J.Paleont.Soc.Korea.V.15,No.1,(1999):pp.21 ~ 42

CONODONTS FROM THE MUNGOG FORMATION (LOWER ORDOVICIAN), YEONGWEOL

Byung-Su LEE* and Jong-Deock LEE*
*Department of Earth and Environmental Science, Chonbuk National University, Chonju.

Abstract : Three sections (Golmacha, Seonghwangchon, and Mohari sections) of the Mungog Formation, Yeongweol, are examined for conodont biostratigraphy. Assemblage zone 1 (= *Semiacontiodus nogamii* - *Cordylodus lindstroemi* - *Utahconus beimadaoensis* Zone), Assemblage Zone 2 (=*Rossodus manitouensis* - *Chosonodina herfurthi* Zone), Assemblage Zone 3 (=*Scolopodus quadraplicatus* - *Paroistodus proteus* - *Drepanoistodus forceps* Zone), and Assemblage Zone 4 (=*Paracordylodus gracilis* Zone) are tentatively established within the formation. The preliminary data on correlation of these zones are briefly summerized. The Cambrian - Ordovician boundary in the Yeongweol area is probably present within beds immediately below Assemblage Zone 1, near the base of the Mungog Formation.

INTRODUCTION

The Mungog Formation, composed mainly of diverse lithotypes of limestone, calcareous or non-calcareous shale and dolostone, was first established by Yosimura (1940), as one of five stratigraphic subdivisions of the Yeongweol-type Choseon Supergroup. Also, Yosimura (1940) reported some macroinvertebrate fossils from the formation, including brachiopod and trilobites, which were later systematically described and illustrated by Kobayashi (1953, 1960, 1966). Shortly after, Kobayashi and Kimura (1942) reported a few graptolite fossils from the formation.

In recent years, very important paleontological studies of the Mungog Formation are added, including conodonts (Won and Lee, 1977; Choi, 1993), problematic fossil *Sphenothallus* (Kim *et al.*, 1990), and trilobite (Park *et al.*, 1994; Kim and Choi, 1995) studies. Also, recent publications regarding sedimentological studies (Paik and Lee, 1989; Woo *et al.*, 1990; Paik *et al.*, 1991; Choi *et al.*, 1993 and Park *et al.*, 1994) discussed the depositional environment of the formation, ranging from subtidal to supratidal facies of shallow shelf environment.

Some discrepancies on the age determination of the Mungog Formation, are noted among the previous workers listed above, concerning both lower and upper limits, or one of them. On the other hand, the lowest conodont occurrence of the formation is closely related to the Cambrian-Ordovician boundary problem, because of the lack of any fossil present in underlying Wagog Formation which has been interpreted as a unit spanning the boundary (Choi *et al.*, 1996), although the traditional boundary has been drawn between the Wagog and Mungog formations (Kobayashi, 1966; Lee, 1987).

Of two conodont biostratigraphic studies hitherto carried out on the Mungog Formation, the first one of Won and Lee (1977) was very limited both in lateral and vertical spacing in scope, and the second one of Choi (1993) employed uncertain lithostratigraphic and biostratigraphic data.

This study was intended to describe the conodont fauna of the Mungog Formation, Yeongweol, to erect biostratigraphic zonal schemes, to correlate them with coeval ones of other parts of the world, and to discuss on the Cambrian-Ordovician boundary in this area, based on diverse and abundant conodont collections.

Senior author has already been collected a lot of conodont specimens from the lower part of the Mungog Formation at Mohari and Golmacha areas, Yeongweol, in the course of conodont study on adjacent Machari Formation (Lee *et al.*, 1991). Supplementary limestone samples were collected chiefly at three sites in 1997 and 1998; Mohari, Seonghwangchon and Golmacha areas.

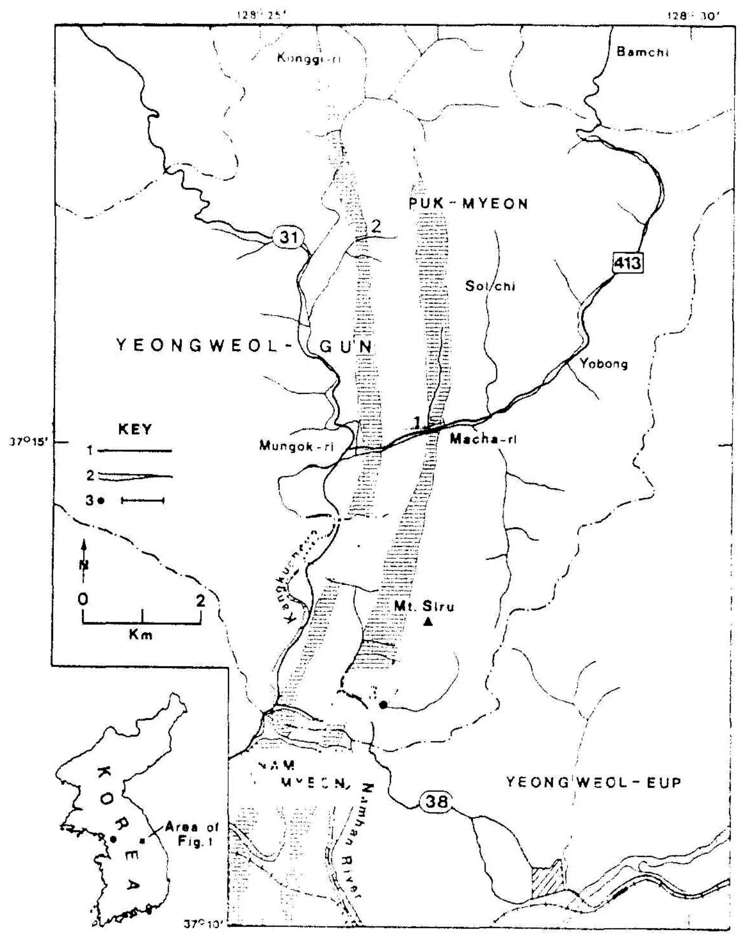


Figure 1. Distribution of the Mungog Formation examined in this study, northwestern Yeongweol area. Explanation to key; 1. National and provincial roads, 2. River and stream lines, and 3. Measured sections. Sectional localities are; 1. Golmacha, 2. Seonghwangchon, and 3. Mohari sections.

All conodont data are deposited at Department of Earth Environmental Science, Chonbuk National University, Chonju.

PREVIOUS WORKS

The Yeongweol-type Choseon Supergroup of Cambro-Ordovician was first surveyed, mapped, and classified into five lithostratigraphic units, i.e. Sambangsan, Machari, Wagog, Mungog and Yeongheung formations in ascending order, and the Mungog Formation was further subdivided into three parts at west part of Mt. Siru, a type locality of the formation (Yosimura, 1940).

Kobayashi (1966) modified this subdivision and added some new stratigraphic data. Recently, Park *et al.* (1994) erected four informal members in the formation based on some important lithofacies such as ribbon rock, dolostone, shale and flat-pebble conglomerate etc., including basal (ribbon rock + dolostone, 50±m), lower (dolostone, 30~35±m), middle (ribbon rock + flat-pebble conglomerate, 30~60±m) and upper (shale + ribbon rock + dolostone, 50~60±m) members.

Yosimura's (1940) fossil collection is systematically described by Kobayashi (1953, 1960), who correlated the Mungog Formation with the Dongjeom Quartzite through the Dumugol Shale to the lower part of the Maggol Limestone of the Duwibong-type Choseon Supergroup, ranging from Tremadocian to Arenigian in age, based on macroinvertebrate fossils. Kobayashi and Kimura (1942) found a few graptolite species, i.e. *Dictyonema* cf. *flabelliforme* and *Clonograptus*(?) sp., from the formation indicating Early Ordovician in age.

Recently, three Tremadocian trilobite assemblage zones were recognized within the Mungog Formation by Park *et al.*(1994), and Kim and Choi(1995), based on biostratigraphically useful taxa, such as *Yosimuraspis, Jujuyaspis, Pseudokainella* (basal), *Kainella* sp. cf. *K. euryrachis* (middle), *Micragnostus coreanicus, Shumardia pellizzarii, Apatokephalus hyotan, Hystricurus megalops, Dikelokephalina asiatica, Asapellus* sp., and *Koraispis spinus* (upper) etc. These trilobite-based age determinations are somewhat different from conodont-based results mentioned below.

Won and Lee (1977) studied conodont fauna of 34 species belonging to 11 genera from the Mungog Formation at two localities, and suggested that the formation could be correlated with the late Tremadocian to early Arenigian. Similarly, Choi (1993) correlated his five Mungog conodont zones with relevant zonal schemes of late Tremadocian to early Arenigian.

Meanwhile, Choi *et al.* (1996) reviewed the Cambrian-Ordovician boudaries in the Taebaegsan region, based primarily on trilobite and conodont data. They regarded the boundary of the Yeongweol-type sequence as a horizon below the base of the Mungog Formation, that is, within the uppermost part of the Wagog Formation.

THE MUNGOG FORMATION

The Mungog Formation (Yosimura, 1940), a Lower Ordovician strata of the Yeongweol- type Choseon Supergroup, is well exposed at northwestern part of Yeongweol-eup and Puk-myeon, Yeongweol-gun, Kangweon province(Fig. 1). In this study, three sectional areas were systematically examined, and lithologic details of each area are summerized in Figs. 2, 3, and 4.

The Mungog Formation consists mainly of several lithologies, including ribbon rocks of diverse patterns, such as straight or planar, nodular, and flaser or wavy bedded ones, intraclastic grainstone to packstone (=flat-pebble conglomerate), peloidal-oolitic-bioclastic grainstone to packstone (dolomitic limestone) and marlstone or shale, as noted by Choi *et al.* (1993), and Paik *et al.* (1991). According to this lithologic association, the formation is subdivided into four members, which are essentially identical to those of Park *et al.*(1994).

Both lower and uppermost beds (members 1, 2, and upper part of 4 of park *et. al,* 1994) are mostly dolomitized, upper beds (member 3) contain frequent intercalations of flat-pebble conglomerates, and also, uppermost beds (member 4) are characterized by the domination of marlstone to shale.

The basal member, less than 35m in thickness, comprises ribbon rocks, thin (<25 cm in thickness) flat-pebble conglomerate, and massive dolomitic limestone. Particularly, dolomitic limestones always

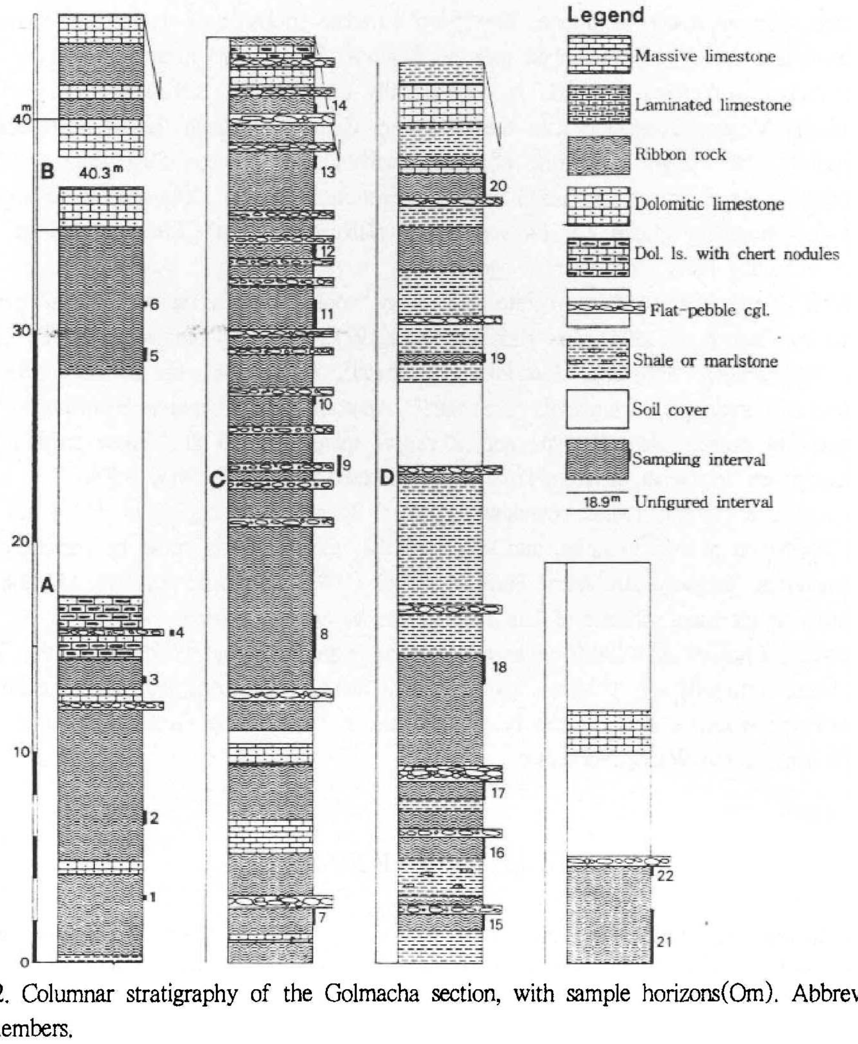


Figure 2. Columnar stratigraphy of the Golmacha section, with sample horizons(Om). Abbreviation : A-D=members.

contain dark, elongated chert nodules which are subparallel to bedding. These are useful to stratigraphic recognition and correlation in the field.

The lower member entirely consists of grey, very thick (40~50 m), poorly bedded dolomitic limestones. In this interval, no other lithologies are not intercalated The middle member, 45~50 m thick, is characterized by an alternation of ribbon rocks and flat-pebble conglomerates, with occasional interbeds of bedded dolomitic limestones containing sparse chert nodules. The upper member, 50~60 m thick, also composed of ribbon rock, greenish grey shale, flat-pebble conglomerate, and dolomitic limestone, which grade into thick-bedded, tabular dolostones of the Yeongheung Formation, the top unit of the Yeongweol-type Choseon Supergroup.

MEASURED SECTIONS

The Mungog Formation in three sites was measured and sampled, that is Golmacha,

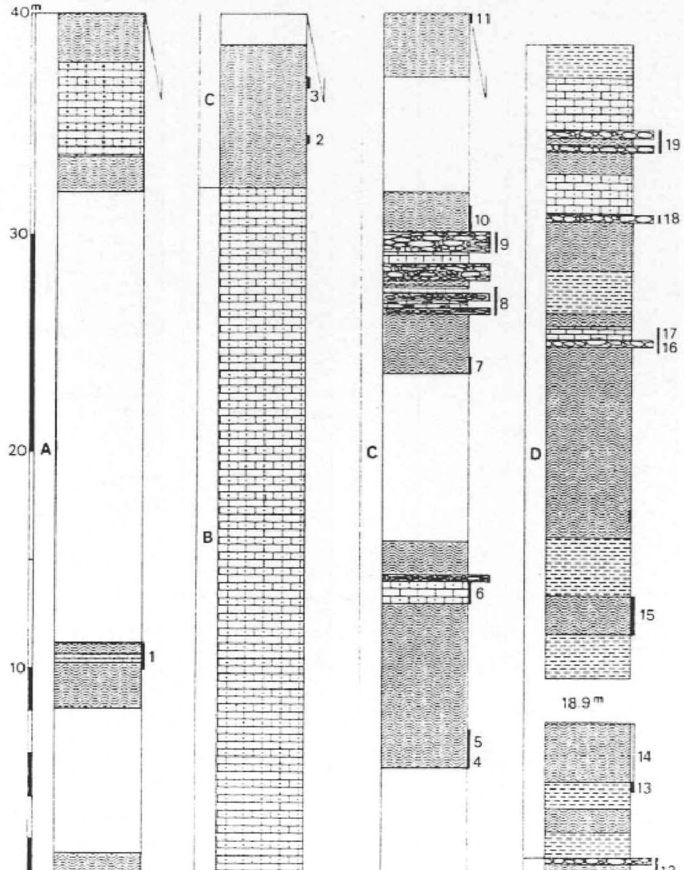


Figure 3. Columnar stratigraphy of the Seonghwangchon section, with sample horizons(Sh). Explanation of legend refers to Fig. 2. Abbreviation : A-D=members.

Seonghwangchon, and Mohari sections. The Golmacha section is well exposed at road side of provincial route 413, northern part between Macha Middle School and entrance of Golmacha village, Machari, Puk-myeon. The Seonghwangchon section is located near Araegol water reservoir, Yeondeogni, Puk-myeon. The Mohari section indicates two intervals 1) along national route 38, near entrance of Dumog village, and 2) a short section structurally controlled within the village, Yeongweol-eup. Location of each section is represented on Fig. 1, and lithologic details with sampling horizons are illustrated in Fig. 2 (Golmacha), 3 (Seonghwangchon), and 4 (Mohari).

Although vertical lithologic variation is not so great between three sections, Golmacha section has the best exposure among them, so we explain the section below. Sixty limestone samples for conodont study were collected at three sections; twenty-two at Golmacha section, 19 at Seonghwangchon section, and 19 at Mohari sections, respectively.

Full length of Golmacha setion measures more than 184m (member 1 = 33.1m, member 2 =

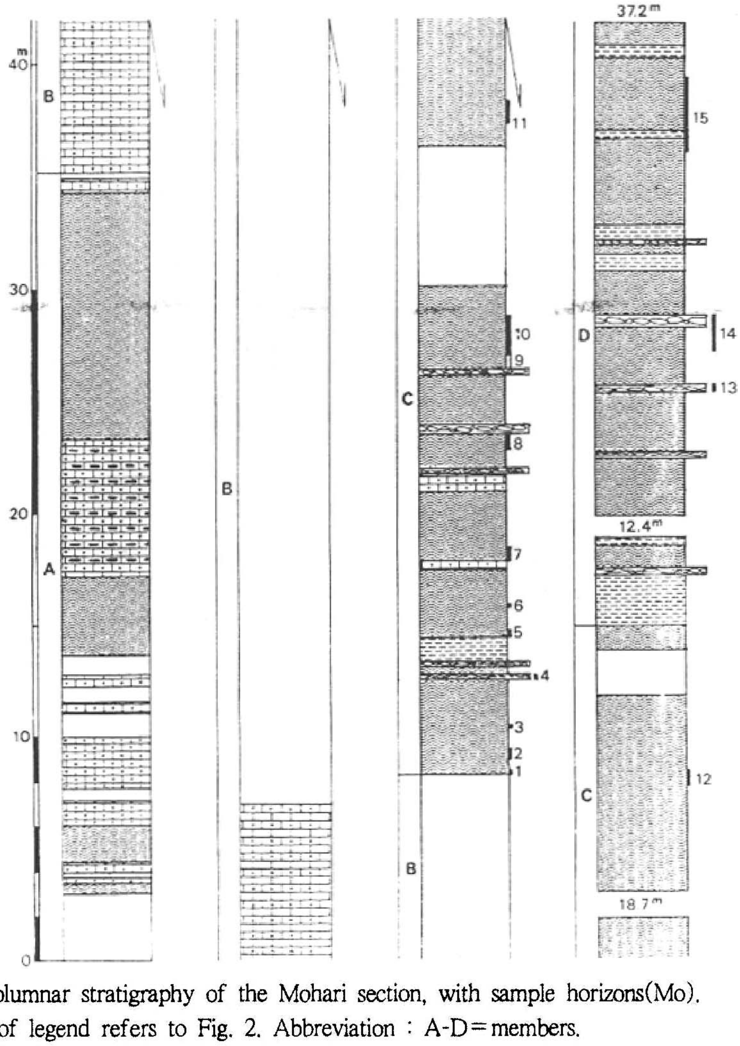


Figure 4. Columnar stratigraphy of the Mohari section, with sample horizons(Mo). Explanation of legend refers to Fig. 2. Abbreviation : A-D=members.

43.9m, member 3 = 49.2m, and member 4 = 58.0 m) Member 1 starts with shale bed, about 20cm thick, rested directly on dark, thick, massive dolostone bed of underlying Wagog Formation, and most of overlying interval consists of thick, dolomitic ribbon rocks of various patterns, except two, thin flat-pebble conglomerate, and also two dolomitic limestone beds with chert nodules (2.8m thick), respectively, in middle part. Five horizons of ribbon rocks and one flat-pebble conglomerate bed are sampled within member 1.

Member 2 is composed exclusively of very thick, poorly bedded or weakly bedded dolomitic limestones, which are underlain and overlain by ribbon rocks of members 1 and 3, respectively. No samples were collected at this interval for conodont biostratigraphic study.

In member 3, dolomitic limestones are presented at lower part, whereas dominant are large amount of ribbon rock with frequent intercalation of flat-pebble conglomerates at upper part. A few beds of flat-pebble conglomerates interbedded in this unit are exceptionally thick bedded (>80cm), although they are about 20±cm in average thickness. Moreover, twenty beds, at least, are intercalated within the member in Golmacha section. These two important keys, namely thickness and frequency of inRercalation of the rocktype, distinguish member 3 from other ones. A dolomitic grainstone bed, about 50cm thick, with chert nodules is included near top of the member. This bed is thin and light-colored, and chert nodules are of low density. Eight samples were collected at beds of ribbon rocks, and flat-pebble conglomerates.

The base of member 4 is recognized by the lU est occurrence of marlstone to shale. Other constituents of the member are ribbon rock, flat-pebble conglomerate, dolomitic limestone, and massive limestone. Dolomitic limestone becomes predominant in upper part. Flat-pebble conglomerates are interbedded within eight horizons. Eight samples were all collected from ribbon rock beds of member 4 for conodont study. Unfortunately, uppermost about 15m interval of the member was not sampled, owing to lack of outcrops or of pure limestones.

CONODONT OCCURRENCE

From three full sections and one short interval, sixty-two limestone samples were collected for conodont biostratigraphic study, using serial sampling method. Detailed sampling localities are shown in Fig. 1, and are described in the preceding section. Each sample varied from 4.0 kg in a sample up to approximately 8.0 kg. All samples were weighed, crushed as large as 2~3cm in diameter, and then processed in dilute acetic acid of about 15%. This was followed microscopic examination of the residues.

Fourty of sixty-two samples yielded 999 descrete conodont specimens, and these are classified into 34 species assignable to 15 genera based on multielement and form taxonomies. Sample horizons and intervals are illustrated in Figs. 2, 3, and 4. Stratigrphic distribution in fossiliferous horizons is shown in Fig 5.

Of sixty-two limestone samples collected in this study, conodonts are recovered from fourty samples at the ratio of 65%; 77% of 17 to 22 samples in Golmacha, 62% of 13 to 21 samples in Seonghwangchon, and 53% of 10 to 19 samples in two Mohari sections. Conodont recovery per sample is counted as relatively low, so only 15 samples are contained more than 10 specimens. Stratigraphically, conodonts are more abundant in lower samples than the upper ones.

Generally, conodonts were below average size; variation between each conodont taxa or within a conodont taxa is so great. Also, most specimens are relatively well preserved with no sign of any deformation, although some are fragmented. Elements are dark grey to black, indicating a high degree of thermal maturity.

FAUNAL SUCCESSION AND CORRELATION

Diverse conodonts of great value in biostratigraphy are recovered from three sections of the Mungog Formation in the Yeongweol area. Unfortunately, the conodont species of each section was not well differentiated stratigraphically owing to the paucity of conodont specimen, especially in the upper part of the formation, and of limestone samples collected. A more refined restudy for additional collections is required to establish a precise biostratigraphical correlation. The fauna useful for biostratigraphy includes *Cordylodus proavus, C. drucei, C. intermedius, C. lenzi, C. angulatus, C. rotundatus, Semiacontiodus nogamii, Monocostodus sevierensis, Utahconus utahensis, U. beimadaoensis, Rossodus manitouensis, Chosonodina herfurthi, Acanthodus lineatus, A. uncinatus, Scolopodus quadraplicatus, Drepanoistodus forceps, Oistodus selene, Paroistodus proteus, Distacodus dumugolensis,* and *Paracordylodus gracilis.*

On the basis of these species, four informal conodont assemblage zones are tentatively erected in Mungog Formation, namely Assemblage Zone 1 (=*Semiacontiodus nogamii - Cordylodus lindstroemi - Utahconus beimadaoensis* Zone), Assemblage Zone 2 (=*Rossodus manitouensis - Chosonodina herfurthi* Zone), Assemblage Zone 3 (=*Scolopodus quadraplicatus - Paroistodus proteus - Drepanoistodus forceps* Zone), and Assemblage Zone 4 (=*Paracordylodus gracilis* Zone) in ascending order. The base of each zone is drawn at the lowest occurrences of the respective key taxa.

Assemblage zone 1 and 2 are assigned to Member 1 or probably lower part of Member 3, assemblage zone 3 and 4 are assigned respectively to Member 3 and 4. Stratigraphic boundary of each zone is at hand unclear due to the lack of detailed sampling. Ranges of conodont taxa are shown in Fig. 5, and correlation of the zones with those of other areas is illustrated in Fig. 6.

Golmacha section(Om)

Lower three assemblage zones listed above are recognized in members 1 and 3 of the Golmacha section.

The lowest conodont occurrence is recorded in sample Om 2, 6.69m above the base of the Mungog Formation, at Golmacha section. Om 2 contains *Cordylodus proavus, C. lindstroemi, C. angulatus, C. rotundatus, C.*(?) sp., *Semiacontiodus nogamii, Oneotodus variabilis, Scolopodus sulcatus, S. warendensis, Utahconus beimadaoensis,* and *Drepanoistodus* spp. This association allows the tentative recognition of Assemblage Zone 1 (*Semiacontiodus nogamii - Cordylodus lindstroemi - Utahconus beimadaoensis* Zone).

Cordylodus proavus is a cosmopolitan species ranging from the *Corbinia apopsis* Subzone of *Saukia* Zone to *Missisquoia* and *Symphysurina* zones of North American trilobite zonal scheme of uppermost Cambrian to lowermost Ordovician. This interval approximately equivalents to Fauna A of Ethington and Clark (1971), and the *Cordylodus proavus* Zone of Miller (1978, 1980).

Semiacontiodus nogamii, procured from Om 2 and Om 3, ranges from the *C. elegance* Subzone of the *C. proavus* Zone to lower Fauna B in association with *Parutahconus nodosus* and *Jujuyaspis* (trilobite).

Cordylodus angulatus and *C. rotundatus* are recovered in Fauna B except lowermost part and lower part of Fauna C of Ethington and Clark (1971) in North America. Lindström(1955) recorded this species through the Upper Tremadocian and into the lower part of Arenigian in Scandinavia. *C. angulatus* persists into the overlying sample Om 3. *Cordylodus angulatus* and *C. rotundatus* have common association, but have different ancestors; *C. intermedius* is the ancestor of *C. angulatus*,

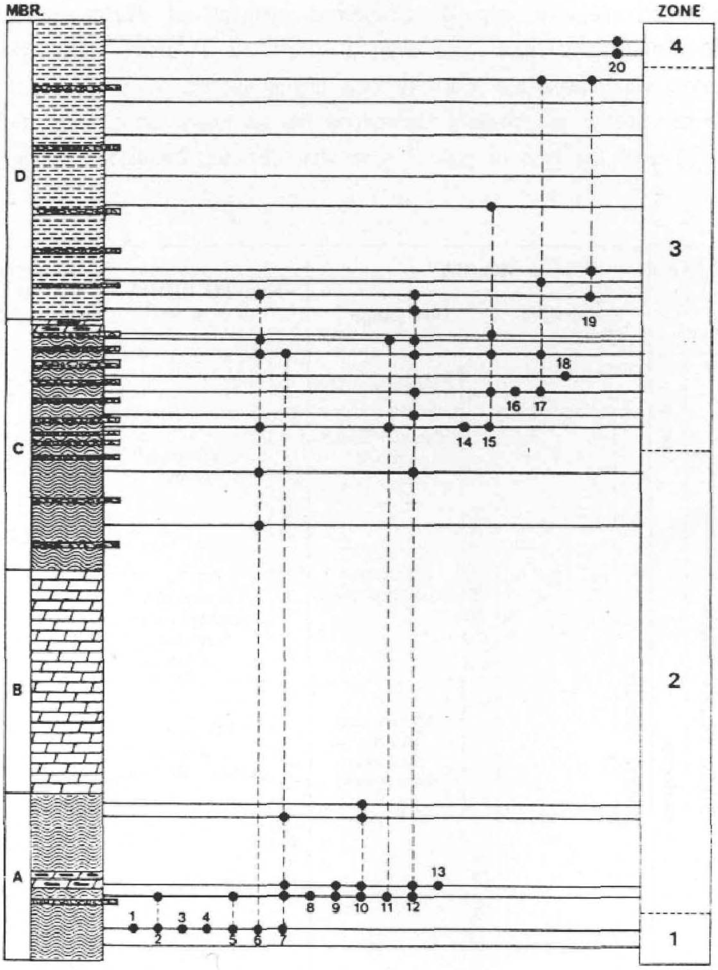


Figure 5. Generalized stratigraphic ranges of selected conodont species from the Mungog Formation, Yeongweol area. Key to numbers : 1. *Cordylodus proavus*, 2. *Semiacontiodus nogamii*, 3. *Cordylodus lindstroemi*, 4. *Cordylodus rotundatus*, 5. *Cordylodus angulatus*, 6. *Utahconus beimadaoensis*, 7. *Scolopodus warendensis*, 8. *Cordylodus drucei*, 9. *Cordylodus intermedius*, 10. *Rossodusmanitouensis*, 11. *Scandodus furnishi*, 12. *Glyptoconus bassleri*, 13. *Chosonodina herfurthi*, 14. *Paroistodus proteus*, 15. *Scolopodus quadraplicatus*, 16. *Drepanoistodus forceps*, 17. *Drepanodus concavus*, 18. *Drepanoistodus basiovalis*, 19. *Distacodus dumugolensis*, and 20. *Paracordylodus gracilis*.

whereas *C. drucei* is the ancestor of *C. rotundatus* (Miller *et al.*, 1980). This lineage is not clearly documented in this study, except that *C. angulatus* and *C. drucei* are obtained commonly from the overlying sample Om 3.

Cordylodus lindstroemi first occurs at the base of Fauna B, which is within the lower part of the *Symphysurina brevispicata* Subzone of the *Symphysurina* Zone. *Utahconus beimadaoensis*, a long-ranging species, occurs from the *Utahconus beimadaoensis* - *Monocostodus sevierensis* Zone of the lowest Ordovician in North China (An *et al.*, 1983). However, a taxonomic revision of *U. beimadaoensis* is required for more detailed stratigraphic range of the species, which is confused at present level in morphology to spp. of *Utahconus*, elements of *Parutahconus nodosus*, *Acodus tetrahedron*, and *Scandodus furnishi*, and even a species of *Paltodus*. Other species from Om 2 including *Scolopodus warendensis* are relatively long-ranging species.

None of the key species as presently understood has its lowest occurrence at the same horizon, making the definition of the base of zone 1 somewhat difficult. Detailed sampling of the basal part

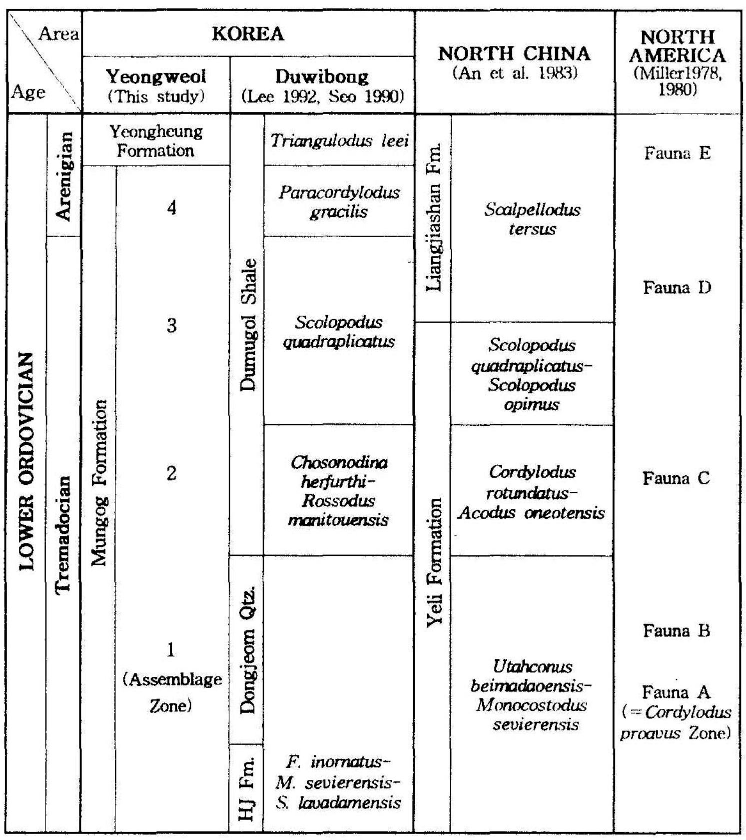


Figure 6. Correlation of conodont biozones of the Lower Ordovician in Korea, North China, and North America.

of the Mungog Formation is required to erect precise zonation. The top of Assemblage Zone 1 appears to be marked by the first appearance of *Rossodus manitouensis* and *Chosonodina herfurthi*, key species of the overlying zone. Miller (1978, 1980) defined the base of Fauna B by the lowest occurrence of *Cordylodus lindstroemi* Druce and Jones (1971), a form considered to represent ontogenetic variants of *Cordylodus* elements with secondary basal tips. Based on this idea and consideration of stratigraphic ranges of other species of Om 2, Assemblage Zone 1 defined herein appears to be correlated with the upper part of the *Cordylodus proavus* Zone and lower *Symphysurina brevispicata* Subzone of the *Symphysurina* Zone of uppermost part of the Lower Tremadocian or probably with the middle part of Fauna B. Accordingly, the Cambrian-Ordovician boundary in the Yeongweol area is probably present within beds immediately below Assemblage Zone 1, near the base of the Mungog Formation.

Assemblage zone 1 or *Semiacontiodus nogamii* -. *Cordylodus lindstroemi* - *Utahconus beimadaoensis* Zone is the lowest conodont assemblage of the Ordovician strata in Korea. In Taebaegsan region, the *Chosonodina herfurthi* - *Rossodus manitouensis* Zone is the lowest Ordovician one established in the Dumugol Shale of the Duwibong-type Choseon Supergroup.

The sample Om 3, 4.25m above Om 2, yielded some important conodonts of *Acodus tetrahedron*, *Cordylodus drucei*, *C. intermedius*, *Drepanodus concavus*, *D. tenuis*, *Drepanodus suberectus*, *Oneotodus erectus*, *Rossodus manitouensis*, *Scandodus furnishi*, *Teridontus nakamurai*, *Scolopodus primitivus*, *S. shuiyuensis*, and *Glyptoconus bassleri* etc., and the sample Om 4, 13.69m above the base of the Mungog Formation, yielded *C. intermedius*, *Rossodus manitouensis*, *Chosonodina herfurthi*, *Drepanoistodus pervetus*, *D. lanceolatus*, *Oneotodus gracilis*, *Scolopodus primitivus*, and *Glyptoconus bassleri* etc. Om 5 (26.42m above base) contains *R. manitouensis*, *D. lanceolatus*, *A. tetrahedron*, and *Scolopodus warendensis*. Om 6 (28.62m above base) also contains *R. manitouensis* with association of *Oistodus inaequalis*, and *Distacodus* sp.

Stratigraphic interval from sample Om 3 to Om 6 of 17.68m thick, is tentatively labelled as Assemblage Zone 2 (=*Rossodus manitouensis* - *Chosonodina herfurthi* Zone). This zone is more or less thin, relative to those of the Dumugol Shale (27~30m thick of Seo, 1991; 30~36m thick of Lee *et al.*, 1997) in Duwibong and Ogdong areas. More detailed sampling may solve this problem. *Rossodus manitouensis* first occurs at 0.75m horizon below the base of first bed of dolomitic limestone containing chert nodules through Om 5 and Om 6 respectively of ribbon rocks. *Chosonodina herfurthi* first occurs from flat-pebble conglomerate bed, directly below the second chert nodule-containing bed, 13.69m above the base of the Mungog Formation.

Cordylodus drucei occurs from the uppermost part of the *C. proavus* Zone or Fauna B. *C. intermedius* is reported hotherto in the lower to middle part of the *Symphysurina* Zone or upper part of Fauna A, and lower part of Fauna B of Ethington and Clark (1971). This species also is known from the Upper Tremadocian strata of Sweden (Van Wamel, 1974), east Baltic region (Viira, 1974), Oaxaca, Mexico (Miller *et al.*, 1974), Iran (Müller, 1973), Australia (Druce and Jones, 1971; Jones, 1971; Druce *et al.*, 1982), northwestern Greenland (Stouge, 1977), USSR (Abaimova, 1972, 1975), and North China (An *et al.*, 1983; Chen *et al.*, 1985). In Korea, *C. intermedius* is recovered from a bed about 5m above the base of the Dumugol Shale near Yeongchun area (Lee *et al.*, 1994), with association of *Acanthodus lineatus*, *Chosonodina herfurthi*, *C. angulatus*, *C. rotundatus*, *Monocostodus sevierensis*, and *Rossodus manitouensis* etc.

Rossodus manitouensis and *Chosonodina herfurthi* co-occurs from the Lower Ordovician of various parts of the world. *R. manitouensis*, first reported from the Upper Tremadocian strata in North America (Repetski, 1983), appears to be restricted to upper conodont Fauna B and Fauna C of North American midcontinental zonal scheme (Landing *et al.*, 1986). *C. herfurthi* with associates of *Loxodus bransoni* and *Clavohamulus densus* etc. is known from strata equivalent to the upper part of Fauna B to Fauna C of North America (Taylor and Landing, 1982), the upper part of the Warendian of Australia (Shergold *et al.*, 1982), the Yeli Formation of North China (An *et al.*, 1983), and the Dumugol Shale of Korea (Müller, 1964; Seo, 1990; Lee *et al.*, 1991, 1994, 1997). Meanwhile, Seo (1990) and Lee *et al.* (1991, 1994, 1997) correlated the *Rossodus manitouensis* - *Chosonodina herfurthi* Zone with the middle to upper part of Fauna C of North America, and the *Cordylodus rotundatus* - *Acodus oneotensis* Zone of North China (An *et al.*, 1983).

No limestone samples were collected in interval from the uppermost part of member 1 (ca. 3.15m thick) through member 2 (ca. 43.86m thick) to the lowermost part of member 3 (ca. 6.84m thick) below Om 7, because limestones of the range are dolomitic. Several long-ranging species are dominant in samples Om 7, Om 8, Om 9, Om 10, Om 11, and Om 12. The conodont fauna includes *Acanthodus lineatus*, *Acodus triangulatus*, *Drepanodus arcuatus*, *D. concavus*, *D. conulatus*, *D. simplex*, *D. tenuis*, *Drepanoistodus forceps*, *Oistodus contractus*, *O. inaequalis*, *Scandodus furnishi*, *Scolopodus floweri*, and *Paroistodus proteus* etc. These are assigned to assemblage zone 3 (=*Scolopodus quadraplicatus* - *Paroistodus proteus* - *Drepanoistodus forceps* Zone), and is approximately known from younger beds than the *Chosonodina herfurthi* - *Rossodus manitouensis* Zone of the Dumugol Shale in Duwibong area (Seo, 1990), and the *Rossodus manitouensis* Zone in Ogdong area (Lee *et al.*, 1994, 1997), except *A. lineatus*, *D. conulatus*, *D. forceps*, and *Paroistodus proteus*. The first species is hitherto reported only from the *Rossodus manitouensis* - *Chosonodina herfurthi* Zone, and

---

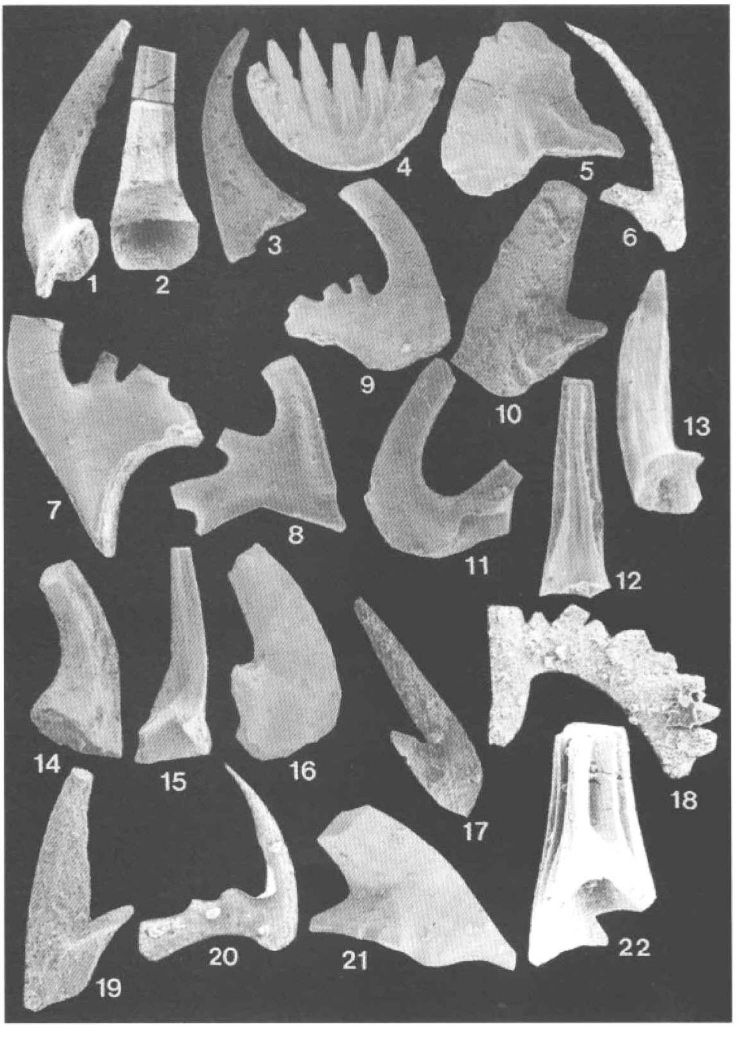
PLATE 1

Fig.1 *Acanthodus uncinatus* (Furnish), Sh 6, lateral view, x36. **Fig.2.** *Acontiodus propinquus* Furnish, Sh 8, posterior view, x136. **Fig.3.** *Proconodontus* sp., Om 4, lateral view, x109. **Fig.4.** *Chosonodina herfurthi* Müller, Om 4, posterior view, x95. **Fig.5.** *Rossodus manitouensis* Repetski & Ethington, posterior view of acontiodiform el., Om 3, x122. **Fig.6.** *Distacodus dumugolensis* Seo, lateral view of oistodiform el., Om 16, x104. **Fig.7.** *Cordylodus intermedius* Furnish, lateral view, Om 3, x69. **Fig.8.** *Cordylodus drucei* Miller, lateral view, Om 3, x141. **Fig.9.** *Cordylodus angulatus* Pander, lateral view, Om 3, x87. **Fig.10.** *Oistodus lanceolatus* Pander, lateral view, Om 4, x80. **Fig.11.** *Cordylodus rotundatus* Pander, lateral view, Om 2, x163. **Fig.12.** *Scolopodus sulcatus* Furnish, posterior view, Om 2, x191. **Fig.13.** *Glyptoconus quadraplicatus* (Furnish), posterolateral view, Om 13, x85. **Fig.14.** *Glyptoconus quadraplicatus* (Furnish), posterolateral view, Sh 9, x89. **Fig.15.** *Rossodus manitouensis* Repetski & Ethington, posterior view of acontiodiform el., Sh 1, x100. **Fig.16.** *Paroistodus proteus* (Lindström), lateral view, Om 9, x53. **Fig.17.** *Drepanoistodus forceps* (Lindström), lateral view, Om 11, x109. **Fig.18.** *Paracordylodus gracilis* (Lindström), lateral view of paracordylodiform el., SH 18, x182. **Fig.19.** *Drepanoistodus inaequalis* (Pander), lateral view, Om 12, x163. **Fig.20.** *Paracordylodus gracilis* (Lindström), lateral view of cyrtoniodiform el., Sh 18, x186 **Fig.21.** *Oistodus selenopsis* Serpagli, lateral view, Sh 1, x83. **Fig.22.** *Paltodus* sp., lateral view, Sh 9, x118.

three remainders are all from younger zone(s) than the *Scolopodus quadraplicatus* Zone of the Dumugol Shale (Seo, 1990). This fauna can be correlatable with Fauna C of North America (Miller *et al.*, 1982; Seo, 1990; Lee *et al.*, 1994, 1997).

Accordingly, a younger conodont biozone overlying assemblage zone 2 can be considered to range from a bed slightly above sample Om 9 probably through Om 11 definitely to Om 13, containing *Drepanodus conulatus, Drepanoistodus forceps, Paroistodus proteus,* and *Scolopodus quadraplicatus.* The top of the zone is unclear. Unfortunately, no time-sensitive conodonts are recovered throught the remainer of the Mungog Formation in this study, except an occassional occurrence of *Distacodus dumugolensis* reported from the upper part of the *Scolopodus quadraplicatus* Zone of the Dumugol Shale (Seo, 1990). Restudy of additional collections from the upper half of the formation may result

PLATE 1



in recovering diagnostic elements.

Seonghwangchon section(Sh)

Three conodont assemblage zones are recognized in the Seonghwangchon section, namely assemblage zone 2 (=*Rossodus manitouensis - Chosonodina herfurthi* Zone), assemlage zone 3 (= *Scolopodus quadraplicatus* Zone), and assemblage zone 4 (=*Paracordylodus gracilis* Zone) in ascending order. Three zones are assigned respectively to members 1, 3, and 4.

Strata about 30.15m below the base of Member 2 contain diagnostic species of informal assemblage zone 2 or the *Rossodus manitouensis-Chosonodina herfurthi* Zone. Especially important species are *C. herfurthi, Cordylodus lenzi, C. angulatus, C. rotundatus, Juanognathus jaanusoni, Oistodus selene, R. manitouensis,* and *Utahconus beimadaoensis.* Stratigraphic extension of the zone is uncertain due to the lack of detailed sampling.

Lower part of Member 3 at Seonghwangchon section (Sh 2, Sh 3, and Sh 4 or Sh 5) contains an long-ranging assemblage of *Drepanodus arcuatus, D. homocurvatus, Glyptoconus bassleri, Scalpellodus tersus, Scolopodus acontiodiformis angularis, Utahconus utahensis,* and *U. beimadaoensis.*

Scolopodus quadraplicatus along with *Acanthodus uncinatus, Drepanodus conulatus, Drepanoistodus proteus,* and *Utahconus beimadaoensis* is recovered from sample Sh 6 21.1m above the base of Member 3. The species is also occured in overlying samples Sh 8 and Sh 9. This interval (16.7m thick) marks assemblage zone 3 correlative of the *S. quadraplicatus* Zone of the Dumugol Shale in Duwibong area (Seo, 1990). Especially, *S. quadraplicatus* and *S. quadrangulatus* co-occur in sample Sh 8. An *et al.* (1983) considered that *S. quadraplicatus* is ancestor of *S. quadrangulatus,* so the former species occurs from strata younger than lower part of the Yeli Formation, whereas the latter species first occurs from the base of the Liangchiashan Formation, respectively.

We were unable to recognize any conodont biozone in the uppermost part of Member 3 and entire length of Member 4, except uppermost 7.62m interval above sample Sh 18 of flat-pebble conglomerates, where some elements of *Paracordylodus gracilis* are collected. *P. gracilis* appears to be present throughout the remainder of the Mungog Formation. These strata are all assigned to Assemblage Zone 4 or *Paracordylodus gracilis* Zone, recognized only in the Seonghwangchon section. This is the uppermost zone of the formation erected herein, and comprises an assemblage of *Drepanodus arcuatus, Drepanoistodus inaequalis, P. gracilis, Scandodus furnishi, Scolopodus quadraplicatus, S. warendensis,* and *Utahconus beimadaoensis.* Seo (1990) correlated this zone with the upper part of Fauna C and the lower part of Fauna D of North America, and the Lower Arenigian fauna of North China.

Mohari section(Mo)

Sample collection for conodonts is restricted to Members 3 and 4 in a road-side (route 38) section with entire length of the Mungog Formation, and to Member 1 in a short section along a stream line of Dumog village. Assemblage zone 3 or *Scolopodus quadraplicatus - Paroistodus proteus - Drepanoistodus forceps* Zone is recognized in road-side section, and assemblage zone 2 or *Rossodus manitouensis - Chosonodina herfurthi* Zone is only recognized in short section, respectively.

Scolopodus quadraplicatus first occurs from sample W 4 at 4.38m above the base of Member 3, and is associated with *Acontiodus propinquus, Drepanodus arcuatus, D. concavus, Drepanoistodus inaequalis, Glyptoconus bassleri, Monocostodus sevierensis, Semiacontiodus nogamii, Scolopodus* *primitivus*, *S. warendensis*, *Teridontus nakamurai*, *Utahconus utahensis*, and *U. beimadaoensis* etc. This fauna tentatively assigned to assembalge zone 3. *S. quadraplicatus* also procured from sample W 14, 20.4m above the base of Member 4.

Of other samples above W 4 with small collections of *Scalpellodus tersus*, *Paroistodus* cf. *proteus*, and *Scolopodus longibasis*, W 13 comprises *Scolopodus bolites*, a characteristic species of the *Paracordylodus gracilis* Zone in Duwibong area. Seo (1990) correlated strata including the species with the Lower Arenigian. If this interpretation is valid, beds bearing *S. bolites* can be compared with a part of the assemblage zone 4 or *P. gracilis* Zone in Seonghwangchon section.

The sample Du 1 of two productive samples in short section along a stream line of Dumog village,

PLATE 2

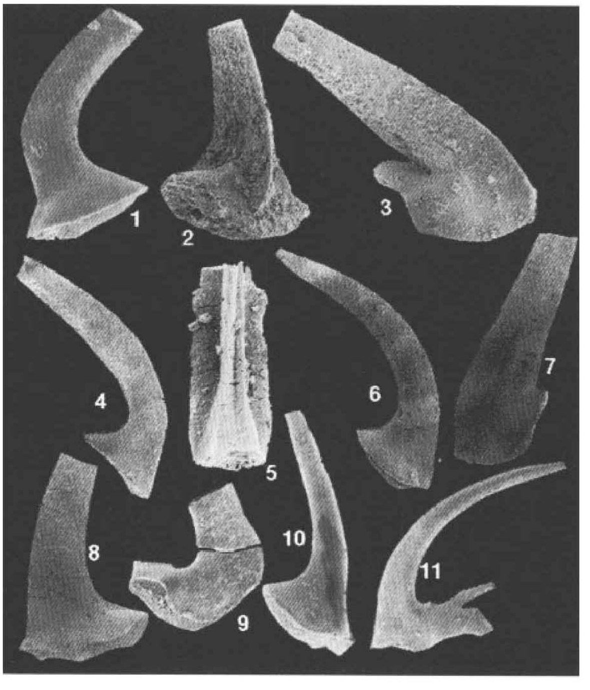


PLATE 2

Fig.1. *Drepanodus concavus* (Branson & Mehl), lateral view, Sh 1, x60. **Fig.2.** *Rossodus manitouensis* Repetski & Ethington, posterior view of acontiodiform el., Sh 1, x135. **Fig.3.** *Oistodus lanceolatus* Pander, lateral view, Sh 1, x89. **Fig.4.** *Drepanodus simplex* Branson & Mehl, lateral view, Om 7, x75. **Fig.5.** *Scolopodus bolites* Repetski, posterior view, W 11, x140. **Fig.6.** *Drepanodus homocurvatus* Lindström, lateral view, Om 8, x57.

Fig.7. *Oistodus contractus* Lindström, lateral view, Om 8, x43. **Fig.8.** *Drepanodus suberectus* (Branson & Mehl), lateral view, Om 8, x79. **Fig.9.** *Cordylodus rotundatus* Pander, lateral view, Om 2, x120. **Fig.10.** *Oneotodus erectus* Druce & Jones, lateral view, Om 3, x140. **Fig.11.** *Cordylodus angulatus* Pander, lateral view, Om 3, x130.

yielded conodont fauna indicative of assemblage zone 2. The fauna comprises *Cordylodus rotundatus, Glyptoconus bassleri, Scalpellodus tersus, Paltodus quinquecostatus, Rossodus manitouensis,* and *Scandodus* sp. etc. In 1991, Lee collected some specimens of *Chosonodina herfurthi* from immediately above Dm 1. From Dm 2, 9.6m below Du 1, *C. angulatus, Glyptoconus bassleri, Semiacontiodus nogamii,* and *Scolopodus gracilis* are also recoverd. This fauna is interpreted to be an older assemblage than the *Rossodus manitouensis* - *Chosonodina herfurthi* Zone, although key species are not recovered.

영월의 문곡층 (하부 오르도비스계)에 대한 코노돈트 생층서

이 병 수* · 이 종 덕*
*전북대학교 자연과학대학 지구환경학부, 전북 전주시 덕진구 덕진동 664-14

요 약 : 영월의 문곡층 3 개 단면 (골마차, 성황촌과 모하리 단면)에서 코노돈트 생층서 연구가 이루어졌다. 문곡층 4 개 층원(member) 가운데 두 번째 층원을 제외한 나머지 층서 구간에 대하여 잠정적이지만 4 개 코노돈트 군집대 설정이 가능한데, 아래로부터 *Semiacontiodus nogamii* - *Cordylodus lindstroemi* - *Utahconus beimadaoensis* 대, *Rossodus manitouensis* - *Chosonodina herfurthi* 대, *Scolopodus quadraplicatus* - *Paroistodus proteus* - *Drepanoistodus forceps* 대 및 *Paracordylodus gracilis* 등이라고 불러도 좋을 듯 하다. 이들의 대비에 관한 예비 자료를 간략히 요약하였다. 영월지역의 캄브리아-오르도비스계 경계는 아마 첫째 군집대 바로 아래 쪽, 문곡층 기저 가까운 층준에 놓일 가능성이 있다.

REFERENCES

Abaimova, G. P., 1972 : Ordovician conodont assemblages of the southeastern Siberian platform. *Sov. Geol.*, no. 10, p.124-130.

Abaimova, G. P., 1975 : Early Ordovician conodonts from the middle course of the Lena River. *Tr. sib. nauchno-issled. Inst. Geol. Geofiz. miner. Syrya (SNIIGGIMS)*, vol. 207, p.1-137.

An, T., 1981 : Recent progress in Cambrian and Ordovician conodont biostratigraphy of China. *Geological Society of America, Special Paper 187*, p.209 - 225.

An, T., Du, G. and Gao, Q., 1985 : Ordovician conodonts from Hubei, China. Geological Publishing House, 64p.

An, T., 1987 : Lower Paleozoic conodonts of south China. Science Publishing Company, 238p.(in Chinese)

An, T., Zhang, F., Xiang, W., Zhang, Y., Xu, W., Zhang, H., Jiang, D., Yang, C., Lin, L., Cui, Z. and Yang, X., 1983 : Conodonts from north China and adjacent regions. Science Publishing Company, Beijing, 233p.(in Chinese)

Barnes, C. R., 1974 : Ordovician conodont biostratigraphy of the Canadian Arctic. p.221 - 240. In

Aitken, J. D. and Glass, D. J.(eds.), *Canadian Arctic Geology. Geologist, Special Paper 5.*

Barnes, C. R. and Poplawski, M. L. S., 1973 : Lower and Middle Ordovician conodonts from the Mystic Formation, Quebec, Canada. *Journal of Paleontology*, vol. 47, p.760 - 790.

Barnes, C. R. and Tuke, M. F., 1970 : Conodonts from the St. George Formation (Ordovician), northern Newfoundland. *Geological Servey of Canada Bulletin*, vol. 187, p.79 - 97.

Branson, E. B. and Mehl, M. G., 1933 : Conodonts from the Jefferson City (Lower Ordovician) of Missouri. *University of Missouri Studies*, vol. 8, p. 53 - 64.

Bruton, D. L., Koch, L. and Repetski, J. E., 1988 : The Naernus section, Oslo region, Norway : trilobite, graptolite and conodont fossils reviewed. *Geological Magazine*, vol. 125, p.451-455.

Chang, W. T., 1988 : The Cambrian System in eastern Asia, correlation chart and explanatory notes. International Union of Geological Sciences, Publication No. 24, 81p.

Chen, J. Y., Teichert, C., Zhou, Z., Lin, Y., Wang, Z. H. and Xu, J. T., 1983 : Faunal sequences across the Cambrian-Ordovician boundary in northern China and its international correlation. *Geologica et Palaeontologica*, vol. 17, p.1-15.

Chen, J. Y., Qian, Y., Zhang, J., Wang, Z., Yin, L. and Erdtmann, B. D., 1985 : Study on Cambrian-Ordovician boundary strata and its biotas in Dayangcha, Hunjiang, Jilin, China. China Prospect Publishing House, 138p.

Chen, J. Y., Qian, Y., Zhang, J., Lin, Y., Wang, Z. H., Wang Z. Z., Yang, J., Wang, Y. X., 1988 : The recommended Cambrian-Ordovician global boundary stratotype of the Xiaoyangqiao section(Dayangcha, Jilin Province), China. *Geological Magazine*, vol. 125, p.415-444.

Choi, D. K., Lee, H. Y. and Kim, D. H., 1996 : The Cambrian-Ordovician boundary in the Taebaegsan region, Korea : a review. *Journal of the Paleontological Society of Korea*, vol. 12, p.57-84.

Choi, J. Y., 1993 : Conodont biostratigraphy and paleoecology of the Lower Paleozoic Mungog Formation in the Yeongweol-gun and Pyeongchang-gun, Kangweondo, Korea. MS thesis, Yonsei University, 129p.(in Korean)

Choi, Y. S., Kim, J. C. and Lee, Y. I., 1993 : Subtidal, flat-pebble conglomerates from the Early Ordovician Mungog Formation, Korea : origin and depositional process. *Journal of the Geological Society of Korea*, vol. 29, p.15-29.

Dong, X. P., 1987 : Late Cambrian and Early Ordovician conodonts from Chuxian, Anhui. Nanjing. *Inst. Geol. Acad. Sci.*, vol. 1, p.145 - 148.

Druce, E. C. and Jones, P. J., 1971 : Cambro-Ordovician conodonts from the Burke River structural belt, Queensland. *Australian Bureau of Mineral Resources Bulletin*, vol. 110, p.1 - 167.

Druce, E. C., Shergold, J. H. and Radke, B. M., 1982 : A reassessment of the Cambrian-Ordovician boundary section at Black Mountain, western Queensland, Australia. *In* Bassett, M. G. and Dean, W. T.(eds.), The Cambrian-Ordovician boundary : sections, fossil distributions, and correlations. *National Museum of Wales, Geology Series*, no. 3, p.193-209, Cardiff, Wales.

Ethington, R. L., 1959 : Conodonts of the Ordovician Galena Formation. *Journal of Paleontology*, vol. 38, p.685 - 704.

Ethington, R. L., 1965 : Lower Ordovician conodonts and other microfossils from the Columbia Ice Fields section, Alberta, Canada. Brigham Young University, *Geology Studies*, vol. 12, p.185 - 205.

Ethington, R. L., 1971 : Lower Ordovician conodonts in North America, p.63 - 82. *In* Sweet, W. C. and Bergstr , S. M.(eds.), Symposium on Conodont Biostratigraphy. Geological Society of America Memoir 127.

Ethington, R. L., 1972 : Lower Ordovician (Arenigian) conodonts from the Pogonip Group, central Nevada. *Geologica et Palaeontologica*, Sonderband 1, p.17 - 28.

Ethington, R. L. and Brand, U., 1981 : *Oneotodus* (Conodonta). *Journal of Paleontology*, vol. 55, p.349 - 247.

Ethington, R. L. and Clark, D. L., 1964 : Conodonts from the El Paso Formation (Ordovician) of Texas and Arizona. *Journal of Paleontology*, vol. 38, p.685 - 704.

Ethington, R. L. and Clark, D. L., 1971 : Lower Ordovician conodonts of North America. *In* Sweet, W. C. and Bergstr , S. M.(eds.), Symposium on conodont biostratigraphy. *Geological Society of America Memoir* 127, p.63-82.

Ethington, R. L. and Clark, D. L., 1982 : Lower and Middle Ordovician conodonts from the Ibex area, western Millard County, Utah. Brigham Young University, *Geology Studies*, vol. 29, p.1 - 127.

Fahräeus, L. E. and Nowlan, G. S., 1978 : Franconian (Late Cambrian) to Early Champlainian (Middle Ordovician) conodonts from the Cow Head Group, western Newfoundland. *Journal of Paleontology*, vol. 52, p.444 - 471.

Furnish, W. M., 1938 : Conodonts from the Prairie du Chien beds of the upper Mississippi valley. *Journal of Paleontology*, vol. 12, p.318 - 340.

Geological Investigation Corps of Taebaegsan Region, 1962 : Geological maps of Taebaegsan region. Geological Society of Korea, 46p.

Ji, Z. and Barnes, C. R., 1996 : Uppermost Cambrian and Lower Ordovician conodont biostratigraphy of the Survey Peak Formation (Ibexian/Tremadoc), Wilcox Pass, Alberta, Canada. *Journal of Paleontology*, vol. 75, no. 5, p.871 - 890.

Jones, P. J., 1971 : Lower Ordovician conodonts from the Bonaparte Gulf Basin and the Daly River Basin, northwestern Australia. *Australian Bureau of Mineral Resources Bulletin*, vol. 177, p.1 - 80.

Kim, B. K., Cheong, C. H. and Choi, D. K., 1990 : Occurrencesof *Sphenothallus* ("vermes") frm the Mumgog and Yobong formations, Yeongweol area, Korea. *Journal of the Geological Society of Korea*, vol. 26, p.454-460.

Kim, D. H. and Choi, D. K., 1995, *Kainella* (Trilobita, Early Ordovician) from the Mungog Formation of Yeongweol area and its stratigraphic significance. *Journal of the Geological Society of Korea*, vol. 31, p.576-582.

Kim, O. J., Lee, H. Y., Lee, D. S. and Yun, S., 1973 : The stratigraphy and gelogic structure of the Great Limestone Series in South Korea. *Journal of the Korea Institute of Mining Geology*, vol. 6, p.81-114.

Kobayashi, T., 1933 : Upper Cambrian of the Wuhutsui basin with special reference to the limit of the Chaumitian (or Upper Cambrian) of eastern Asia, and its subdivision. *Japanese Journal of Geology and Geography*, vol. 23, p.37-61.

Kobayashi, T., 1934 : The Cambro-Ordovician formations and faunas of South Chosen, Paleontology, Part II., Lower Ordovician. *Journal of the Faculty of Science, Imperial University of Tokyo.* Section 2, vol. 2, no. 9, p.524 - 585.

Kobayashi, T., 1953 : Geology of South Korea with special reference to the Limestone Plateau of

Kogendo. The Cambro-Ordovician formations and the faunas of South Chosen, Part IV., *Journal of the Faculty of Science, Imperial University of Tokyo*, Section 2, vol. 8, p.145 - 293.

Kobayashi, T., 1953 : On the Kainellidae. *Japanese Journal of Geology and Geography*. vol. 23, p.37-61.

Kobayashi, T., 1960 : The Cambro-Ordovician formations and faunas of South Korea, Part VI, Paleontology V, *Journal of the Faculty of Science, Imperial University of Tokyo*. Section II, Additional Lower Ordovician fossils from South Korea. vol. 12, p.217-275.

Kobayashi, T., 1966 : The Cambro-Ordovician formations and faunas of South Korea. Part X, Stratigraphy of the Choseon in Korea and South Manchuria and its relation to the Cambro-Ordovician formations and faunas of other areas, Section A., The Chosen Group of South Korea. *Journal of the Faculty of Science, University of Tokyo*, Section 2, vol. 16, p.209-311.

Landing, E., 1988 : Cambrian-Ordovician boundary in North America : revised Tremadocian correlations, unconformities and "glacioeustasy". *In* Landing, E.(ed.) The Canadian paleontology and biostratigraphy seminar. *New York State Museum, Bulletin* 462, p.48-58.

Landing, E., 1993 : Cambrian-Ordovician boundary in the Taconic allochton, eastern New York, and its interregional correlation. *Journal of Paleontology*, vol. 67, p.1-19.

Landing, E. and Barnes, C. R., 1981 : Conodonts from the Cape Clay Formation (Lower Ordovician), southern Devon Island, Arctic Archipelago. *Canadian Journal of Earth Sciences*, vol. 18, p.1609 - 1628.

Landing, E., Barnes, C. R. and Stevens, R. K., 1986 : Tempo of earliest Ordovician graptolite faunal succession : Conodont-based correlations from the Tremadocian of Quebec. *New York State Science Service, Journal Series*, No. 482, p.1928 - 1949.

Lee, B. S., 1989a : Conodonts from the Hwajeol Formation(Upper Cambrian-lowest Ordovician) in northern district of Taebaeg City, Kangweon-do, Korea. *Journal of the Geological Society of Korea*, vol. 25, p.322-336.

Lee, B. S., 1989b : Upper Cambrian-lowest Ordovician conodont fauna of the Hwajeol Formation, Cheungsan area, Kangweon-do, Korea. *Journal of the Paleontological Society of Korea*, vol. 5, p.124-136.

Lee, B. S., 1990 : Conodont fauna of the Hwajeol Formation(Upper Cambrian-lowest Ordovician) in the Sabuk area, Kangweon-do, Korea. *Journal of the Geological Society of Korea*, vol. 26, p.293-303.

Lee, B. S., 1992 : Additional conodonts from the Upper Cambrian-lowest Ordovician boundary beds in the Paekunsan Syncline. *Journal of the Geological Society of Korea*, vol. 28, p.590-603.

Lee, B. S and Lee, H. Y., 1988 : Upper Cambrian conodonts from the Hwajeol Formation in the southern limb of the Baegunsan Syncline, eastern Yeongweol and Samcheog areas, Kangweon-do, Korea. *Journal of the Geological Society of Korea*, vol. 24, p.356-375.

Lee, B. S. and Lee, J. D., 1993 : A reassessment on conodont biostratigraphy of the Cambrian-Ordovician boundary sections in the Paekunsan Syncline. *Journal of the Paleontological Society of Korea*, vol. 9, p.155-165.

Lee, B. S., Lee, J. D. Chun, H. Y., 1994 : Conodont biostratigraphy of the Cambrian-Ordovician transition in the Ogdong-Yeongchun area. *Journal of the Paleontological Society of Korea*, vol. 10, p.83-98.(in Korean)

Lee, B. S., Lee, J. D. and Chun, H. Y., 1998 : Conodont biostratigraphy of the Dumugol Shale (Lower Ordovician) in Ogdong, Yeongweol-gun and Yeongchun, Danyang-gun, Korea. *Journal of Paleontological Society of Korea*, vol. 14.(in press)

Lee, B. S., Lee, J. D., and Ko, E. J., 1996 : Lithostratigraphy and conodont biostratigraphy of the Choseon Supergroup (Cambro-Ordovician) in the eastern Danyang area. *Journal of Paleontological Society of Korea*, vol. 12, p.85 - 104.

Lee, B. S., Seo, K. S. and Lee, H. Y., 1991 : Conodonts from the lower Dumugol Shale (Lower Ordovician) of the Cheungsan-Sabuk area, Kangweon-do, Korea. *Journal of Paleontological Society of Korea*, vol. 7, p.63 - 75.

Lee, H. Y., 1970 : Conodonten aus der Choson-Gruppe (Unteres Ordovizium) von Korea. *Neues Jahrbuch f Geologie und Pal ntologie Abhandlungen*, vol. 136, p.303 - 344.

Lee, H. Y., 1975 : Conodonts from the Dumugol Formation (Lower Ordovician) South Korea. *Journal of the Geological Society of Korea*, vol. 11, p.75 - 93.

Lee, H. Y., 1980 : Lower Paleozoic conodonts in South Korea. *In* Kobayashi, T., Toriyama, R., Hashimoto, W. and Kanno, S.(eds.), Geology and paleontology of southeast Asia. University of Tokyo Press, vol. 21, p.1 - 9.

Lee, H. Y., 1987 : Paleozoic Eratrhem, Choseon Supergroup. *In* Lee, D. s.(ed.), Geology of Korea, *Geological Society of Korea*, Seoul, p.49-82.

Lee, H. Y. and Lee, J. D., 1971 : Conodont fauna from the Great Limestone Series in Dongjeom district, Samcheog-Gun, Gangweon-Do and its stratigraphic significance. *Journal of the Geological Society of Korea*, vol. 7, p.89-101.

Lee, S. J., 1989 : Conodont biostratigraphy and paleontology of the Lower Paleozoic Yeongheung Formation in the Yeongweol area, Kangweondo, Korea. MS thesis, Yonsei University, 107p.

Lindström, M., 1955 : Conodonts from the lowermost Ordovician strata of south-central Sweden. *Geologiska Foreningens Stockholm Forhandlinger*, vol. 76, p.517 - 604.

Lindström, M., 1971 : Lower Ordovician conodonts of Europe. *In* Sweet, W. C. and Bergstr, S. M.(eds.), Symposium on Conodont Biostratigraphy. Geological Survey of America Memoir 127, p.21 - 61.

Miller, J. F., 1978 : Upper Cambrian and lower Ordovician conodont faunas of the House Range, Utah. *In* Miller, J. F.(ed.), Upper Cambrian to Middle Ordovucian Conodont Faunas of Western Utah. *Southwest Missouri State University, Geoscience Series*, 5, p.1 - 33.

Miller, J. F., 1980 : Taxonomic revisions of some Upper Cambrian and Lower Ordovician conodonts with comments on their evolution. *University of Kansas Paleontological Contributions*, Paper 99, p.1 - 43.

Miller, J. F., 1988 : Conodonts as biostratigraphic tools for redifinition and correlation of the Cambrian-Ordovician boundary. *Geological Magazine*, vol. 125, p.349-462.

Miller, J. F., Taylor, M. E., Stitt, J. H., Ethington, R. L., Hintze, R. F. and Taylor, J. F., 1982 : Potential Cambrian-Ordovician boundary stratotype sections in the western United States. *In* Bassett, M. G. and Dean, W. T.(eds.), The Cambrian-Ordovician boundary : sections, fossil distributions, and correlations. *National Museum of Wales, Geology Series*, no. 3, p.155-180, Cardiff, Wales.

Moskalenko, T. A., 1967 : Conodonts from the Chunsk Stage (Lower Ordovician) of the Moiero

River and Podkamennaya Tunguska. *In* Ivanovskii, A. B. and Sokolov, B. S.(eds.), New data on the biostratigraphy of the Lower Paleozoic deposits of the Siberian platform. *Akademiya Nauk SSSR, Sibirskoye Otdeleniye, Instituta Geologii Geofiziki*, p.98 - 116.

Mound, M. E., 1968 : Conodonts and biostratigraphy of the lower Arbuckle Group (Ordovician), Arbuckle Mountains, Oklahoma. *Micropaleontology*, vol. 14, p.393 - 434.

Müller, K. J., 1964 : Conodonren aus dem unteren Ordovizium von S · Korea. N*eues Jahrbuch f Geologie und Palaeontologie, Abhandlungen*. vol. 119, p.93-102.

Müller, K. J., 1973 : Late Cambrian and Early Ordovician conodonts from northern Iran. *Report of the Geological Survey of Iran*, vol. 30, p.1-77.

Nicoll, R. S. and Shergold, J. H., 1991 : RevisedLatean (pre-Payntonian-Datsonian) conodont biostratigraphy at Black Mountain, Georgina Basin, western Queensland, Australia. *BMR Journal of Australian Geology and Geophysics*, vol. 12, p.93-118.

Norford, B. S., Introduction to papers on the Cambrian-Ordovician boundary. *Geological Magazine*, vol. 125, p.323-326.

Nowlan, G. S., 1985 : Late Cambrian and Early Ordovician conodonts from the Franklinian Miogeosyncline, Canadian Arctic Islands. *Journal of Paleontology*, vol. 59, p.96 - 122.

Paik, I. S. and Lee, Y. I., 1989 : Storm deposits of the Lower Ordovician Mungog Formation in the vicinity of Machari, Yeongweol, Gangweondo, Korea. *Journal of the Geological Society of Korea*, vol. 25, p.337-346.

Paik, I. S., Woo, K. S. and Chung, G. S., 1991 : Stratigraphic, sedimentologic and paleontologic investigation of the Paleozoic sedimentary rocks in Yeongweol and Gabsan areas : depositional environments of the Lower Ordovician Mungog Formation in the vicinity of Yeongweol. *Journal of the Geological Society of Korea*, vol. 27, p.357-370.

Park, K. H., Choi, D. K. and Kim, J. H., 1994 : The Mungog Formation (Lower Ordovician) in the northern part of Yeongweol area : lithostratigraphic subdivision and trilobite faunal assemblages. *Journal of the Geological Society of Korea*, vol. 30, p.168-181.

Pei, F. and Cai, S., 1987 : Ordovician conodonts of Henan Province, China. Regional Geological Survey Party, Henan Province. 128p.

Repetski, J. E., 1982 : *Rossodus manitouensis* (Canadian) a new Early Ordovician index fossil. *Journal of Paleontology*, vol. 57, p.289 - 301.

Repetski, J. E., 1982 : Conodonts from El Paso Group (Lower Ordovician) of westernmost Texas and southern New Mexico. New *Mexico Bureau of Mines and Mineral Resources*, 121p.

Seo, K. S., 1990 : Conodont biostratigraphy of the Dumugol Formation (Lower Ordovician) in the Baegunsan synclinal zone, Yeongweol and Samcheog areas, Kangweon-do, Korea. Ph. D. thesis, Yonsei University, 156p.(in Korean)

Seo, K. S., Lee, H. Y. and Ethington, R. L., 1994 : Early Ordovician conodonts from the Dumugol Formation in the Baegunsan syncline, eastern Yeongweol and Samcheog areas, Kangweon-do, Korea. *Journal of Paleontolgy*, vol. 68, p.599-616.

Serpagli, E., 1974 : Lower Ordovician conodonts from Precordilleran Argentina (Province of San Juan). *Societa Paleontologica Italiana*, vol. 13, p.17 - 98.

Shergold, J. H., Cooper, R. A., Druce, E. C. and Webby, B. D., 1982 : Synopsis of selected sections at the Cambrian-Ordovician boundary in Australia, New Zealand, and Antarctica. *In* Bassett, M.

G. and Dean, W. T.(eds.), The Cambrian-Ordovician boundary : sections, fossil distributions, and correlations. *National Museum of Wales, Geology Series*, no. 3, p.211-227, Cardiff, Wales.

Shergold, J. H. and Nicoll, R. S., 1992 : Revised Cambrian-Ordovician boundary biostratigraphy, Black Mountain, western Queensland. *In* Webby, B. D. and Laurie, J. R.(eds.), Global perspective on Ordovician geology, p.81-92, Balkema, Rotterdam.

Stouge, S., 1977 : A Lower Ordovician conodont fauna from the Cape Clay Formation, northwestern Greenland. *Geological Society of America, Abstract Programs*, vol. 9, p.656.

Szaniawski, H., 1980 : Conodonts from the Tremadocian chalcedony Beds, Holy Cross Mountains (Poland). *Acta Paleontologica Polonica*, vol. 25, p.101 - 121.

Taylor, R. S. and Landing, E., 1982 : Biostratigraphy of the Cambrian-Ordovician transition in the Bear River range, Utah and Idaho, western United States. *In* Bassett, M. G. and Dean, W. T.(eds.), The Cambrian-Ordovician boundary : sections, fossil distributions, and correlations. *National Museum of Wales, Geology Series*, no. 3, p.181- 191, Cardiff, Wales.

Van Wamel, W. A., 1974 : Conodont biostratigraphy of the Upper Cambrian and Lower Ordovician of northwestern and, south-eastern Sweden. *Utrecht Micropaleontological Bulletins*, vol. 10, p. 1 - 126.

Won, M. Z. and Lee, H. Y., 1977 : Age and biostratigraphy of the Mungog (Samtaesan) Formation by means of the conodont fauna. *Journal of the Geological Society of Korea*, vol. 13, p.97-107.(in Korean)

Woo, K. S., Chung, G. S. and Pail, I. S., 1990 : Diagenetic histories of the Lower Ordovician Mungog Formation near Machari area, Yeongweol, Kangweondo, Korea : textural results. *Journal of the Geological Society of Korea*, vol. 26, p.350-357.

Viira, V., 1974 : Konodonty Ordovika Pribaltiki, Eesti NSV Teaduste. *Institut Geologii Akademii Nauk Estonskoi SSR*, Published by "Valgus", Talin, 132p.

Yosimura, I., 1940 : Geology of the Neietsu district, Kogendo, Tyosen(Korea). *Journal of the Geological Society of Japan*, vol. 47, p.112-122.(in Japanese)

Zhou, Z. Y., Wang, Z. H., Zhang, J. M., Lin, Y. K. and Zhang, J. I., 1984 : Cambrian-Ordovician boundary sections and the proposed candidates for stratotype in North and Northeast China. Stratigraphy and paleontology of systematic boundaries in China, Cambro-Ordovician boundary(2). Anhui Science and Technology Publishing House, p.1-60.