

A Study on Biostratigraphy and Bioprovince of the Middle Ordovician Conodonts from South Korea

—With Special reference to the Conodonts from the Yeongheung Formation—

한국의 중부 오오도비스계에서 산출된 코노돈트 화석군의 생층서 대비와
생물구 특성에 관한 연구(영흥층의 코노돈트 화석군을 중심으로)

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ABSTRACT: Three of the fifty six samples collected from the Yeongheung Formation in Yeongweol area, Kangweon-Do, yielded about two hundred identifiable conodonts. These are classified into twenty nine form species referable to seventeen form genera and one multielement species. The Yeongheung conodont fauna are from the Middle Ordovician, suggesting a roughly equivalent age to the fossil zone six to seven of the Middle and Upper Ordovician conodont fauna in North America (Sweet, Ethington & Barnes, 1971) and they also have a close kinship with the Copenhagen Formation in Central Nevada and the upper part of the Womble Limestone in South Arkansas, North America. The conodont fauna of the Yeongheung Formation also has several species in common with the upper part of the Maggol Formation, and the Duwibong Formation in Samcheok area. Bioprovincially the Yeongheung conodont fauna has an intimate affinity with the North American Mid-Continent fauna than to the North Atlantic-Appalachia fauna.

要 約

江原道 寧越郡 一帶에 넓게 分布된 所謂 寧越型 朝鮮系의 最上部層인 永興層으로부터 코노돈트 化石에 依한 同層의 地質時代와 層序 對比를 爲하여 4個地域에서 56個의 標品을 採取하였다. 採取된 56個의 標品中 3個의 標品에서 200餘個體의 코노돈트 化石이 產出되었으며 이들의 大部分은 永興層 上部(標品番號 365)로부터 抽出되었다.

抽出된 永興層의 코노돈트는 17屬 29種의 單一種(Simple element species)과 1種의 複合種(Multi-element species)으로 分類되었고 이들은 北美 中部大陸의 中上部 오오도비스系의 第6 乃至 第7 코노돈트 化石帶에 對比되며 特히 北美 中部 Nevada의 Copenhagen層과 남 Arkansas의 Womble 石灰岩 上部의 化石群과 近親關係를 보이고 있다. Copenhagen層의 化石群과는 *Belodella erecta*, *Panderodus(?) alabamensis*, *Oepikodus copenhagenensis*, *Oistodus forceps*, *Drepanodus homocurvatus*, *D. suberectus* 및 *Oistodus inclinatus* 등 모두 7種의 共通種 乃至 類似種을 所有 하고 있으며 Womble 石灰岩 上部 化石群과는 *Oepikodus copenhagenensis*, *Oistodus forceps*, *Scolopodus giganteus* 등 3種의 單一種과 *Plectodina* sp. Repetski & Ethington의 複合種이 共通種으로 記載되었다. 한편 이미 報告된 바 있는 國內의 中部 오오도비스系 化石群과의 比較 結果 莫洞 石灰岩의 上部化石群 斗園峰石灰岩과는 各各 6種 및 5種의 共通種이 產出되었다. 따라서 永興層의 地質 時代는 Copenhagen層의 中部 또는 Womble 石灰岩의 上部와 거의 同一時代일 것으로 생각되며 이는 北美의 中部 오오도비스系의 Porterfieldian 下部와 유럽의 Llandeilo 上部 乃至 Caradocian 下部에 해당될 것으로 보인다. 永興層 코노돈트 化石群은 生物區 特性으로 보아 北大西洋 生物區보다는 北美 中部大陸型和 密接한 近親性을 나타내고 있다.

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Introduction

The Yeongheung Formation is the uppermost formation of the Choson Supergroup which is exposed in the Yeongweol area, Kangweon-do, South Korea. It was first designated by Yoshimura(1940) and further studied by many geologists, for example, the Taebaegsan Geological Investigation Corps(1962), Prof. T. Kobayashi(1966), Prof. O.J. Kim et al (1973) and others. Its stratigraphic position, however, is not so clearly defined, because no distinct fossils have been identified from the formation. Recently the writer collected fifty six samples for conodont study and three of them yielded about two hundred conodonts.

The purpose of this work is to classify the conodont fauna systematically and to make a biostratigraphic correlation with the established faunas in other countries.

Some species of these fauna which have already been identified in preliminary stratigraphic work, (Lee, H.Y., 1978 in Korean) have been reexamined in this work. All conodont specimens with accompanying illustrations are deposited in the Department of Geology, Yonsei University(YSUG).

Stratigraphic Summary

The Yeongheung Formation overlies the Mungok (synonyms Samtaesan) Formation conformably and underlain by the Permo-Carboniferous Pyeongan Group with unconformity. The formation consists chiefly of dark grey crystalline dolomitic limestones and also bluish grey limestones with some thin bedded calcareous shales. Its total thickness is estimated at about 400 meters.

Kobayashi (1966) reported some megafo-

ssils such Orthid, Actinoceroids and *Basiliella* but no definitely identified fossils have yet been described. From information based on the megafossils he pointed out that the formation may be equivalent to the stratigraphic position which extends from the upper Maggol Limestone to the Duwibong Formation in the Samcheok area. On the other hand the Taebaegsan Geological Investigation Corps (1962) regarded that the age of the formation may be later than that of the Choson Supergroup, because they thought the formation overlies the subjacent Mungok Formation of the Supergroup unconformably. Son et al (1969) expressed the same idea, but Kim et al (1973) stated that the Yeongheung Formation certainly belongs to the Choson Supergroup and its age also is of the Ordovician.

Collecting-localities

All fifty-six samples, each of which weighed about two or three kilograms, were collected from carbonate rocks of the Yeongheung Formation in the following four sections in its type localities (see fig.1)

Locality 1 : Road side between Machari and Bamchi, Buk-Myeon, Yeongweol-Gun, 2.2Km northeast of Machari.

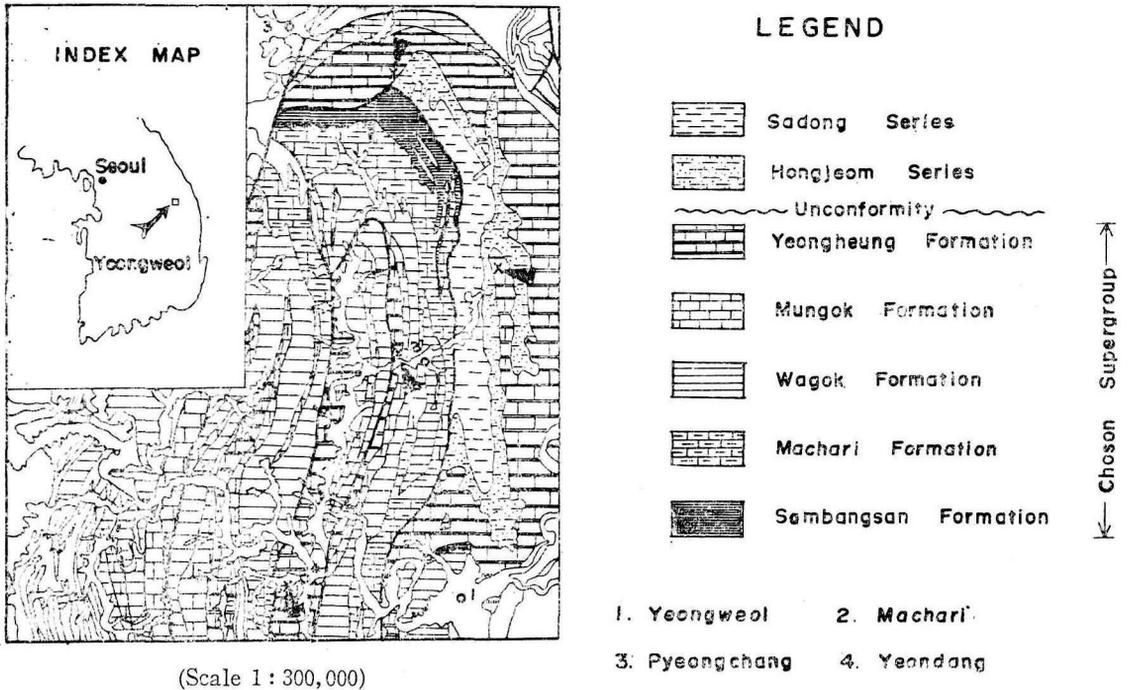
Number of collected samples; 18 (Sample No. 348—365)

Conodont-yielding sample; one (Sample No. 365)

Lithologic character of conodont-yielding sample; Dark grey microcrystalline dolomitic limestone.

Locality 2 : Road side between Omandong and Machari, Buk-Myeon, Yeongweol-Gun, 1.2Km west of Machari.

Number of collected samples; 10 (Sample No. 648—657)



Text-fig. 1. Index map showing the sample localities.

Conodont-yielding sample; one (Sample No. 656)

Lithologic character of conodont-yielding sample; Dark grey massive crystalline dolomitic limestone.

Locality 3: Road side between Pyeongchang and Mitan, Pyeongchang-Gun, 2.8Km west of Myeondunjae.

Number of collected samples; 19 (Sample No. 589—607).

Conodont-yielding sample: none.

Locality 4: Road side in side in southern and western area of Yeondang Primary School, Nam-Myeon, Yeongweol-Gun.

Number of collected sample; 9 (Sample No. 578—586)

Conodont-yielding sample; one (Sample No. 582)

Lithologic character; Dark grey crystalline dolomitic limestone.

Conodont Fauna

Three of the fifty six samples collected in four different localities yielded about two hundred conodonts. The conodonts are relatively well preserved and all of them were darkly coloured. These are classified into twenty nine form species referable to seventeen genera and one multielement species, among them seven form species could not be identified as coming from a specific level due to poor preservation and scarcity of the specimens, and two new form species remain in the open state.

The conodont distribution of the Yeongheung Formation is represented in fig. 2.

Species of conodont	Yeongheung Formation			
	365	582	656	Total
<i>Acodus</i> sp.	1			1
<i>Belodella erecta</i> (Rhodes & Dinley)	1			1
<i>B.</i> nov. sp. Barnes & Poplawsk	13			13
<i>Bryantodina staufferi</i> Bergström & Sweet	6			6
<i>Drepanodus homocurvatus</i> Lindström	9			9
<i>D. suberectus</i> (Branson & Mehl)	3			3
<i>D.</i> spp.	23	3	8	34
<i>Microcoelodus</i> cf. <i>asymmetricus</i> Branson & Mehl	1			1
<i>Neoprioniodus</i> nov. sp.	1			1
<i>Oistodus</i> aff. <i>breviconus</i> Branson & Mehl	3			3
<i>O. forceps</i> Lindström	8			8
<i>O. inclinatus</i> Branson & Mehl	4			4
<i>Oistodus</i> sp.	7		4	11
<i>Oepikodus</i> cf. <i>copenhagensis</i> Ethington & Schumacher	15			15
<i>Panderodus</i> (?) <i>alabamensis</i> Ethington & Schumacher	2			2
<i>P. compressus</i> Branson & Mehl	3			3
<i>P. striatus</i> Stauffer	15			15
<i>Polycaulodus abortivus</i> Branson & Mehl	3			3
<i>P. resupinatus</i> Branson & Mehl	2			2
<i>P.</i> cf. <i>reversus</i> Sweet	2			2
<i>Plectodina aculeata</i> (Stauffer)	4			4
<i>P.</i> sp. Ropetski & Ethington				
Cordylodiform element	1			1
Trichonodelliform element	7			7
Zygognathiform element	1			1
<i>Prioniodina</i> sp. A	3			3
<i>Prioniodina</i> sp. B	2			2
<i>Protopanderodus</i> cf. <i>leonardi</i> serpagli	1			1
<i>P.</i> nov. sp. Barnes & Poplawski	1			1
<i>Roundya</i> nov. sp.	3			3
<i>Scandodus</i> cf. <i>serratus</i> Moskalenko	1			1
<i>Scandodus</i> sp.			7	7
<i>Scolopodus giganteus</i> Sweet & Bergström			2	2
<i>Tricladiodus?</i> <i>aurilobus</i> Lee	1			1
New Form	1			1
indet	23			23
Total	177	3	21	201

Text-fig. 3. Distribution of conodont fauna from the Yeongheung Formation

Biostratigraphical Correlation

Of the Yeongheung conodonts recovered

from three samples only one conodont assemblage, which was collected from the upper part of the formation (locality 1,

Sample No. 365, about 30 m beneath the boundary between the Carboniferous Hongjeom Formation and the Yeongheung Formation), is considered in stratigraphic correlation, because the other two assemblages are not only very few in numbers but also indistinct in specific level. The following consideration, therefore, is only related to the conodont fauna of the Sample No. 365. This conodont assemblage consists of twenty-nine form species referable to sixteen form genera with one new form and one multielement species. Of these long-lived form species such as *Drepanodus homocurvatus*, *D. suberectus*, and the newly described species as well, the indistinct forms in the specific level have limited value in stratigraphic correlation.

The form species *Belodella erecta* has been known hitherto from the Ordovician to the Devonian in Europe, North America and Korea (See Lee 1977, p. 127), so that it is not a good stratigraphic indicator. But the form species was often recovered with the typical Middle Ordovician conodonts. The form species *Belodella* nov. sp. Barnes & Poplawski and *Protopanderodus* nov. sp. were identified from the Middle Ordovician Mystic Formation, Quebec, Canada (Barnes & Poplawski, 1973) with the above described form species. The form species *Bryantodina* cf. *staufferi* seems to be closely related to the original form which was described from the Middle Ordovician Lexington (Bergström & Sweet, 1966) which may be roughly equivalent in stratigraphic position to the fauna zone nine to ten of the Middle and Upper Ordovician conodont faunas in North America (Sweet, Ethington & Barnes 1971).

The form species *Microcoelodus asymmetr-*

icus and *Polycaulodus resupinatus* were first found together from the Middle Ordovician Joachim Limestone, and the former has also been reported as being in the Harding Formation (Sweet, 1955) and the Glenwood Formation (Webers, 1966) in North America, and also from the *Coleodus* & *Neocoelodus* zone of Siberian Platform (Moskalenko, 1970), all of which belong to the Middle Ordovician, generally equivalent to fossil zone seven to eight in the North American conodont fauna (Sweet & Bergström, 1976). The form species *Polycaulodus reversus* was also identified from the Harding Formation.

The form species *Oistodus breviconus*, and also the form species *Polycaulodus abortivus* were first known from the Middle Ordovician Plattin Formation which is approximately corresponds with the fossil zone seven to eight of the North American Middle and Upper Ordovician conodont fauna and the former has been reported further as being in the Amphyx Limestone and the Chasmops Series in Norway, which dates to the Caradocian of the Middle Ordovician (Hamar, 1966).

The form species *Oepikodus copenhagenensis* and *Panderodus? alabamensis* were first reported from the Copenhagen Formation. With these unique forms the well-known form species *Belodella erecta*, *Drepanodus homocurvatus*, *D. Suberectus*, *Oistodus forceps* and *O. inclinatus* are common species in the above-mentioned formation and the Yeongheung Formation. The middle member of the Copenhagen Formation was correlated with the upper Ashby and/or lower Porterfield of Middle Ordovician by Ethington and Schumacher (1969), and Bergström (1971) correlated the lower Porterfieldian with *Nemagraptus gracilis* zone of the graptolite

zation and upper part of the *Pygodus anserinus* zone of the North Atlantic conodont zonation respectively. Recently he (1976) made a stratigraphic correlation of these graptolite and conodont zones with the fossil zone six of the North American Mid-Continent fauna. The form species *Plectodina aculeata* which is also designated as a *Cordylodus*-like element of the multi-element species in the same name, has been found in many formations of the Middle Ordovician in North America, and Sweet *et al.* (1971) reported that the stratigraphic distribution of the multi-element-species *P. aculeata* including the *Cordylodus*-like element is limited in the fossil zone seven to eight of the North American section.

Recently one of the multi-element species *Plectodina*, which may be cospecific with the corresponding forms of the Yeongheung fauna, was identified from the upper part of the Womble Limestone, South Arkansas of North America (Repetski & Ethington 1977).

The multi-element species consists of five simple elements; Trichonodelliform, Zygonathiform, Cordylodiform, Eoligonodiform and Cyrtonodiform elements, and the first three of these were collected from the Yeongheung Formation. Besides this species the form species *Drepanodus suberectus*, *Oepikodus copenhagenensis*, *Oistodus forceps* and *Scolopodus giganteus* are commonly found in the Womble Limestone and the Yeongheung Formation. The conclusion of Repetski and Ethington (1977) based on their conodont study is that the upper part of the Womble Limestone is equivalent to the lower part of the type Porterfieldian Stage in Virginia. This indicates that the stratigraphic horizon is equivalent to the Copen-

hagen Formation.

The last of the above described species has been also found in the lower to middle Middle Ordovician.

The form species *Scandodus serratus* was known recently from several sedimentary horizons in the Siberian Platform which correlates in age to the Lower to Middle Caradocian of the Middle Ordovician according to Moskalenko (Moskalenko, 1973) and the unique form *Tricladiodus aurilobus* has been recovered only from Middle Ordovician in Korea since it was first reported as being found in the Mandal Formation, North Korea (Lee, 1975a).

Among the Yeongheung fauna only one form species, *Protopanderodus leonardi*, has been described from the Lower Ordovician. This species was identified from the San Juan Formation, Precordilleran Argentina, South America. This belongs to Arenigian of Lower Ordovician (Serpagli 1974), but the stratigraphic limitation of the species is not so clear yet.

On the basis of the multioccurrences of the above mentioned species it is certainly clear that the upper part of the Yeongheung Formation can be dated to the Middle Ordovician, suggesting a roughly equivalent age to the fossil zone six to seven of the Middle and Upper Ordovician conodont fauna in North America. This may be correlated with the Llandeilian to lower Caradocian in North-western Europe. The Yeongheung fauna seems to have a close kinship with the Copenhagen Formation in Central Nevada and the upper part of the Womble Limestone, South Arkansas in North America. The Yeongheung fauna has seven species in common with the Copenhagen Formation and five species in com-

mon with the Womble Formation.

The fauna of the Yeongheung Formation is also closely related to the upper part of the Maggol Formation and the Duwibong fauna. It has six species in common with the former and five in common with the latter.

Bioprovincial Interpretation

Through the highly concentrated Ordovician conodont studies undertaken during the last several decades it has been determined that the Ordovician conodont faunas are divided into two bioprovinces, that is, the North Atlantic-Appalachia fauna and the North American Mid-continent fauna,

subdividing the latter into two or three small subprovinces.

The Yeongheung conodont material like other Ordovician conodonts of previous works in Korea is not sufficient to make clear its bioprovincial affinity. But the conodont assemblage which is derived from the upper part of the Yeongheung Formation shows a close kinship with the North American Mid-continent fauna. The form genera *Bryantodina*, *Panderodus*, *Plectodina*, *Polycaulodus* and *Microcoelodus* have been chiefly reported from the Mid-continent of North America, whereas no typical species of the North Atlantic fauna have been found in this fauna.

Systematic Description

Genus *Acodus* Pander, 1856

Acodus? sp.

pl.1, fig.17.

Remarks: The single specimen at hand is similar to *Oistodus inclinatus* Branson & Mehl in morphology of the cusp which is stretched straight posteriorly. But the Yeongheung specimen has a distinct lateral

carina, so that it may be assigned to the form genus *Acodus*.

Occurrence: Yeongheung Formation (Sample No. 365)

Material: one (YSUG 00303)

Genus *Belodella* Ethington, 1959

Belodella erecta (Rhodes & Dinley, 1957)

pl.2, fig.9

1957 *Belodus erectus* Rhodes & Dinley, p.359, pl.38, fig.8.

1977 *Belodella erecta*-Lee, p.130, pl.2, fig.8 (non fig.9. further synonymy through 1977 are included).

1977 *Belodella erecta*-Barnes, pl.2, fig.7.

Remarks: According to Serpagli's description, the form species varies in configuration of the antero-lateral costae. In some specimens the costae are distinctly developed, whereas others do not have any such

costae. The single specimen at hand bears the latter's feature.

Occurrence: Yeongheung Formation (Sample No. 365)

Material: one (YSUG 00313)

***Belodella* nov. sp. Barnes, 1977**

pl.2, figs.1, 2

1973 *Belodella* nov. sp. Barnes, p.769—770, pl.4, figs.5,9,10,18,18a, text-fig.2F.

1977 *Belodella* nov. sp.-Barnes, pl.2, figs.5,6.

Remarks: The form species *Belodella* nov. sp. Barnes is characterized by faint, hair-like lines which runs inwards, perpendicular to the posterior margin at the point of maximum curvature and its main cusp can not be distinctly distinguished from the basal part. The specimens at hand agree

well with the form species in these features, so that the Yeongheung specimens may be assigned to the species.

Occurrence: Yeongheung Formation(Sample No. 365)

Material: 13

Figured specimens: YSUG 00306—00307

Genus *Bryantodina* Stauffer, 1935

***Bryantodina* cf. *staufferi* Bergström & Sweet, 1966**

pl.1, figs.9, 10, 13

1966 *Bryantodina?* *staufferi* Bergström & Sweet p.321—323, pl.34, figs.3,4 (non pl.33, figs.10,11, pl.34, figs.1,2).

Remarks: According to the original description of the multielement species *Bryantodina staufferi* it consists of *Bryantodina*-like and *Ozarkodina*-like elements. The *Bryantodina*-like elements are characterized by straight, unbowed anterior and posterior processes which are surmounted by laterally compressed, apically discrete, sharp-pointed denticles. The Yeongheung specimens at hand conform well to the type figure of the *Bryantodina*-like elements of the multielement species especially in the straight, unbowed anterior and posterior processes,

and the aboral sides of both processes are also excavated by a shallow groove with inconspicuously flaring walls as in the original specimens. But the denticle of the posterior process near the cusp is variable in size in the Korean specimens while the corresponding one is shortest in the original form.

Occurrence: Yeongheung Formation(Sample No. 365)

Material: 6

Figured specimens: YSUG 00295, 00296, 00297

Genus *Drepanodus* Pander, 1856

***Drepanodus homocurvatus* Lindström, 1955**

1933 *Oistodus curvatus* Branson & Mehl, p.110—111, pl.9, figs.4,10,12.

1955 *Drepanodus homocurvatus* Lindström, p.563, pl.2, figs.23,24,39.

1973 *Drepanodus homocurvatus*-Barnes, p.231.

1976 *Drepanodus homocurvatus*-Lee, p.164, pl.1, fig.10, tex-fig.2J, (further synonymie through 1976 are included)

1977 *Drepanoistodus suberectus*-Barnes, p.106, pl.3, fig.18 (non figs 19,20).

1975 *Drepanodus homocurvatus*-Suhm & Ethington, p.1132.

1978 *Drepanoistodus forceps*-Fahraeus & Nowlan, p.459, pl.1, figs.22,23 (non. fig.24,25).

Occurrence: Yeongheung Formation(Sample No. 365)

Materials: 9

***Drepanodus suberectus* (Branson & Mehl, 1933)**

- 1933 *Oistodus suberectus* Branson & Mehl, p.111, pl.9, fig.7.
- 1955 *Drepanodus suberectus*-Lindström, p.568, pl.2, figs.21,22.
- 1974 *Drepanodus* cf. *suberectus*-Barnes, p.227.
- 1975 *Drepanodus suberectus*-Lee, p.174, (further synonymie through 1975 are included).
- 1976 *Drepanodus suberectus*-Bergström & Carnes, p.48.
- 1976 *Drepanodus suberectus*-Lee, p.164.
- 1977 *Drepanodus suberectus*- Repetski & Ethington, p.99.
- 1977 *Drepanodus suberectus*-Barnes, p.106, pl.3, fig.19. (non figs. 18,20)
- 1978 *Drepanoistodus forceps*-Fahraeus & Nowlan, p.459, pl.1, fig.24, (non figs.22,23,25).

Occurrence: Yeongheung Formation(Sam- Materials: 3
ple No. 365)

Genus *Microcoelodus* Branson & Mehl, 1933

***Microcoelodus* cf. *asymmetricus* Branson & Mehl, 1933**

pl.2, fig.16

- 1933 *Microcoelodus asymmetricus* Branson & Mehl, p.91, pl.7, figs.5,10,11,14,15.
- 1943 *Microcoelodus asymmetricus*-Branson & Mehl, p.383, pl.64, figs.37,39,41,46.
- 1944 *Microcoelodus asymmetricus*-Branson, p.71, pl.10, figs.13,24,25,31,32.
- 1955 *Microcoelodus asymmetricus*-Sweet, p.243, pl.28, fig.4.
- 1966 *Microcoelodus asymmetricus*-Webers, p.65, pl.4. fig.10.
- 1970 *Microcoelodus asymmetricus*-Moskalenko, p.71, pl.12, figs.1,2.

Remarks: The single specimen at hand resembles the form species *Microcoelodus asymmetricus* Branson & Mehl in the arrangement of the lateral denticles. The original Joachim specimens have two or three discrete denticles on one side of the main denticle and none or one on the other side.

same pattern, that is, two small denticles on one side of the main denticle and one on the other side. The latter, however, does not have the tongue-like extension on one side.

Occurrence: Yeongheung Formation(Sam-
ple No. 365)

Material: One (YSUG: 00321)

The Yeongheung specimen also has the

Genus *Neoprioniodus* Rhodes & Müller, 1956

***Neoprioniodus* nov. sp.**

pl.2, fig.17

Description: Unit somewhat large, laterally compressed bar-like form. Cusp distinct, large and moderately recurved posteriorly. Anterior and posterior sides of cusp are rounded, and inner lateral face broadly convexed, while outer face is slightly

grooved longitudinally.

Anticusp slightly projected and broadly rounded at basal angle. Posterior process bears four denticles on its oral margin which are long, slender, recurved and discreted each other. The denticle posterior to main

cusps is smallest and the others decreasing gradually in size backwards.

Aboral side moderately arcuated and excavated equally through the unit.

Remarks: The specimen at hand is cha-

racterized by its recurved main cusp and the rounded basal angle of the anticusp.

Occurrence: Yeongheung Formation(Sample No. 365)

Material: one (YSUG: 00322)

Genus *Oepikodus* Lindström, 1955

***Oepikodus* cf. *copenhagenensis* Ethington & Schumacher, 1969**

pl.2, figs.5, 6

1969 *Oepikodus copenhagenensis* Ethington & Schumacher, p.465, pl.63, figs.5,9, text-fig.4L.

non 1969? *Oepikodus* aff. *O. copenhagenensis*- Ethington & Schumacher, p.465, pl.63, fig.14.

1977 *Oepikodus copenhagenensis*-Repetski & Ethington, tab. 2, pl.2, fig.22.

Remarks: The specimens at hand are closely related to the form species *Oepikodus copenhagenensis* Ethington & Schumacher from the Copenhagen Formation, North America. In the former the denticles on posterior oral margin gradually decrease backwards

in size, whereas in the Yeongheung specimens the corresponding denticles are more or less equal in size.

Occurrence: Yeongheung Formation(sample No. 365)

Material: 15

Figured specimens: YSUG0311—00312

Genus *Oistodus* Pander, 1856

***Oistodus* aff. *breviconus* Branson & Mehl, 1933**

pl.1, figs.1, 2

1933 *Oistodus breviconus* Branson & Mehl, p.109, pl.9, figs.13,14.

1953 *Oistodus breviconus*- Rhodes, p.294, pl.21, figs.95,96.

1964 *Oistodus breviconus*-Bergström, p.29—30.

1966 *Oistodus breviconus*-Hamar, p.63, pl.1, fig.19, text-fig.4, No.11.

Remarks: The form species *Oistodus breviconus* Branson & Mehl from the Plattin Formation, North America is characterized by the sharply reclined short cusp and the posteriorly expanded base. The specimens at hand may be compared with the species in these characteristics, but the aboral

margin of the Yeongheung specimens are more sinuated, so that it is highly convexed downwards.

Formation: Yeongheung Formation(Sample No. 365)

Material: 3

Figured specimens: YSUG 00287—00288

***Oistodus forceps* Lindström, 1955**

pl.1, figs.4, 5

1955 *Oistodus forceps* Lindström, p.574—576, pl.4, figs.9—13, text-fig.3M.

1957 *Oistodus forceps*-Lindström, p.164.

1957 *Oistodus forceps*-Lamont & Lindström, p.62.

1960 *Oistodus forceps*-Lindström, p.90,91,92, figs.2—6,3—9,4—13.

1961 *Oistodus forceps*-Wolska, p.351. pl.3, figs.5,6. pl.168, figs.14,15, test-fig.2DE.

- 1962 *Oistodus forceps*-Sweet & Bergström, p.1231—1232.
 1965 *Oistodus forceps*-Barnett, p.71, pl.1, fig.7.
 1965 *Oistodus forceps*-Ethington & Clark, p.194—195, pl.1, fig.18.
 1966 *Oistodus forceps*-Fahraeus, p.23, pl.3, figs.1a-c, text fig.2h.
 1967 *Oistodus forceps*-Moskalenko, p.109—110, pl.24, fig.1.
 1968 *Oistodus forceps*-Viira, p.119.
 1968 *Oistodus forceps*-Mound, p.413, pl.3, fig.19—23.
 1969 *Oistodus forceps*-Ethington & Schumacher, p.466, pl.68, fig.16,
 1970 *Oistodus forceps*-Fahraeus, fig.2.
 1971 *Oistodus forceps*-Ethington & Clark, p.67, pl.2, fig.8.
 1971 *Oistodus forceps*-Bednarzyk, pl.1, fig.5.
 1971 *Drepanoistodus forceps*-Lindström, p.42, fig.8, (non Drepanoidiform element)
 1972 *Drepanoistodus* cf. *forceps*-Bergström, Epstein & Epstein, p.38, fig.3.
 1973 *Oistodus forceps*-Moskalenko, pl.25, fig.9.
 1974 *Oistodus forceps*-Viira, pl.4, figs.1, 5—7, 11—14, 17.
 1974 *Drepanoistodus forceps*-Serpagli, p.46, pl.10, fig.8 abc (non figs.9—12)
 1977 *Oistodus forceps*-Repetski & Ethington, tab.2.
 1978 *Drepanoistodus forceps*-Fahraeus & Nowlan, p.459, pl.1, fig.25 (non figs. 22, 23 and 24).

Remarks: The specimens at hand conform to the type figure and the original description of the species which was first described from the Ordovician of South-central Sweden (Lindström)
 Occurrence: Yeongheung Formation (Sample No. 365)
 Material: 8
 Figured specimens: 00290—00291

***Oistodus inclinatus* Branson & Mehl, 1933**

pl.1, fig.3

- 1933 *Oistodus inclinatus* Branson & Mehl, p.110, pl.9, fig.8.
 1974 *Oistodus* cf. *inclinatus*-Barnes, p.227.
 1975 *Oistodus inclinatus*-Lee, p.175—176, pl.2, figs.10, 11m (further synonymie through 1975 are included).
 1976 *Oistodus inclinatus*-Lee, p.170, pl.2, fig.17.
 1977 *Drepanoistodus suberectus*-Barnes, p.106, pl.3, fig.20 (non figs, 18—19).

Remarks: The specimens at hand agree well with the type figure and the original description of the species which was first described from the Plattin Formation, North America (Branson & Mehl, 1933).
 Occurrence: Yeongheung Formation (Sample No. 365)
 Material: 4
 Figured specimen: YSUG00289

Genus *Panderodus* Ethington, 1959

***Panderodus? alabamensis* (Sweet & Bergström. 1962)**

pl.1, fig.8

- 1962 *Belodina alabamensis* Sweet & Bergström, p.1223—1224, pl.170, figs.10, 11.
 1969 *Panderodus* (?) *alabamensis*-Ethington & Schumacher, p.469, pl.69, fig.8.
 1976 *Panderodus alabamensis*-Bergström & Carnes, p.48.

Remarks: Although the Yeongheung specimens were partially broken, they could be assigned to the form-species *Panderodus alabamensis* (Sweet & Bergström) through their characteristic features. As indicated by Ethington & Schumacher, (1969) they

have the *Panderodus*-like configuration with the exception of the weakly denticulated posterior margin.

Occurrence: Yeongheung Formation(Sample No. 365)

Material: 2

Figured specimen: 00294

***Panderodus compressus* Branson & Mehl, 1933**

1933 *Paltodus compressus* Branson & Mehl, p.109, pl.8, fig.19.

1959 *Panderodus compressus*-Ethington, p 284, pl.39, fig.4.

1975a *Panderodus compressus*-Lee, p.177—178, pl.1, fig.13, (further synonymies through 1975 are included)

1977 *Panderodus compressus*-Lee, p.137.

Occurrence: Yeongheung Formation(Sample No. 365)

Materials: 3

***Panderodus striatus* Stauffer, 1935**

pl.1, fig.11

1935 *Paltodus striatus* Stauffer, p.613, pl.74, fig.3,16.

1975a *Panderodus striatus*-Lee, p.178, pl.1, fig.4, (further synonymy through 1975 are included).

1977 *Panderodus striatus*-Lee, p.138.

Occurrence: Yeongheung Formation(Sample No. 365)

Material: 15

Figured specimen: 00298

Genus *Plectodina* Stauffer, 1935

***Plectodina aculeata* (Stauffer, 1930)**

pl.2, figs.10, 11.

1930 *Prioniodus aculeatus* Stauffer, p.126, pl.10, fig.12.

1932 *Prioniodus aculeatus*-Stauffer, p.258—259, pl.40, fig.2.

1935 *Plectodina dilata*-Stauffer, p.152, pl.11, figs.43,47.

1935 *Prioniodus cristulus*-Stauffer, p.616, pl.73, figs. 48,49,57,58.

1935 *Plectodina dilata*-Stauffer, p.613, pl.73, fig.51.

1966 *Plectodina aculeata*-Bergström & Sweet, p.373—377, p.32, fig.15,16 (non pl.33, figs.22,23, pl. 34, figs.5,6, text-fig.9 A-F).

1966 *Cordylodus aculeatus*-Webers, p.61, pl.8, fig.13,14, pl.9, fig.4,6.

1968 *Cordylodus aculeatus*-Kohut, p.397.

1971 *Plectodina aculeata*-Sweet & Ethington & Barnes, p.67, pl.2, fig.14 (non figs. 12,13).

1971 *Plectodina aculeata*-Atkinson, p.28,29,30,31,32,33, pl.2, fig.6 (non figs.4,5,8).

1971 *Plectodina aculeata*-Clark & Babcock, p.37.

1974 *Plectodina aculeata*-Barnes, p.231.

1976 *Plectodina aculeata*-Sweet & Bergström, p.127.

non1977 *Plectodina aculeata*-Barnes, p.107, pl.4, figs.19,23.

Remarks: The specimens at hand conform well with the type figure and the original description of the species from the Decorah shale (Stauffer 11930).

Occurrence: Yeongheug Formation (Sample No. 365)

Material: 4

Figured specimen: 00314, 00315

***Plectodina* sp. Repetski & Ethington**

pl. 2, figs. 4, 7, 8

1977 *Plectodina* sp. Repetski & Ethington, p.100, pl.2, fig.14, 16, 17.

Remarks: The Yeongheung specimens at hand, although not well preserved, conform in general morphology to the multielement species *Plectodina* sp. which was described by Repetski & Ethington (1977) from the upper part of the Womble shale, Ouachita Mountains, Arkansas in North America. The North American form consists of four elements, Trichonodelliform, Zygognathiform-, Cordylodiform-, Eoligonodiform- and

Cyrtoniodiform-element, of which the first three elements were collected from the Yeongheung Formation.

Occurrence: The Yeongheung Formation (Sample No. 365)

Material: Cordylodiform element 1 (YSUG 00309)

Trichonodelliform element 7 (Figured specimen: 00308)

Zygognathiform element 1 (YSUG: 00310)

Genus *Polycaulodus* Branson & Mehl, 1933

***Polycaulodus abortivus* Branson & Mehl**

pl.1, figs.12, 15

1933 *Polycaulodus abortivus* Branson & Mehl, p.106 pl.8, fig.29.

1970 *Polycaulodus bidentatus*-Moskalenko, p.82, pl.11, fig.1.

Remarks: The specimens at hand are assigned to the species *P. abortivus* Branson & Mehl by their subequal size of the two short denticles with circular cross sections. The specimens from Siberian Platform (Moskalenko, 1970) may be cospecific with *P. abortivus*. The form species *P. bidentatus*,

which also bears two denticles on the oral side, is distinguished from the above-described species through the unequal size of the denticles.

Occurrence: Yeongheung Formation (Sample No. 365)

Material: 3

Figured specimens: 00299, 00300

***Polycaulodus resupinatus* Branson & Mehl, 1933**

pl.1, fig.16

1933 *Polycaulodus resupinatus* Branson & Mehl, p.86-87, pl.6, fig.18.

1976 *Polycaulodus resupinatus*-Lee, p.170, pl.2, fig.17, (further synonymies though 1976 are included).

1977 *Polycaulodus resupinatus*-Lee, p.140, pl.2, fig.14.

Remarks: The specimens at hand agree with the type figure and the original description in general morphology. The anterior denticle of the Yeongheung specimens

is larger than that of the original form and the aboral side somewhat arcuated but these features may fall within the variation range of the species.

Occurrence: Yeongheung Formation(Sam-
ple No. 365)

Materials: 2
Figured specimen: 00302

Polycaulodus cf. reversus Sweet, 1955

pl. 1, figs. 18, 19

1955 *Polycaulodus reversus* Sweet, p.251, pl.28, fig.26.

1965 *Polycaulodus reversus*-Mound, p.31, pl.4, fig.16.

Remarks: The form species *Polycaulodus reversus* Sweet is characterized by three large discrete denticles which decrease gradually in size in the direction of the curvature. The specimens at hand may be compared to the original form in this feature, although the anterior denticle of the specimen in fig. 18, pl.1 is somewhat smaller than the second one. In the speci-

men illustrated in fig.18, pl.1 a node like denticle is present at the anterior end as in the original form. The specimen from the Joins Formation (Mound, 1965) may not be conspecific with this form species.

Occurrence: Yeongheung Formation(Sam-
ple No. 365)

Material: 2

Figured specimens: 00304, 00323

Genus *Prioniodina* Bassler, 1925

Prioniodina sp. A

pl. 1, fig. 20

Description: Unit nearly straight with large main cusp, which is moderately compressed laterally with sharp anterior and rounded posterior edges, showing an asymmetrical cross section.

Anterior and posterior processes are broken. The remaining denticles are slender, slightly compressed laterally, and decrease rapidly in size towards the extremities.

Base slightly excavated under main cusp and grooved slightly through out the pro-

cesses.

Remarks: The specimens at hand are poorly preserved. Therefore it is not possible to assign them to a distinct specific level. They are, however, very similar to *P. macrodentata*, which was described from the Fort Pena Formation (Graves & Ellison, 1941).

Occurrence: Yeongheung Formation(Sam-
ple No. 365)

Materials: 3

Figured specimen: 00305

Prioniodina sp. B

pl.2, figs.14, 18

Description: Main cusp larger than the other denticles, slightly recurved and broadly rounded in cross section with blunt or sharp anterior and posterior edges. Anterior process shorter than posterior one, slightly arched downwards and flexed laterally with two or three peg-like denticles on oral side

which decrease rapidly forwards in size. Posterior process relatively long, laterally compressed and nearly straight or slightly arched in aboral margin with four or five peg-like denticles on oral side, which are inclined backwards with somewhat equal size. Aboral margin slightly excavated

under main cusp and grooved through both extremities.

Remarks: The specimens at hand are characterized by the short anterior process with two or three peg-like denticles and the posterior one, on which nearly equal-sized four or five denticles are arranged.

The unit which is illustrated in fig.18,

pl.2, is similar to the genus *Ligonodina*, but the anterior process of the former is not so distinctly curved laterally as the latter's.

Occurrence: Yeongheung Formation (Sample No. 365)

Materials: 2 (YSUG 00319, 00320)

Genus *Protopanderodus* Lindström, 1971

***Protopanderodus* cf. *leonardi* Serpagli, 1974**

pl.2, fig.13

1965 *Scandodus?* n.sp.1 Ethington & Clark, p.119, pl.1, fig.6.

1974 *Protopanderodus leonardi* Serpagli, p.77, pl.16, figs.1a-4c pl.27, figs. 12-16, text-fig.18.

Remarks: The specimens at hand may be compared in general morphology with *Protopanderodus leonardi* which was described by Serpagli (1974) from the lower Ordovician Sanjuan Formation in South America. The species is characterized by the unexpanded base and strongly proclined cusp. The Yeongheung specimen is distin-

guishable, however, from the original form through the lateral costae which are asymmetrically situated. The corresponding ones are situated nearly symmetrically in the latter's form.

Occurrence: Yeongheung Formation (Sample No. 365)

Material: one (YSUG 00318)

***Protopanderodus* nov. sp. Barnes & Poplawski, 1973**

pl.1, fig.14

1973 *Protopanderodus* nov. sp. Barnes & Poplawski, p.784-785, pl.2, figs.5,6,6a, 12,12a, pl.3, fig.10, text-fig.2 CD.

Remarks: Barnes and Poplawski (1973), who found the species from the Mystic Formation, Quebec, Canada, recognized a morphological variety of the species, probably representing transitional series. The single specimen at hand agrees well with symmetrical acantiodiform element of

the original descriptions and illustrations. In the Yeongheung form, however, no longitudinal microstriae were found.

Occurrence: Yeongheung Formation (Sample No. 365)

Material: one (YSUG 00301)

Genus *Roundya* Hass, 1953

***Roundya* nov. sp.**

pl.2, figs.12,15

Description: Cusp stout, large and nearly erect or slightly reclined with sharp anterior and posterior edges. Lateral sides

highly compressed, so that the cross section shows lens-shape. A sharp costa runs longitudinally along the middle part of each

lateral side and it makes a small lateral denticle on base. Base slightly expanded posteriorly with a small posterior denticle on its sharp oral margin. A distinct anterobasal angle is projected in one of illustrated specimens(pl.2, fig.12). Basal cavity moderately deep.

Remarks: The form-species is character-

ized by a large main cusp and three small denticles, each of which is present on both lateral sides and the posterior oral margin of the base.

Occurrence: Yeongheung Formation(Sample No. 365)

Material: 3

Figured specimens: YSUG 00316, 00317

Genus *Scandodus* Lindström, 1955

***Scandodus cf. serratus* Moskalenko, 1955**

pl.2, fig.3

1973 *Scandodus serratus* Moskalenko, p.41—42, pl.3, fig.4—7.

Remarks: The form species *Scandodus serratus* is characterized by the indentation of the anterior margin of cusp. The single specimen at hand may be compared with the above described species in this feature. The latter is distinguished, however, from the former through its general morphology.

The Yeongheung specimen is somewhat stumpy, whereas the Siberian form is more slender.

Occurrence: Yeongheung Formation(Sample No. 365)

Material: one. (YSUG 00307)

Genus *Scolopodus* Pander, 1856

***Scolopodus giganteus* Sweet & Bergström, 1962**

1962 *Scolopodus giganteus* Sweet & Bergström, p.1247, pl.169, fig.14, text-fig.1.J.

1976 *Scolopodus giganteus*-Lee, p.173, pl.1, figs.16,17, text-fig.2L.(further synonymies are included).

Occurrence: Yeongheung Formation(Sample No. 656)

Material: 2

Genus *Tricladiodus* Mound, 1965

***Tricladiodus? aurilobus* Lee, 1975**

1975 *Tricladiodus? aurilobus* Lee, p.181, pl.2, fig.14,15,16.

1976 *Tricladiodus? aurilobus*-Lee, p.174.

1977 *Tricladiodus? aurilobus*-Lee, p.141, pl.2, fig.14, pl.3, fig.5.

Occurrence: Yeongheung Formation(Sample No. 365)

Material: one.

New Form A.

pl.1, fig.7

Description: Cusp upright with pointed apex. Anterior side broadly rounded and bounded by sharp costae on both lateral

sides. Posterior side is flat with a sharp, highly projected carina which runs along the mid-portion, narrowing gradually towa-

rds apex. Base is broken.

Remarks: The specimen at hand is distinguished from all other described species through the unique morphological feature, which looks like a boat-shape from the

posterial view.

Occurrence: Yeongheung Formation(Sample No. 365)

Material: one. (YSUG 00293)

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Explanation of plate 1

All figures x 60, unless otherwise indicated.

- Figs. 1—2. *Oistodus* aff. *breviconus* Branson & Mehl, Lateral sides, YSUG 00287—00288, Sample No.365, The Yeongheung Formation, The road side, 2.0km northeast from Machari (Machari-Jeongseon traffic road).
- Fig. 3. *Oistodus inclinatus* Branson & Mehl, Lateral side, YSUG 00289, Sample No. 365, and locality; The same as fig.1.
- Figs. 4—5. *Oistodus forceps* Lindström, Lateral side, YSUG 00290—00291, Sample No.365, Formation and locality; The same as fig.1.
- Fig. 6. *Belodella* nov. sp. Barnes & Poplawski, Lateral side, YSUG 00292, Sample No. 365, Formation and locality; The same as fig.1.
- Fig. 7. New form. Posterior side, YSUG. 00293, Sample No. 365. Formation and locality; The same as fig.1.
- Fig. 8. *Panderous*(?) *alabamesis* Ethington & Schumacher, Lateral sides, YSUG 00294, Sample No.365, Formation and locality; The same as fig.1.
- Figs.9-10,13 *Bryantodina* cf. *staufferi* Bergström & Sweet, Lateral sides, YSUG 00295, 00296, 00297, Sample No. 365, Formation and Locality; The same as fig.1.
- Fig. 11. *Panderodus striatus* Stauffer, Lateral side, YSUG 00298, Sample No.365, Formation and locality; The same as fig.1.
- Figs. 12,15. *Polycaulodus abortivus* Branson & Mehl, Lateral sides, YSUG 00299—00300, Sample No. 365, Formation and locality; The same as fig.1.
- Fig. 14. *Protopanderodus* nov. sp, Barnes & Poplawski, Lateral side, YSUG. 00301, Sample No. 365, Formation and locality; The same as fig.1.
- Fig. 16. *Polycaulodus resupinatus* Branson & Mehl, Lateral side, YSUG 00302, Sample No. 365, Formation and locality; The same as fig.1.
- Fig. 17. *Acodus*? sp. Lateral side. YSUG 00303, Sample No. 365, Formation and locality; The same as fig.1.
- Figs. 18-19. *Polycaulodus* cf. *reversus* Branson & Mehl, Lateral side, YSUG 00304,00323, Sample No. 365, Formation and locality; The same as fig.1.
- Fig. 20. *Prionodina* sp. A. Lateral side, YSUG 00305, Sample No.365, Formation and locality; The same as fig.1.

Explanation of Plate 2

All figures x 80, unless otherwise indicated.

- Figs. 1—2. *Belodella* nov. sp. Barnes Lateral sides, YSUG 00306—00307, Sample No. 365, The Yeongheung Formation, The road side, 2.0Km northeast from Machari (Machari-Jeongseon traffic road).
- Fig. 3. *Scandodus* cf. *serratus* Moskalenko, Lateral side, YSUG 00307, Sample No.365, Formation and locality; The same as fig.1.
- Figs. 4,7,8. *Plectodina* sp. trichonodelliform (posterior side) cordylodiform (lateral side) and zygonathiform (posterior side) elements respectively. YSUG: 00308, 00309, 00310, Sample No.365, Formation and locality; The same as fig.1.
- Fig. 9. *Belodella erecta* (Rhodes & Dinley), Lateral side, YSUG 00313 Sample No. 365, Formation and locality; The same as fig.1.
- Figs. 5—6, *Oepikodus* cf. *copenhagenensis* Ethington & Schumacher, Lateral sides, YSUG 00311, 00312, Sample No.365, Formation and locality; The same as fig.1.
- Figs. 10-11. *Plectodina aculeata* (Stauffer), Lateral sides, YSUG 00314, 00315, Sample No. 365, Formation and locality; The same as fig.1.
- Figs. 12,15. *Roundya* nov. sp., Lateral sides, YSUG 00316, 00317, Sample No.365, Formation and locality; The same as fig.1.
- Fig. 13. *Protopanderodus leonardi* Serpagi, Lateral side, YSUG 00318, Sample No.365, Formation and locality; The same as fig.1.
- Figs. 14,18. *Prioniodina* sp. B, Lateral side, YSUG 00319, 00320, Sample No. 365, Formation and locality; The same as fig.1.
- Fig. 16. *Microcoelodus* cf. *asymmetricus* Branson & Mehl, Posterior side, YSUG 00321, Sample No. 365, Formation; The same as fig.1,
- Fig. 17. *Neoprioniodus* nov. sp., Lateral side, YSUG 00322, Sample No. 365, Formation and locality: The same as fig.1.

