	44
TOTAL	4	2	5	1	1	2	1	4	56	6	16	13	3	7	61	45	26	69	322

Table 2. Numbers of conodont specimens recovered from each sample of Jigunsan Sh.

FORMATION	JIGUNSAN SHALE															
LOCALITY	Sec. 1				Sec.2			Sec.3			Sec. 4					TOTAL
SPECIES / SAMPLE NUMBER	2139	2140	2141	2142	2161	2162	2163	2164	2165	2166	2181	2182	2183	2184	2185	
Acodus sp.								2						1	1	4
Acontiodus viriosus	1							1				1				4
*Aurilobodus aurilobus symmetricus el.											1					1
asymmetricus el.																0
*A. simplex symmetricus el.	2															2
asymmetricus el.		1	1						1		1	2			2	8
*A. sp. A										2						2
*Belodella rigida oistodontiform el.		2		1			1						1		1	6
adenticulated biconvex el.	1	1		2				1				1		1	2	9
denticulated triangular el.				1			1								1	3
denticulated plano-biconvex el.																0
Belodina n sp.									1						10	11
*Dapsilodus compressus drepanodontiform el.																0
acodontiform el.																0
distacodontiform el.		1														1
Distacodus sp.															1	1
Drepanodus homocurvatus		1						1			1	1		1		5
D. sp.	1	12	1			2	2	1			1		3	4	10	45
*Drepanoistodus suberectus oistodontiform el.					1										6	7
suberectiform el.	2				1	2	2		1		1	1		2	8	20
homocurvatiform el.	1				1	2	1	2	1			1			1	10
*Eoplacognathus jigunsanensis sinistal ambalodontiform el.															1	1
dextral ambalodontiform el.																0
polyplacognatiform el.															1	1
E. sp.	1	2				1		1	1						3	9
*E. sp. A ambalodontiform el.				1												1
polyplacognatiform el.				1												1
*E. suecicus sinistal ambalodontiform el.													1		1	2
dextral ambalodontiform el.															2	2
polyplacognatiform el.	1						1	1						2		5
*Erraticodon tangshanensis hindeodelliform el.												1				1
cordylodontiform el.	1														1	2
prioniodiniform el.									3			1			1	5
trichonodelliform el.											1					1
Oneotodus mitratus	1				1		1							1	1	5
Oistodus parallelus						1							1	1	3	6
O. sthenus		2			1									2		5
O. venustus	1											1		1		3
O. sp.	1												1		4	6
*Panderodus gracilis gracilis el.					1	1									2	4
transitional el.	1		1												1	3
compressus el.															5	5
*Plectodina sp. A subcordylodontiform el.	6	2				1	1	2						5	8	25
hindeodelliform el.		1					1							3	2	7
prioniodiniform el.			1													1
Scandodus n sp.	2					2		2		1			1			8
S. sp.						1		1	1	2	1				5	11
Scolopodus euspinus	20	3			4	4	1	4	1			5	4	5	25	76
S. nogamii	9	1			2	3			1		3	3	2	2	13	39
*Tangshanodus tangshanensis cordylodontiform el.	1	1	1	2		1	2						1		6	15
gothodontiform el.	1			7			3		1	1					6	19
oepicodontiform el.	3			8		2	3	1	1		1	1	1		13	34
trichonodontiform el.	1			5		1						1	1		2	11
dichognathiform el.				1		3		1		1	2	1		1	13	23
prioniodiniform el.	2							1								3
oistodontiform el.				3			1									4
*Triangulodus changshanensis drepanodontiform el.	3	2				3		2		1	2			2	3	18
oistodontiform el.						4		2			1			2	2	11
distacodontiform el.	2					1	1								2	6
trichonodelliform el.							1				1	1		1	2	6
T. n sp.	1						2	1	1						7	12
Indet	2	1						1	1			1		2		8
TOTAL	68	33	5	32	12	35	25	28	15	8	17	24	17	39	186	542

limited only from the Jigunsan Shale. Especially, *Eoplacognathus suecicus* and *E. jigunsanensis* Assemblage Zone is established at the upper part of the formation because of their restricted occurrence at that horizon.

The conodonts of the Duwibong Limestone are classified into 12 species of 8 genera by multielement classification with 18 form species of 10 form genera. The prominent species of this formation are *Aurilobodus aurilobus, A. simplex, "Oistodus" parallelus, "O." sthenus, "O." venustus* and *Plectodina* sp. A. and the species *Aurilobodus serratus, A.* sp. A, *"Drepano-*

Table 3. Numbers of conodont specimens recovered from each sample of Duwibong Ls.

FORMATION	DUWIBONG LIMESTONE																											
LOCALITY	Section 1										Sectuon 2								Section 4									TOTAL
SPECIES / SAMPLE NUMBER	2129	2130	2131	2132	2133	2134	2135	2136	2137	2138	2153	2154	2155	2156	2157	2158	2159	2160	2172	2173	2174	2175	2176	2177	2178	2179	2180	
Acodus sp.	3													6	1						2				1	1		14
Acontiodus viriosus	4				1	1	1			1	1		7	4													3	22
*Aurilobodus aurilobus symmetricus el.		1	1							1											2		1	1				7
asymmetricus el.						3	1	3		1		1		1							5		2	1			1	19
*A. serratus																			2									2
*A. simpex symmetricus el.																												0
asymmetricus el.						1		1						1														3
*A. sp. B								1													3	1						5
*Belodella rigida oistodontiform el.		1	1			1			2			1		1				1									1	9
adenticulated biconvex el.			1		1	1			1	3		1		1		2					1							12
denticulated triangular el.		1	2		1	2			1	4		1				1		1			1					1		16
denticulated plano-biconvex el.						1						1					1				1				1	1		6
*Dapsiloduscompressus drepanodontiform el.									1																			1
acodontiform el.			1																									1
distacodontiform el.		1			1	2			1							1					1							7
Distacodus sp.			1										2															3
Drepanodus flexuosus													2		1													3
D. homocurvatus									1				1	5				2			1							10
D. n sp.			2			1																		1				4
D. sp.	16	1	4		4	2	3	3	15	8	8	1	16	16	5	1		4	3	1	10			2	3	1	2	129
*Drepanoistodus suberectus oistodontiform el.									1							1								1				3
suberectiform el.		1	2		2	1		2	3	1		2				1					2			1		1	1	20
homocurvatiform el.		1	2									1						1						1				6
*Erraticodon tangshanensis hindeodelliform el.			1		3				5									2						2			2	15
cordylodontiform el.		1	1				1		1											1	2		1	2	1			11
prioniodiniform el.			3		1			6	2									1			5		2	2	3			25
trichonodelliform el.			1					1							1										1	1		5
angulodontiform el.						2															1				1			4
plectospathognathiform el.					1		1	1		1											2						3	9
Oneotodus mitratus								2	1					1	1													5
Oistodus parallelus					1				1	1											1							4
O. sthenus						1						1													2	1	1	6
O. venustus																					1						2	3
O. sp.						1												1			2	1		1				6
Ozarcodina sp. A								1		1				1														3
*Panderodus gracilis gracilis el.					2	2		1	1	1		1								1	2							11
transitional el.			5		1	1		4	3	2		3			1			1			3				1		1	26
compressus el.			2	2	1	5	1	2	1	2		1		1			1	2			2			1	1			25
*Plectodina onychodonta suncordylodontiform el.			2		2									5														9
cyrtoniodontiform el.					1							2		9							1							13
trichonodelliform el.			1											1														2
zygognathiform el.					1									3														4
dichognathiform el.												1		8	2													11
prioniodiniform el.		3	6		10	3	2	2	1			6		42							5				1			82
*P. sp. A subcordylodontiform el.																											2	2
hindeodelliform el.																											3	3
prioniodiniform el.																												0
Scandodus n sp.									1	1					1			1					1				1	6
S. sp.	7	4	2		3		3		1	2	3	1	4	5				1	2		1			5	5	3	3	55
Scolopodus euspinus		1	7	1	5	1	20	13	30	7		7				1	1	5	3	1	13		2	7	10	5	22	162
S. nogamii		1			1		8	5	11	10		2						8	1	2	3	1	4	1	2			60
*Triangulodus changshanensis drepanodontiform el.		1	1		1				2	2		2		2	3	2									1			17
oistodontiform el.						2						2			3	2					1				1		1	12
distacodontiform el.						1	2							2				1			1							7
trichonodelliform el.			2			2	1		1			1	1	4							2		1			2		17
Indet			3		5	8	2	2	7	2	1	3	3	5	3	1		3	2	1	7			3	3	2	1	67
TOTAL	30	18	54	3	49	45	46	50	95	51	13	42	36	123	23	13	3	36	13	7	84	3	14	12	38	19	49	985

dus n. sp. and *Plectodina onychodonta* occur only from the Duwibong Formation. Among them, occurrence of *Plectodina onychodonta* and *Aurilobodus serratus* is restricted in the lower and upper part of the Duwibong Limestone, respectively so that *Aurilobodus serratus* Zone and *Plectodina onychodonta* zone are established for the corresponding horizons.

The numerical distributions of the conodont species from the Maggol Limestone, Jigunsan Shale and Duwibong Limestone are presented at Table 1, 2 and 3, respectively.

BIOSTRATIGRAPHIC CORRELATION AND BIOPROVINCIALISM

In this subject, the species with long stratigraphic range, the newly established species and the inexactly identified species are excluded owing to their limited value for stratigraphic correlation. The stratigraphic range chart of the conodonts from this study is given in Figure 3.

Each of the biozones mentioned above is well correlated with the conodont biozones in

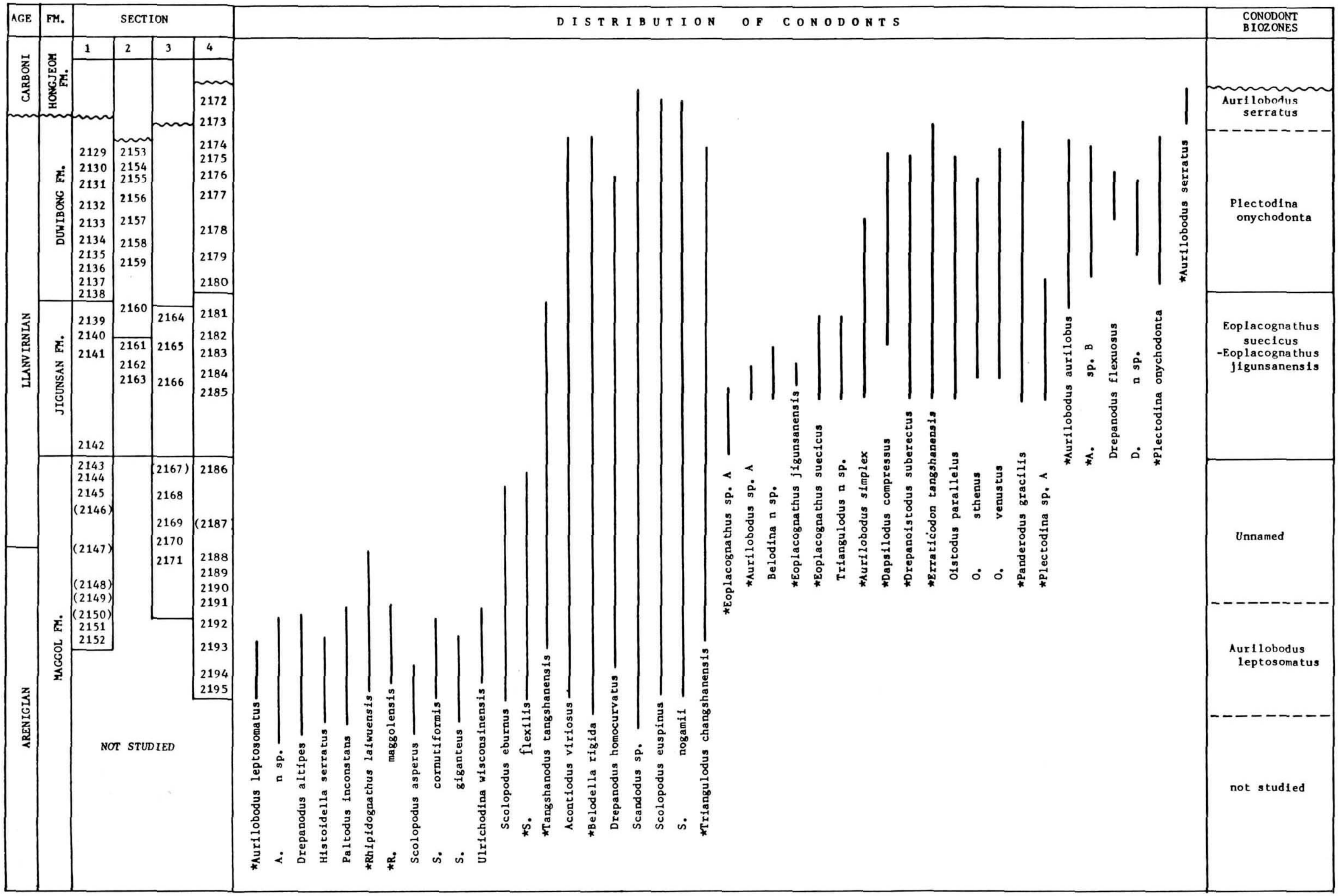

Fig. 3. Stratigraphical range and biostratigraphical zonation of conodonts recovered from samples in study area.

China, Europe and North America. Herein, the synthetic description and correlation of each biozone are given in Table 4.

Aurilobodus leptosomatus Zone: the biozone is characterized by the occurrence of *Aurilobodus leptosomatus*. *Aurilobodus leptosomatus* was firstly described from the Lower Machiakou Formation of Hebei Tangshan in North China (An et al., 1983) and consists of two elements, namely asymmetrical and symmetrical elements. The other important species of this zone are *A.* n. sp., *"Histoidella" serratus*, *"Loxodus" dissectus*, *Rhipidognathus maggolensis*, *R. laiwuensis* and *"Ulrichodina"* aff. *wisconsinensis*. These species are mostly disappeared at the end of this zone with the zone indicator. This biozone is well correlated with the *Aurilobodus leptosomatus* Zone to *Tangshanodus tangshanensis* Zone of the Lower Machiakou Formation in North China except for the upper part of the latter zone. In China, *Tangshanodus tangshanensis* Zone was established at the upper part of the Lower Machiakou Formation, but in this area *Tangshanodus tangshanensis* has not value to construct conodont zone because of its long range occurrence. The Zone is also correlated with fauna 2 and 3 of the Middle and Upper Ordovician conodont zone in North American Midcontinent(Sweet & Bergström, 1976) and with the *"Paraoistodus" originalis* Zone of Late Arenigian in Europe (Bergström, 1971).

The Unnamed Zone: this biozone has not any distinctive conodont taxon which occurs

Table 4. Biostratigraphic correlation between stratigraphic units in this study and those in North China, North America and Europe.

EUROPE (Bergström, 1977, 81)		NORTH AMERICA (Ethington & Clark, 1980)		NORTH CHINA (An et al. 1981, 83) Hebei Thangshan			Shandong Yimongshan	SOUTH KOREA Sangdong area (Lee et al., 1986)		studied area
Age	North Atlantic lineage zones	Stage	Conodont faunas	Fm.	Memb.	Conodont zones	Conodont zones	Fm.	Conodont zones	Conodont zones
Llandeilian	Pygodus anserinus	Chazyan	6	Fengfeng Fm.			Unnamed			
Llandeilian	Pygodus serra: E. lindström / E. robustus	Chazyan	6	Upper Machiakou Fm.			Aurilobodus serratus	Duwibong Ls.	Aurilobodus serratus	Aurilobodus serratus
Llandeilian	Pygodus serra: E. reclinatus / F. foliaceus	Chazyan	5	Upper Machiakou Fm.	Third	Plectodina onychodonta	Plectodina onychodonta	Duwibong Ls.	Plectodina onychodonta	Plectodina onychodonta
Llanvirnian	Eoplacognathus suecicus	Chazyan	5	Upper Machiakou Fm.	Second	Eoplacognathus suecicus-Acontiodus linxiensis	Eoplacognathus suecicus-Acontiodus linxiensis	Jigunsan Sh.	Eoplacognathus suecicus-Eoplacognathus jigunsanensis	Eoplacognathus suecicus-Eoplacognathus jigunsanensis
Llanvirnian	Ambalognathus variabilis	Chazyan	4	Upper Machiakou Fm.	First	Unnamed	Unnamed	Maggol Ls.		Unnamed
Arenigian	Microzarcodina parva	Whiterokian	3	Lower Machiakou Fm.	Third	Tangshanodus tangshanensis	Tangshanodus tangshanensis	Maggol Ls.	Not studied	
Arenigian	Paraoistodus originalis	Whiterokian	3	Lower Machiakou Fm.	Second			Maggol Ls.		Aurilobodus leptosomatus
Arenigian	Prioniodus navis	Whiterokian	2	Lower Machiakou Fm.	Second / First	Aurilobodus leptosomatus-Loxodus dissectus	Aurilobodus leptosomatus-Loxodus dissectus	Maggol Ls.		Aurilobodus leptosomatus
Arenigian	Prioniodus triangulaeis	Whiterokian	1	Lower Machiakou Fm.	First			Maggol Ls.		
Arenigian	Oepikodus evae	Whiterokian	1	E		Paraserratognathus paltodiformis				Not studied

only from this zone, and its conodont assemblage is generally poor in its diversity and abundance. This biozone contains *"Acontiodus" viriosus, "Scandodus"* sp., *Scolopodus flexilis* and *Tangshanodus tangshanensis.* Especially, *Scolopodus flexilis* seems to be a very important species in correlating the upper limit of the Maggol Limestone with that of North China. The occurrence of the species is extended to the First Member of the Upper Machiakou Formation in Hebei Tangshan, North China(An et al., 1983). Therefore, the unnamed zone is correlated tentatively with the First Member of the Upper Machiakou Formation in North China, with fauna 4 in North American Midcontinent and with the *Microzarkodina parva* Zone and *Eoplacognathus variabilis* Zone of the latest Arenigian to earliest Llanvirnian in Northwestern Europe.

Eoplacognathus suecicus-E. jigunsanensis Assemblage Zone: *Eoplacognathus suecicus* was firstly reported from the Skarlöv Limestone in Sweden(Bergström, 1971), and afterwards it has been known as an index fossil of a subzone at the base of *Pygodus serra* Zone. *Eoplacognathus jigunsanensis* was firstly described from the Jigunsan Shale in South Korea (Lee et al., 1986) and it consists of three elements, namely sinistral and dextral ambalodontiform elements and polyplacognathiform element. The biozone contains the following species of conodonts; namely *Aurilobodus* sp. A., *"Belodina"* n. sp., *Drepanoistodus suberectus, Eoplacognathus jigunsanensis, E.* sp. A., *E. suecicus, Erraticodon tangshanensis, Tangshanodus tangshanensis* and *"Triangulodus"* n. sp. Conodonts of this biozone are not only various in species diversity but also rapid in evolutionary trend, so that possibility of subzonation may be expected in this zone. Especially, *Eoplacognathus* sp. A. occurs only from lower part of the Jigunsan Shale, hence it shows a great potentiality of subzonation. The zone is in well concordance with the *Eoplacognathus suecicus* Zone of the Upper Machiakou Formation in North China and the same zone of middle Llanvirnian in Europe.

Plectodina onychodonta Zone: The species *Plectodina onychodonta* which is the characteristic species of the biozone in the Duwibong Limestone was firstly reported from the Upper Machiakou Formation of Hebei Tangshan in North China(An et al., 1983) and it consists of six elements, namely subcordylodontiform, cyrtoniodontiform, dichognathiform, prioniodiniform, trichonodelliform and zygognathiform elements. The other main conodont species from this zone are *Aurilobodus aurilobus, A.* simplex, *A.* sp. B., *"Dapsilodus compressus, "Drepanodus"* n. sp. Based on the conodont assemblage mentioned above the zone is well correlated with *Plectodina onychodonta* Zone at the third Member of the Upper Machiakou Formation in North China, and with late Llanvirnian in Europe. In North America, the multielement species of *Plectodina onychodonta* is closely related in morphology to elements of *?Phragmodus* sp. A and *?Plectodina* sp.(Ethington & Clark, 1981) described from the Crystal Peak Dolomite Ibex, Utah State which falls within the fauna 5 of the North American Midcontinent conodont fauna. Hence it may be suggested that the zone may be correlated with the fauna 5 of the North American Midcontinent conodonts.

Aurilobodus serratus Zone: *Auilobodus serratus* was firstly known from the Upper Machiakou Formation in Sandong-yimonghan, North China (Xiang & Chang, 1983), and they established *Aurilobodus serratus* Zone at uppermost part of the Upper Machiakou Formation. The conodonts of this zone are rare in occurrence and only the single species, *Aurilobodus serratus* was described. The zone in the Duwibong Limestone is correlated with the *Aurilobodus serratus* Zone at the Upper Machiakou Formation in Hebei Tangshan, North China, as well as probably with the fauna 6 of the North America. It may be also correlated with the latest Lanvirnian to early Landeilian in Northwestern Europe.

Recently, Lee, Y. N. & Lee, H. Y.(1986) established three conodont biozones; for the upper part of the Choseon Supergroup in the Nokjeon-Sangdong area which lies in western extension of the strata in this study, namely the *Eoplacognathus suecicus-E. jigunsanensis* Assemblage Zone in the Jigunsan Shale, the *Plectodina onychodonta* Zone and the *Aurilobodus serratus* Zone in the Duwibong Formation, respectively. The biostratigraphic zones of the two formations in this study, namely the Jigunsan Shale and the Duwibong Limestone, are completely coincident to the former's scheme.

The fact that conodont fauna has provincial characters through the geologic ages has been known by many authors. In case of the middle and late Ordovician, conodont provinciality may be divided into the North Atlantic Province and the North American Midcontinent Province, that have been known by Sweet et al. (1959). Bergstrom et al. (1972), Barnes et al. (1973), Sweet & Bergstrom(1974), Barnes & Faraeus(1975) and Fraeus(1976). Recently Charpentier(1984) suggested especially that Ordovician conodonts are divided into two provinces by the difference of marine water temperature, namely tropical-semitropical or low latitude condition in North American Midcontinent Province and cold or high latitude condition in North Atlantic Province.

Conodont faunas from this study show closer relationship to those of North China than any other fauna that is to say 13 genera of multielement apparatus are common in both areas among 14 genera which are identified from the Jigunsan and Duwibong Formations in this study. It may be interpreted, therefore, that the Korean fauna during that age surely belonged to the North China fauna which was very similar to Laurentia Block.

The fauna of upper part of the Maggol Limestone has also close kinship with that of North China. All seven multielement genera of this formation have been also reported from North China. Partially the Korean faura has North American and North Atlantic elements. The Maggol fauna has some typical genera of the North American Midcontinent fauna; especially *"Histoidella"* and *"Multioistodus"* have been only reported from the North American Midcontinent and its related area. On the other hand, the fauna of the Jigunsan Shale contains *Eoplacognathus* and *Baltoniodus* which are the typical North Atlantic conodonts with the typical genera of the North American Midcontinent fauna such as *"Belodina", Belodella, Plectodina* and *Panderodus.* Hence, the fauna of the Jigunsan Shale shows a mixed fauna of the North Atlantic Province and the North American Midcontinent Province while the fauna of the Duwibong Limestone has such genera as *"Belodina", Panderodus, Plectodina* and *"Polycaulodus",* which are typical of the North American Midcontinent. That is, the fauna of the Duwibong Limestone shows also a kinship with the North American Midcontinent fauna.

Previously, some of scholars have tried to interprete bioprovincialism about Maggol Limestone, Jigunsan Shale and Duwibong Limestone. Kobayashi (1966) suggested based on studies of macrofossils such as trilobites and cephaolopods that the fauna of the Jigunsan Shale has closer relationship to that of Europe rather than North American fauna, whereas the fauna of the Duwibong Limestone has more intimately related to Arctic-North American Midcontinent fauna than that of Europe. Lee(1977) and Cheong et al.(1979) asserted that the fauna of the Jigunsan Shale has a close kinship with European fauna, holding some species of the typical North American Midcontient fauna, while the fauna of the Duwibong Limestone was exclusively related to North American Midcontinent fauna. Also, Lee et al.(1986) confirmed, based on conodont studies, that the result of the study by Lee et al.(mentioned above 1972, 79) was right.

Kobayashi(1966) also established three fossil horizons in middle to upper part of Maggol Formation on the basis of macrofossil studies, namely *Manchuroceras* horizon, *Polydesmia* horizon and *Sigmorthoceras* horizon roughly in ascending order, and he stated that the upper part of the Maggol Formation including these three fossil horizons is rare in megafossils, so that it could not be divided into definite fossil zones. Therefore, he suggested only that the

Manchuroceras horizon is of upper Canadian and the *Polydesmia* and *Sigmorthoceras* horizons are dated to lower and middle Chazyan of North America, respectively.

On the other hand, Lee, H. Y.(1976) insisted based on conodont study that the upper part of the Maggol Formation is closely related to those of the Fort Pena Formation and the Port Ferry Formation which belong to the North American Mid-Continent fauna. Subsequently, Hwang, I.S.(1986) and Kim, S. H.(1987) studied conodonts of the Maggol Limestone and they indicated that the Maggol conodont fauna is closely related to those of North China Block, and the North American Midcontinent. Consequently the result of this study is well in agreement with the result of the previous conodont studies in interpretation of the bioprovincialism.

CONCLUSION

1. The Jigunsan Shale is well traced in the study area, so that the Maggol Limestone incorporated by the Geological Investigation Corps of Taebaegsan Region should be divided into the Maggol Limestone, Jigunsan Shale and Duwibong Limestone in ascending order.

2. A total of 63 samples were collected from the Maggol Limestone, Jigunsan Shale and Duwibong Limestone and 60 samples of them yielded 1849 individuals of conodonts. These are classified into 21 multielement species referable to 16 multielement genera and 21 form species of 12 form genera.

3. Conodont biozones are established in three formations of the study area by means of conodont fauna; *Aurilobodus leptosomatus* Zone and Unnamed Zone in the upperpart of the Maggol Limestone, *Eoplacognathus suecicus-E. Jigunsanensis* Assemblage Zone in the Jigunsan Shale and *Plectodina onychodonta* Zone and *Aurilobodus serratus* Zone in the Duwibong Limestone in ascending order, respectively.

4. Biostratigraphically, the fauna of upper part of the Maggol Limestone is dated to Lower Machiakou Formation-First Member of the Upper Machiakou Formation in North China, to late Arenigian and earliest Llanvirnian in Europe, which is nearly equivalent to the fauna 2, 3 and lower part of 4 of the North American Midcontient conodont fauna

5. The fauna of the Jigunsan Shale is correlated with middle part of the Upper Machiakou Formation in North China, middle Llanvirnian in Europe and upper part of the fauna 4 of the North American Midcontinent.

6. The fauna of the Duwibong Limestone corresponds to upper part of the upper Machiakou Formation in North China, to late Llanvirnian-early Llandeilian in Europe and the fauna 5 to 6 of the North America.

7. Bioprovincially, the Maggol, the Jigunsan and Duwibong conodont faunas are closely related to those of North China and the first and third have also some typical elements of the North American Midcontinent rather than the North Atlantic fauna, while the Jigunsan Fauna has some mixed of North Atlantic and the North American Midcontinent.

SYSTEMATIC DESCRIPTION

Genus *Aurilobodus* Xiang & Zhang, 1983
Type species *"Tricladiodus"? aurilobus* Lee 1975
Aurilobodus n. sp.
pl. 3, fig. 16


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EXPLANATION OF PLATES

Plate 1

Fig. 1. *Oneotodus mitratus*
Anterolateral view, 90x, Sample No. 2139, YSUG00873 Jigunsan Sh.

Fig. 2-4 *Panderodus gracilis* (Branson & Mehl, 1933)
2. gracilis el., Lateral view, 110x,
Sample No. 2185, YSUG00874 Jigunsan Sh.
3. transitional el., Lateral view, 160x,
Sample No. 2177, YSUG00875 Duwibong Ls.
4. compressus el., Lateral view, 94x,
Sample No. 2174, YSUG 00876 Duwibong Ls.

Fig. 5-10 *Erraticodon tangshanensis* Yang & Xu, 1983
5. cordylodontiform el., Postero-lateral view, 150x,
Sample No. 2131, YSUG 00877 Duwibong Ls.
6. prioniodiniform el., Lateral view, 110x,
Sample No. 2185, YSUG00878 Jigunsan Sh.
7. trichonodelliform el., Posterior view 94x,
Sample No. 2196, YSUG00879 Maggol Ls.
8. hindeodelliform el., Lateral view, 86x,
Sample No. 2131, YSUG00880 Duwibong Ls.
9. angulodontiform el., Posterior view, 100x,
Sample No. 2178, YSUG00881 Duwibong Ls.
10. plectospathognathiform el., Posterior view, 120x,
Sample No. 2135, YSUG00882 Duwibong Ls.

Fig. 11-18 *Tangshanodus tangshanensis* An, 1983
11. oistodontiform el., Lateral view, 200x,
Sample No. 2142, YSUG00883 Jigunsan Sh.
12. oistodontiform el., Lateral view, 160x,
Sample No. 2142, YSUG00884 Jigunsan Sh.
13. cordylodontiform el., Lateral view, 160x,
Sample No. 2139, YSUG00885 Jigunsan Sh.
14. trichonodelliform el., Lateral view, 220x,
Sample No. 2142, YSUG00886 Jigunsan Sh.
15. prioniodiniform el., Lateral view, 110x,
Sample No. 2171, YSUG00887 Maggol Ls.
16. oepicodontiform el., Lateral view, 160x,
Sample No. 2163, YSUG00888 Jigunsan Sh.
17. dichognathiform el., Posterior view, 130x,
Sample No. 2142, YSUG00889 Jigunsan Sh.
18. gothodontiform el., Lateral view, 150x,
Sample No. 2185, YSUG00890 Jigunsan Sh.

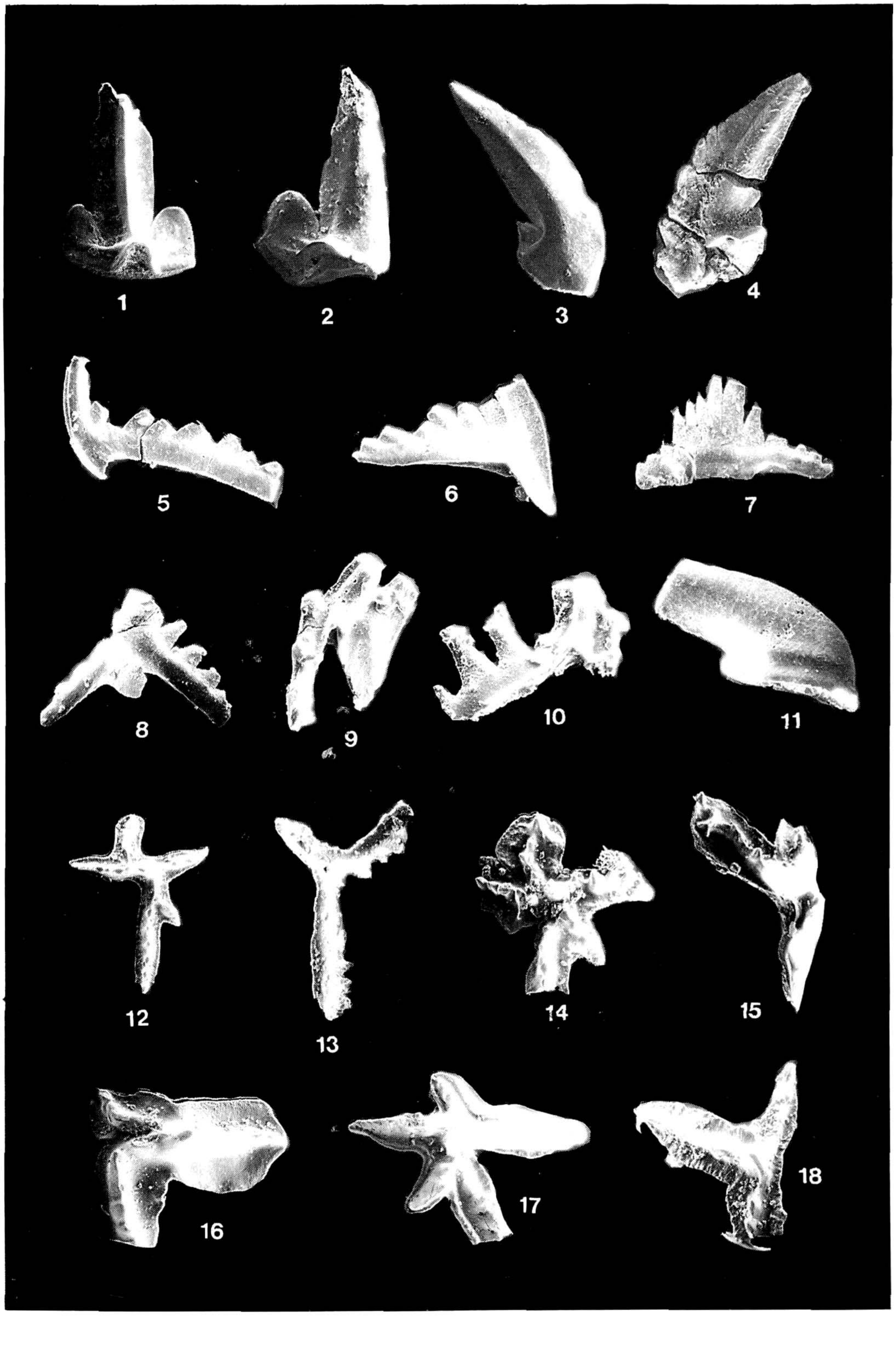
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Plate 2

Fig. 1-2. *Aurilobodus aurilobus* (Lee, 1975)

1. symmetricus el., Posterior view, 94x,
   Sample No. 2177, YSUG00891 Duwibong Ls.
2. asymmetricus el., Posterior view, 78x,
   Sample No. 2174, YSUG00892 Duwibong Ls.

Fig. 3. *Aurilobodus* sp. B An, 1983

Fig. 4. *Aurilobodus serratus* Xiang & Zhang, 1983
Lateral view, 78x, Sample No. 2172, YSUG00893 Duwibong Ls.

Fig. 5-10 *Plectodina onychodonta* An & Xu, 1983

5. subcordylodontiform el., Lateral view, 150x,
   Sample No. 2156, YSUG00894 Duwibong Ls.
6. cyrtoniodontiform el., Lateral view, 160x,
   Sample No. 2174, YSUG00895 Duwibong Ls.
7. prioniodiniform el., Lateral view, 110x,
   Sample No. 2156, YSUG00896 Duwibong Ls.
8. dichognathiform el., Antero-lateral view, 220x,
   Sample No. 2156, YSUG00897 Duwibong Ls.
9. zygognathiform el., Posterior view, 200x,
   Sample No. 2156, YSUG00898 Duwibong Ls.
10. trichonodelliform el., Posterior view, 180x,
    Sample No. 2131, YSUG00899 Duwibong Ls.

Fig. 11. *Drepanodus* n. sp.
Lateral view, 130x, Sample No. 2131, YSUG00900 Duwibong Ls.

Fig. 12-13. *Eoplacognathus* sp. A

12. polyplacognathiform el., upper view 78x,
    Sample No. 2142, YSUG00901 Jigunsan Sh.
13. ambalodontiform el., Upper view, 72x,
    Sample No. 2184, YSUG00902 Jigunsan Sh.

Fig. 14-16. *Eoplacognathus suecicus* Bergström, 1971

14. polyplacognathiform el., Upper view, 86x,
    Sample No. 2134, YSUG00903 Jigunsan Sh.
15. dextral ambolodontiform el.,Upper view, 72x,
    Sample No. 2142, YSUG00904 Jigunsan Sh.
16. sinistral ambalodontiform et., Upper view, 100x,
    Sample No. 2138, YSUG00905 Jigunsan Sh.

Fig. 17-18 *Eoplacognathus* n. sp. (Lee, 1986)

17. polyplacognathiform el., Upper view, 94x,
    Sample No. 2138, YSUG00906 Jigunsan Sh.
18. sinistral ambalodontiform el., Upper view, 120x,
    Sample No. 2185, YSUG00907 Jigunsan Sh.

PLATE 3

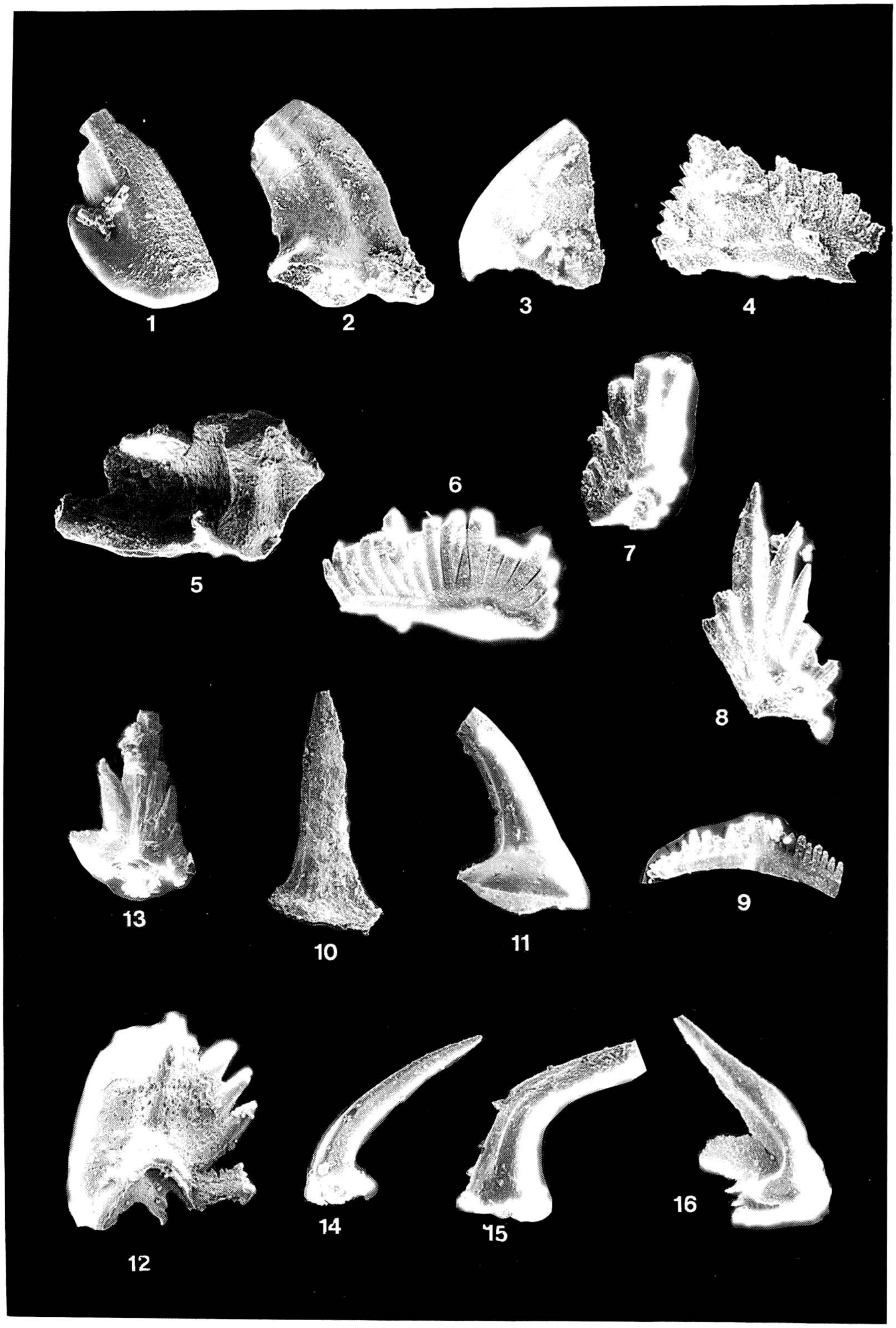

Plate 3

Fig. 1. *Aurilobodus* cf. sp. A An et al., 1983
Lateral view, 160x, Sample No. 2166, YSUG00908 Jigunsan Sh.

Fig. 2. *Aurilobodus simplex* Xiang & Zhang, 1983
symmetricus el., Posterior view, 150x,
Sample No. 2140, YSUG00909 Jigunsan Sh.

Fig. 3. *Ulrichodina* aff. *wisconsinensis* Furnish, 1938
Lateral view, 120x, Sample No. 2193, YSUG00910 Maggol Ls.

Fig. 4. *Histoidella serratus* Harris, 1962
Lateral view, 220x. Sample No. 2193, YSUG00911 Maggol Ls.

Fig. 5. *Aurilobodus leptosomatus* An, 1983
Posterior view, 240X, Sample No. 2193, YSUG00912, Maggol Ls.

Fig. 6-9. *Rhipidognathus laiwuensis* Zhang, 1983

6. prioniodiniform el., Posterior view, 86x,
Sample No. 2171, YSUG00913 Maggol Ls.
7. bryanthodiniform el., Posterior view, 86x,
Sample No. 2196, YSUG00914 Maggol Ls.
8. trichonodelliform el., Posterior view, 200x,
Sample No. 2196, YSUG00915 Maggol Ls.
9. ozarkodiniform el., YSUG00916 Lateral view, 78x.

Fig. 10-11. *Scolopodus flexilis* An, 1980

10. erectiform el., Lateral view, 44x,
Sample No. 2171, YSUG00917 Maggol Ls.
11. arcuartiform el., Lateral view, 160x,
Sample No. 2193, Maggol Ls. Lateral
Sample No. 2196, YSUG00918 Maggol Ls.

Fig. 12-13. *Rhipidognathus maggolensis* (Lee, 1976)

12. trichonodelliform el., Posterior view, 150x
Sample No. 2196, YSUG00919 Maggol Ls.
13. bryanthodiniform el., Lateral view 72x,
Sample No. 2193, YSUG00920 Maggol Ls.

Fig. 14-15. *Scolopodus eburnus* Jiang, 1983
Lateral views, 90x, Sample No. 2171, YSUG00921-922 Maggol Ls.

Fig. 16. *Aurilobodus* n. sp.
Lateral view, 78x, Sample No. 2195, YSUG00923 Maggol Ls.

Description. Unit asymmetrical with high main cusp and an ear-shaped lateral process at the base of one side. Cusp rather narrow, slightly reclined with sharp anterior and posterior margins. Outer lateral side smoothly rounded while inner lateral one bears a rounded carina which runs from tip to the base. Anterior margin slightly recurved, making a sharp angle with the postero-basal margin. Base arched downwards with curved, rather narrow and sharply keeled posterior extension and slightly wide anterior part. Basal cavity narrow slit which flares to the inner side beneath cusp.

Remarks: The new species differs from *A. aurilobus* in the shape of cusp, from *A. simplex* in having large ear-shaped lateral process and it also differs from *"Oistodus" linguatus* in the different shape of lateral process and basal cavity.

Occurrence: *Aurilobodus leptosomatus* Zone of the Maggol Limestone

Material: 3 specimens

Genus *"Drepanodus"* Pander, 1856
Type species *"Drepanodus" arcuatus* Pander, 1856
Drepanodus n. sp.
Pl. 2, fig. 11

Diagnosis: Unit simple. Posterior margin makes an angle of 90 degree with postero-basal margin. Rised zone along the lower margin of base resemble stripe form.

Description: Unit laterally symmetrical. Cusp recurved with sharp posterior margin and rounded anterior margin having waterdrop shape in cross section. Base flared and small. Antero-basal margin strongly curved and continues to anterior margin of cusp. Postero-basal margin having an angle of 90 degree with posterior margin of cusp. Lower margin of base straight and strongly flared. It looks like stripe form. Basal cavity rather deep, waterdrop shape in cross section.

Remarks: this new species is similar to *"Oistodus"* in general character, but the angle between posterior margin of base and cusp is not geniculated.

Occurrence: *Plectodina onychodonta* Zone of the Duwibong Limestone

Material: 4 specimens

Genus *Eoplacognathus* Hamer, 1966
Type species *"Ambalodus" lindstroemi* Hamar, 1966
Eoplacognathus sp. A.
Pl. 2, fig. 12-13

Description: Sinistral ambalodontiform element-unit makes 'y' shape in upper view with long anterior process, short lateral and posterior processes. Anterior process straight and denticles of the processes lightly twisted. Posterior process also straight to the anterior process and its end sharply pointed. Lateral process having an angle of 90 degree with posterior process and bears the same size as posterior process but end of it blunted and rounded.

Polyplacognathiform element-unit bears 4 processes. Anterior process lies on the same line of posterior process, but the former rather longer than the latter. Antero-lateral process bified and their angle is about 90 degree. Long antero-lateral process being nearly parallel to postero-lateral process.

Remarks: The new species differs from *E. suecicus* in following characters. Sinistral ambalodontiform element of the new species has 'y' shape and different length of the processes and three processes meet with an angle of 120 degree. In the polyplacognathiform element antero-posteral process is nearly straight and slender, and the bifid phase of antero-lateral process differs from *E. suecicus.*

Occurrence: lowermost part of the Jigunsan Shale

Material: ambalodontiform el. 2, polyplacognathiform el. 2

강원도 장성-동점지역에 분포하는 상부 조선누층군의 코노돈트 생층서

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이 논문은 강원도 태백시 장성—동점 일대에 분포하는 조선누층군 상부층들(막골석회암,직운산셰일,두위봉석회암)에 대한 코노돈트 생층서 연구이다. 코노돈트 연구를 위해 막골석회암 상부와 직운산셰일 및 두위봉석회암에서 25개, 15개 및 27개의 시료를 각각 채취하였으며 이들에서 332개체, 542개체, 985개체의 코노돈트가 각각 선별되었다. 이들을 분류한 결과 막골석회암 상부의 화석군은 7속 8종의 복합요소종과 11속 20종의 개체요소종으로, 직운산셰일 화석군은 10속 14종의 복합요소종과 10속 12종의 개체요소종으로, 두위봉석회암 화석군은 8속 12종의 복합요소종과 10속 18종의 개체요소종으로 각각 감정되었다. 이중 *Aurilobodus* n. sp.가 신종으로 기재되었다. 코노돈트의 산출층위와 빈도를 기준으로 하여 각 지층에 생층서 분대를 설정한 바, 막골석회암의 상부에는 *Aurilobodus leptosomatus* 대와 Unnamed 대로, 직운산셰일에는 *Eoplacognathus suecicus-E. jigunsanensis* 복합대로, 두위봉석회암에는 *Plectodina onychodonta* 대와 *Aurilobodus serratus*대로 각각 구분하였다. 이들을 북부중국, 유럽 및 북미와 층서대비를 한 결과, 막골석회암 상부는 북부중국의 Lower Machiakou층의 중부와 Upper Machiakou층의 하부에, 유럽의 Arenigian에서 초기 Llanvirnian 및 북미 화석대의 2—3대에 각각 대비된다. 직운산셰일은 북부중국의 Upper Machiakou층의 중부와 유럽의 중기 Llanvirnian 및 북미의 4대에 대비되며, 두위봉석회암은 북부중국의 Upper Machiakou층의 상부와 유럽의 후기 Llanvirnian에서 Llandeilian 및 북미의 5—6대에 각각 대비되며 백운산 향사대에서 행한 기존연구(이웅남, 이하영, 1986)와도 일치한다. 한편, 생물구유연관계에 있어서 막골석회암 상부와 두위봉석회암은 북미대륙 중부형 생물구에 가까우나 직운산셰일은 북대서양 생물구와 북미대륙 중부형 생물구의 혼합상을 보여준다.

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