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CONODONTS FROM THE MANITOU FORMATION, COLORADO, U. S. A.

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ABSTRACT

The Manitou Formation is tentatively divided into two parts ; namely the lower part that consists chiefly of limestone containing a variety of species with numerous specimens and the upper part that is mainly constituted dolomites having the scarcity of specimens and a low variety of species. Depositional environments of the lower and the upper part might be different. A total of 22,323 identifable conodonts were recovered from 36 samples of the Manitou Formation in Missouri Gulich and Williams Canyon. They are classified into 4 multielement species referable to 4 genera and 26 form species belonging to 15 genera. Two species, *Clavohamulus birdbeakensis* n. sp. and *Clavohamulus manitouensis* n. sp. are newly described. The Manitou Formation is correlated with the Dumugol Formation in Korea, the Yeli Formation in China, the Ninmaroo Formation in Australia and the *Ceratopyge* Bed in Sweden, respectively. Condont fauna of the Manitou Formation belong to the typical North American Mid-continent Province.

INTRODUCTION

The Manitou Formation designated after geographical name of the Manitou Park and Manitou Springs in Colorado was first described by Cross (1896) without the specified type section. Richardson (1915) assigned this formation to Ordovician age based on fossils and stratigraphic level and first also referred to Manitou Springs area as the type section. Cloud and Barnes (1948) described and measured the type section of the Manitou Formation and collected lower Ordovician fossils from it.

Maher (1950) subdivided the Manitou Formation into 27 beds based on lithology and stranamelgrahic position. Berg and Ross (1959) reported that the Manitou Formation contains in its basal portion species of four lowermost Ordovician trilobite zones of Utah (Ross, 1951 ; Hintze, 1952), the B, C, D, and E zones.

Ethington and Clark (1971) established conodont Fauna C of North American Midcontinent from this formation, which is equivalent with upper Tremadocian in age.

Early Ordovician conodonts collected from many areas of the world were correlated with the Fauna C of North American Midcontinent. Lower Ordovician conodont faunas have been interpreted to comprise two different realms, namely the North America Midcontinental Realm that was located at lower latitudes having warm water environment and the North

Atlantic Realm that was situated at the higher latitudes with cold-water conditions (Bergström *et al.*, 1972).

Representative among Tremadocian conodonts of the North American Midcontinent Province is as followings : *Acanthodus lineatus* (Furnish), *Acanthodus uncinatus* Furnish, *Acodus oneotensis* Furnish, *Loxodus bransoni* Furnish, *Clavohamulus densus* Furnsh, *"Oistodus" triangularis* Furnish, *Variabiliconus bassleri* (Furnish) and *Rossodus manitouensis* Repetski and Ethington.

The purpose of this study is to report the condodonts that occur abundantly in the Manitou Formation at the exposure in Missouri Gulich, north Wooddland Park, Colorado (see Berg and Ross, 1959 ; see Maher, 1950, for description of the exposure), and also to correlate these Tremadocian conodonts with those reported from Korea (Müller, 1964 ; Seo., 1989), Siberia (Abaimova, 1975), China (An *et al.*, 1983), and Australia (Druce and Jones, 1971).

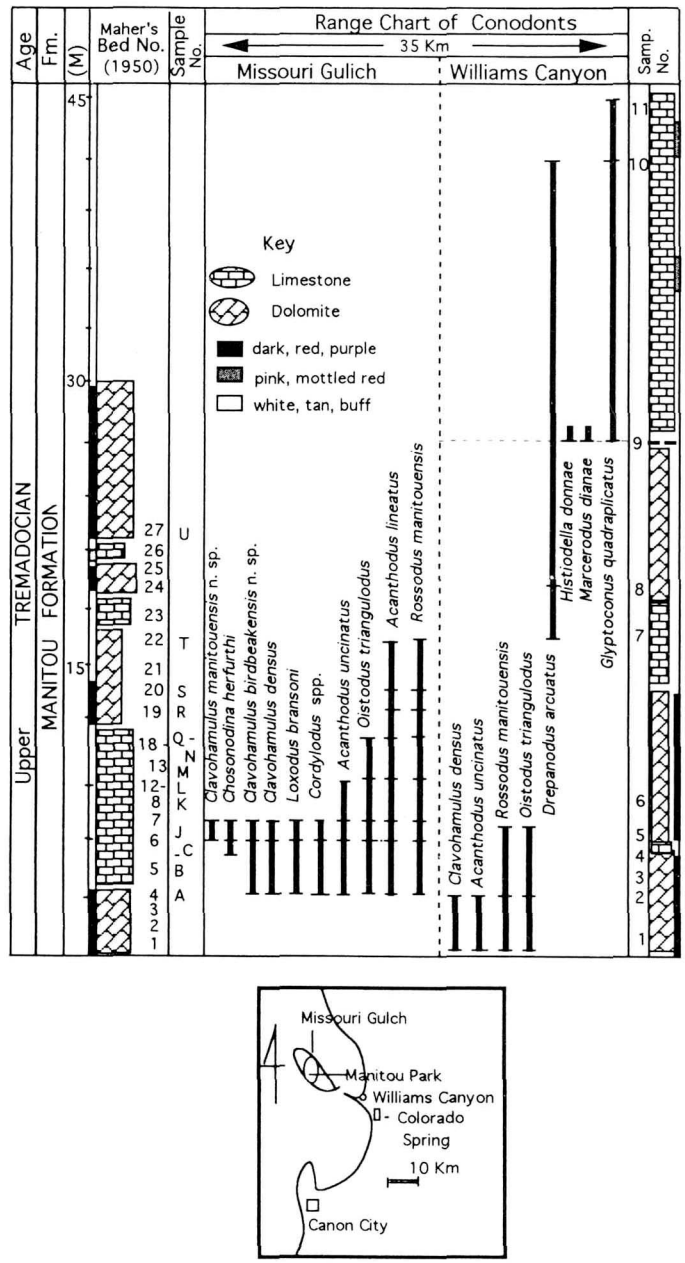
MANITOU FORMATION AND SAMPLE LOCALITIES

The Manitou Formation consists of finely to coarsely crystalline dolomites and a minor amount of limestones that is estimated at 60 meters in total thickness at its type locality in Williams Canyon. The dolomitic rocks are buff, tan, pink, and maroon and many of them are mottled in various combinations of these colors, and no fossils have been found. Conodonts occur mainly in limestone beds.

In Missouri Guluch to the northwestern part of the Manitou Park, the Manitou Formation consists chiefly of dense, red dolomites at upper part and limestones with some intercalation of thin dolomite beds at lower part. Conodonts as well as other kind of fossils have never found from the upper parts which are composed of the dolomites above 30 meters.

The deposotional enviornment of lower part may be different with upper part of the Manitou Formation. The dominance of dolomitic rocks in the upper part and of limestones in the lower part within the formation may be due to increasing of temperature and salinity in the contemporaneous sea water upwardly.

Berg and Ross (1959) reported that trilobites from the basal part of the Manitou at Missouri Gulch are species of the lowermost Ordovician and are assigned to the B, C, and D zones defined in Utah by Ross (1951). Trilobites collected from the lower part of the Manitou Formation in Williams Canyon contain only those of the D zone, but the younger species occurs higher in the E or F zones in Berg and Ross's section (1959). On the basis of these facts mentioned above Maher (1950) proposed that the uppermost 4.2 meters of strata were removed from the Manitou Formation at Williams Canyon. Our study agree well with Berg and Ross's opinion (fig. 1). The Manitou Formation overlies the Ute Pass Dolomite and is overlain by the Williams Canyon Limestone. Ethington collected 36 samples from the detailed section of the Manitou Formation in Missouri Gulch, Douglas County, Colorado and in Williams Canyon established by Maher (1950). Localities from which collections were obtained are shown in figure 1. Bed numbers refer to the detailed sections published by Maher (1950) and sample number indicates the measured number collected by Ethington for this study. 21,151 individuals were produced within the stratigraphical interval ranging from the base to the bed number 22 (about thirty meter's thickness) by Maher that consist mainly of gray to red limestones, and those correspond to sample numbers A to J in this study. They occupy 94.75 percentages of the total collections in this study.



Text - fig. 1. Columnar sections of the Manitou Formation and rang chart of the index fossils from the Williams Canyon and Missouri Gulch. The Williams Canyon, Missouri Gulch sections are from Maher (1950). Map is the index map of study areas.

CONODONT OCCURRENCE

A total of 22,323 individuals yielded from 36 samples collected from the Manitou Formation in Missouri Gulch (21 samples) and Williams Canyon (15 samples). These conodonts are assigned to 4 multielement species referable to 4 genera and 26 form species belonging to 15 genera. Two species, *Clavohamulus birdbeakensis* n. sp., *Clavohamulus manitouensis* n. sp. are newly described.

In Missouri Gulich, conodonts produced in lower part of the Manitou Formation are *Acanthodus lineatus* Furnish, *Acanthodus uncinatus* Furnish, *Acodus oneotensis Furnish, Acontiodus iowensis* Furnish, *Acontiodus propinguus* Furnish, *Chosonodina herfurthi* Müller, *Clavohamulus densus* Furnish, *Clavohamulus elongatus* Miller, *Clavohamulus birdbeakensis* n. sp., *Clavohamulus manitouensis* n. sp., *Cordylodus* spp., *Drepanodus concavus* (Branson and Mehl), *Drepanoistodus pervatus* Nowlan, *Iapetognathus preaengensis* Landing, *Loxodus bransoni* Furnish, *Monocostodus sevierensis* Miller, *"Oistodus" triangularis* Furnish, *Oneotodus costatus* Ethington and Brand, *Oneotodus erectus* Druce and Jones, *Oneotodus variabilis* Lindström, *"Rossodus" manitouensis* Ethington and Repetski, *"Scolopodus" longibasis* Seo, Lee and Ethington, *Scolopodus sulcatus* Furnish, *Teridontus nakamurai* (Nogami), *Utahconus* sp, and *Variabiliconus bassleri* (Furnish).

In Williams Canyon, conodonts are similar to condont fauna of the Missouri Gulich, but they include conodonts indicating Arenigian age, such as *Drepanodus arcuatus* Pander, *Glyptoconus quadraplicatus* Furnish, *Histiodella donnae* Repetski, *Marcerodus dianae* Fåhraeus and Nowlan which begin to appear from above sample 9.

When we compare the Manitou conodonts to those from the Dumugol Formation of Korea (Seo, 1989), Ibex, Utah (Ethington and Clark, 1981), Mississippi Valley (Furnish, 1938), El Paso of western Mexico (Repetski, 1982), the Yeli Formation of North China (An *et al.*, 1983), the Ninmaroo Formation of Australia (Druce and Jones, 1971), and the Lena River of Siberia (Abimova, 1975), the Manitou Formation might be deposited under the warm and shallow marine environment.

As shown on this figure, distribution of specimens recovered from the Manitou Formation correlate with those from Tremadocian in age of North America, Europe, China, Korea, and Australia as figure 2 and we can know that conodont fauna from the Manitou Formation is quite different with fauna of Sweden.

Most of well preserved conodonts are pale yellow displaying a color alternation index of 1 to 11/2 (Epstein *et al.*, 1977), which suggests a burial temperature of less than 100℃.

PROVINCIALISM OF EARLY ORDOVICIAN CONODONT

Lindström (1976) reported that the so-called *"Acanthodus-Chosonodina-Loxodus"* Fauna (or ACL-Fauna for short) is representative species in Tremadocian. Ethington and Clark (1971) reported Fauna C of the North American Midcontinent as an equivalent to Tremadocian Fauna in age, and representative conodonts of Fauna C are *Oistodus* sp. (=*Rossodus manitouensis* Repetski and Ethington), *Loxodus bransoni* Furnish, *Acanthodus lineatus* Furnish, *Paltodus bassleri* Furnish, *Acodus oneotensis* Furnish, *"Oistodus" triangularis* Furnish, *Clavohamulus densus* Furnish, *Paltodus spurius* Ethington and Clark, *Acontiodus propinquus* Furnish, *Chosonodina herfurthi* Müller. Repetski and Ethington (1983) considered *Rossodus manitouensis* as one of the Tremadocian index fossils. For this study we identified and analyzed conodonts from the Tremadocian and its equivalent strata in North America, North Europe, China,

Australia, Korea, and Iran, and we considered key species of Tremadocian as followings, *Acanthodus lineatus* Furnish, *Acanthodus uncinatus* Furnish, *Chosonodina herfurthi* Müller, *Clavohamulus densus* Furnish, *Loxodus bransoni* Furnish, and *Rossodus manitouensis* Repetski and Ethington.

In this study *Acanthodus lineatus* Furnish amount to 4,944 among the total of 22,323 individuals, comprising about 22 percentages of the total collections. *Acanthodus uncinatus* Furnish comes up to 1,100 individuals, comprising about 4.93 percentages of the total collections (22, 323 individuals). *Chosonodina herfurthi* Müller to 49 individuals, comprising about 0.22 percentages of the total collections (22,323 individuals). *Loxodus bransoni* Furnish reached 547 individuals, comprising about 2.45 percentages of the total collections. *Rossodus manitouensis* Repetski and Ethington reached 3,170 individuals, comprising about 1.88 percentages of the total collections. Numbers and ratio of specimens studied from North Amedrica, Korea, China, Australia and Siberia are shown on Table 1 and Table 2. And the range chart of these conodont species from the Manitou Formation is shown on Figure 1.

Acanthodus lineatus Furnish, *Acanthodus uncinatus* Furnish, *Rossodus manitouensis* Repetski and Ethington have been recovered from upper Tremadocian Formation in everywhere, while *Chosonodina herfurthi* Müller, *Loxodus bransoni* Furnish and *Clavohamulus densus* Furnish have been known from the restricted continentals (see fig. 2). *Loxodus bransoni* Furnish and *Clavohamulus densus* Furnish have been not reported from the Tremadocian of China, Korea, and Australia except North America and Siberia yet.

Repetski and Ethington (1977) reported *Loxodus bransoni* Furnish and *Chosonodina herfurthi* Müller from the Collier Shale in Arkansas and Oklahoma. They interpreted both the species as an offshore (or deep water) form, because the Collier Shale was presumably deposited under the deep-water environment.

Text - fig. 2. Distribution of conodont species identified from the Manitou Formation compared with distribution in the Dumugol Formation, *Ceratopyge* Bed, Yeli Formation, Nimaroo Formation, and Lenar River area.

AGE																																
ORDOVICIAN	CANADIAN	UPPER TREMADOCIAN		Conodont Species	*Acanthodus lineatus*	*A. uncinatus*	*Acodus oneotensis*	*Acontiodus iowensis*	*Acontiodus propinquus*	*Chosondina herfurthi*	*Clavohamulus densus*	*C. birdbeakensis* n. sp.	*C. manitouensis* n. sp.	*Cordylodus angulodus*	*Cordylodus intermedius*	*Cordylodus proaus*	*Drepanodus concavus*	*"Drepanodus "prvetus*	*Drepanoistodus* sp.	*Loxodus bransoni*	*"Oistodus" triangularis*	*Oneotodus erectus*	*Oneotus variabilis*	*"Rossodus "manitouensis*	*Scandodus* sp.	*Scolopodus longibasis*	*Scolopodus sulcatus*	*Teridontus nakamurai*	*Utahconus* sp.	*Variabiliconus bassleri*	*preaengensis*	*Appetognathus*
Korea		Dumugol Formation		Seo et al., 1991	*		*		*	*				*							*	*	*			*				*		
America		Manitou Formation		(This Study)	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
North Atlantic		Ceratopyge Bed		Lindström, 1955										*	*	*						*									
China		Yeli Formation		An et al., 1983	*	*	*		*	*			*	*	*				*				*	*			*					
Austr -alia		Ninmaroo Formation		Druce & Jones, 1971	*	*	*		*	*				*	*	*				*	*	*	*						*	*		
Siberia		Lena River		Abaimova, 1975	*		*		*					*	*	*			*	*		*	*			*	*		*			

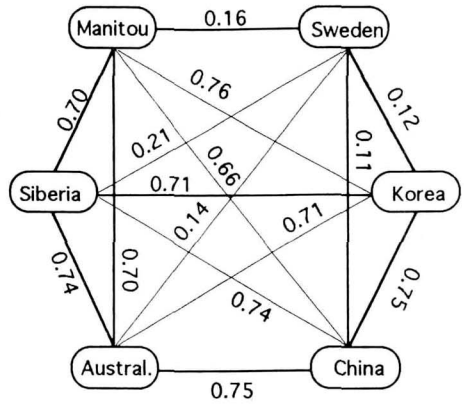
Table 1. Number of specified species specimens for five selected index fossils of Tremadocian to a total of identified conodont specimen from Korea, America, Australia, North China and Siberia. Number of individual for specified speices/total specimens reported from Korea, America, Australia, North China and Siberia.

Species / Localities	*Acanthodus lineatus*	*Acanthodus uncinatus*	*Chosonodina herfurthi*	*Loxodus bransoni*	*Rossodus manitouensis*
Korea (Dumugol Fm.)	137/1812	(?)	19/1812	0	131/1812
America (Manitou Fm)	4944/22323	1100/22323	49/22323	547/22323	3170/22323
Australia, (Ninmaroo Fm.)	49/3086	37/3086	48/3086	0	49/3086
N. China, (Yeli Fm., Tangsan)	(?)	(?)	18/1316	0	18/1316
N. China, (Yeli Fm.,Pyungchun)	(?)	(?)	34/1316	0	98/1316
Siberia, Lenna River	5/298	8/298	0	12/298	21/298

Table 2. Ratios of selected species which were reidentified by authors from Korea, America, Australia, North China and Siberia.

Species / Localities	*Acanthodus lineatus*	*Acanthodus uncinatus*	*Chosonodina herfurthi*	*Loxodus bransoni*	*Rossodus manitouensis*
Korea (Dumugol Fm.)	7.56(%)	0.00 (%)	1.05 (%)	0.00 (%)	1.71(%)
America (Manitou Fm)	22.00	4.93	0.22	2.45	13.88
Australia, (Ninmaroo Fm.)	1.56	0.00	1.05	0.00	1.57
N. China, (Yeli Fm., Tangsan)	0.00	0.00	3.82	0.00	8.47
N. China, (Yeli Fm.,Pyungchun)	0.00	0.00	2.58	0.00	7.14
Siberia, Lenna River	1.69	2.68	0.00	4.03	7.05

Trmadocian conodont faunae including *Loxodus bransoni* Furnish, and *Chosonodina herfurthi* Müller are found in shallow water as well as the deep water depositional environment at lower paleolatitude, but *Loxodus bransoni* Furnish and *Clavohamulus densus* Furnish are produced only from the shallow water depositional environment of lower paleolatitudes (Repetski and Ethington, 1977).



Text - fig. 3. Similarity index is calculated based on Simpson's formular (1960).

Ethington and Clark (1984, p. 95) reported that *Loxodus bransoni* Furnish and *Chosonodina herfurthi* Müller were collected from the Mazarn Formation of the Ouwachita Mountain in west - central Arkansas which comprise the mixed fauna formed at between North American Midcontinent fauna and North Atlantic fauna. The Mazarn Formation of the Ouachita Mountain seem to be formed at lower latitude at that time (Scotese, 1990).

These different occurrences of the species mentioned above in area and depositional environment may be due to the current of the contemporaneous sea water.

We examined a simularity coefficient indices of Simpson (1960) using the Tremadocian conodont fossils reported from various continents (fig. 3). The simularity coefficient index between the Manitou conodont fauna and the Dumugol in Korea, and the equivalent faunas in Australia, Siberia and China is 0.76, 0.70, 0.70 and 0.66, respectively while the simularity coefficient index between the Manitou conodont fauna and the *Ceratopyge* conodont fauna is 0.16. These imply that paleoenvironment of the Manitou conodont fauna was similar to those of Dumugol in Korea, Australia, Siberia and China, but different from that of *Ceratopyge* conodonts.

CONCLUSION

1. A total of 22,323 identifiable conodonts were recovered from 36 samples of the Manitou Formation, and two species ; *Clavohamulus birdbeakensis* n. sp. and *Clavohamulus manitouensis* n. sp. are newly described.
2. The recovered specimens represent 26 form species referable to 15 genera and the remainder is identified to 4 multielement species of 4 genera.
3. The Manitou conodont fauna is an early Ordovician in age and is correlated with Fauna C in North America, and those of the Dumugol Formation in Korea, the Ninmaroo Formation of Australia, and the Lena River of Siberia, respectively.

4. The Manitou Formation belong to North American Mid-continent Province, and it was deposited under the warm and shallow marine environment at low paleolatitude.
5. Simularity coefficient index between the Manitou conodont fauna and those from the Dumugol, Australia, Siberia, China, and Sweden conodont fauna is 0.76, 0.70, 0.70, 0.66 and 0.16, respectively.

SYSTEMATIC PALEONTOLOGY

Most of conodont individuals recovered from the Manitou Formation in this study represent 26 form species referable to 15 genera and these are indicated with the designation s. f. (*sensu formo*) after the name. The remainder is classified into 4 multielement species of 4 genera. In this paper the new species, *Clavohamulus birdbeakensis* n. sp. and *Clavohamulus manitouensis* n. sp., are described, and discussed. Specimens collected for this study are deposited at the Geology Department, University of Missouri-Columbia.

Genus *CLAVOHAMULUS* Furnish, 1938

Type species : *Clavohamulus densus* Furnish, 1983

Clavohamulus birdbeakensis n. sp.
Pl. 1, fig. 16, 17, 18

Diagnosis : A birdbeak-like element in lateral view, having many granules in anterior surface restrictedly.

Description : Unit is proclined and show a bird beak-like shape in lateral view. Cusp is rounded at anterior margin and keeled in posterior margin, which are straight from a curved portion to tip of cusp. The anterior margin of cusp has many granules at the projecting part. Basal part of the unit compressed anteroposteriorly so that it forms a cobra's head-like shape in posterior view. Basal cavity is shallow and forms an ovoidal shape, expanding anteriorly. White matter is observed through the entire of unit except basal margin. Surface of unit is ornamented with fine longitudinal striae.

Remarks : The morphology of this distinctive form can be clearly identified the species as a new species of *Clavohamulus*. It differs from any of the other known species in shape of apparatus. This species have been reported from lower part of the Manitou Formation and recovered from the Maher's section 6 only.

Etymology : After shape of this specimen.

Occurrence : Sample J of the Manitou Formation, Missouri Gulch Section, Douglas County, Colorado.

Type : UMC 1135. the specimen on figure 17.

Material : 190 specimens.

Clavohamulus (?) *manitouensis* n. sp.
Pl. 1, fig. 3, 4.

1971, *Clavohamulus* ? sp. Ethington and Clark, pl. 1, fig. 9.

Diagnosis : Elements bilaterally symmetrical, alate, anteriorly convex and posteriorly concave, bulged basal cavity ; concave side with a main denticle in the center.

Description : Unit is a bilaterally symmetrical, alate ramiform element. Anterior surface of unit is broadly rounded and convex while posterior side is concave with a carina like a stout median denticle. Both lateral processes are smoothly curved posteriorly and have closly fused four to five denticles on upper side of it. Basal cavity is shallow and bulged in posterior side. White matters are observed through the entire unit.

Remarks : This distinctive form is clearly distinguished from any of the other known species in morphology of unit. *Clavohamulus densus* differs from this species having the denticle on the lateral process This species was first reported from the Manitou Formation, Missouri Gulch Section, Douglas County, Colorado by Ethington and Clark (1971). This species has never reported from the other area except the Manitou Formation. This specimens product from the Maher's section 6 only.

Etymology : After name of formation producing this species.

Occurrence : Sample J of the Manitou Formation, Missouri Gulch Section, Douglas County, Colorado.

Type : UMC 1134. the specimen on figure 3.

Material : 59 specimens.

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미국 콜로라도지역의 마니토우(MANITOU)층에서 산출된 코노돈트화석

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요 약

본 연구에서 Manitou층을 잠정적으로 두 개의 부분으로 분류하였다. 즉, 다양한 종과 많은 개체가 산출되며, 주로 석회암으로 구성된 하부 층준과 코노돈트 화석이 거의 산출되지 않고, 주로 dolomite로 구성된 상부 층준으로 대별하였다. 이들 지층 하부와 상부는 서로 다른 퇴적환경하에서 퇴적되었을 것으로 추정된다. Missouri Gulich와 Williams Canyon에 분포하는 Manitou층에서 채취한 36개의 표품으로부터 총 22,323개체의 코노돈트 화석이 산출되었다. 이들 화석은 복합요소 분류 방법에 의해 4속 4종과 단순분류방법에 의해 15속 26종으로 분류하였다. *Clavohamulus birdbeakensis*와 *Clavohamulus manitouensis* 등 2종의 새로운 종이 발견되었으며, 이를 기재하였다.

Manitou층은 한국의 두무골층, 중국의 Yeli층, 호주의 Ninmaroo층 그리고 스웨덴의 *Ceratopyge*층과 각각 대비된다. Manitou층의 코노돈트 화석군은 전형적인 North American Mid - Continent 생물구에 속한다.

REFERENCE

Abaimova, G. P. 1975 : Early Ordovician condonts of the middle fork of the Lena River. Trudy Sibirskogo Nauchno - Issledovatelskogo instituta, *Geofiziki Mineralnogo Sirya* (SNIGGIMS), vyp. 207, 129p.

An, T. X., Zhang F., Xiang, W., Zhang, Y., Zhang, W., Xu, W., Zhang, H., Jiang, D., Yang, C., Lin, L., Cui, Z. and Yang, Z. 1983 : The Conodonts of North China and the adjacent Regions, Science Publishing Company, Beijing, 223p. (in Chinese).

Berg, R. R. and Ross, JR. R. J. 1959 : Trilobites from the Peerless and Manitou Formations, Colorado. *Journal of Paleontology,* v. 33, p. 106 - 119.

Bergström, S. M., Epstein, A. G. and Epstein, J. B. 1972 : Early Ordovician North Atlantic Province conodonts in eastern Pennsylvania. *U. S. Geological Survey Professional Paper,* v. 800, p. D37 - D44.

PLATE 1

Sample numbers from which the specimens were obstained are given in the parenthesis. 1 - 2, *Clavohamulus densus* Furnish s. f., basal views of both, 1, UMC 1134 - 18 (J), ×80, 2, UMC, 1134 - 19 (1), ×80 ; 3 - 4, *Clavohamulus manitouensis* n. sp. s. f., 3, holotype, basal view, UMC 1134 - 20 (G), ×80, 4, paratype, basal view, UMC 1135 - 1 (J), ×80 ; 5, *Clavohamulus elongatus* Miller s. f., basal view, UMC 1135 - 2 (F), ×60 ; 6 - 7, *Iapetognathus preaengensis* Landing s. f., lateral views of both, 6, UMC 1135 - 3 (H), ×80, 7, UMC 1135 - 4 (H) ×60 ; 8, *Chosonodina herfurthi* Müller s. f., convex side view, UMC 1135 - 5 (J), ×80 ; 9, *Cordylodus rotundatus* Pander s. f., inner lateral view, UMC 1135 - 6 (D), ×80 ; 10 - 11, *Cordylodus proavus* Müller s. f., inner lateral views of both, 10, UMC 1135 - 7 (J), ×80, 11, UMC 1135 - 8 (A), ×60 ; 12 - 13, *Cordylodus angulatus* Pander s. f., inner lateral views of both, 12, UMC 1135 - 9 (E), ×80, 12, UMC 1135 - 10 (E), ×60 ; 14, *Cordylodus lenzi* Müller s. f., inner lateral view, UMC 1135-11 (G), ×80 ; 15, *Loxodus bransoni* Furnish s. f., lateral view, UMC 1135 - 12 (J), ×80 ; 16 - 18, *Clavohamulus birdbeakensis* n. sp. s. f., 16, paratype, posterolateral view, UMC 1135 - 13 (J), ×80, 17, holotype, anterolateral view, UMC 1135 - 14 (J), ×80, 18, paratype, anterolateral view, UMC 1135 - 15 (J), ×80 ; 19 - 20, *Acodus oneotensis* Furnish s. f., lateral views of both, 19, UMC 1135 - 16 (1), ×80, 20, UMC 1135 - 17 (I), ×80 ; 21, *Acanthodus lineatus* (Furnish), s. f., lateral view, UMC 1135 - 18 (F), ×80 ; 22 - 23, *Acanthodus uncinatus* Furnish s. f., lateral views of both, 22, UMC 1135 - 19 (J), ×80, 23, UMC 1135 - 20 (J), ×80 ; 24, *Acontiodus iowensis* Furnish, 1938 s. f., posterior view, UMC 1136 - 1 (G), X60 ; 25, *Acontiodus propinquus* Furnish s. f., posterior view, UMC 1136 - 2 (J), ×80 ; 26 - 27, *Drepanoistodus pervatus* Nowlan, 26, lateral view of suberectiform element, UMC 1136 - 3 (H), ×80, 27, lateral view of drepanodiform element, UMC 1136 - 4 (J), ×60 ; 28 - 29, *Drepanodus concavus* (Branson and Mehl), 28, lateral view of drepanodiform element, UMC 1136 - 5 (E), ×80, 29, lateral view of suberectiform element, UMC 1136 - 6 (E), ×80 ; 30 - 33, *Oistodus triangularis* (Furnish), 30, 31, lateral views of distacodiform element, 30, UMC, 1136 - 7 (J), ×80, 31, UMC 1136 - 8 (J), ×60, 32 - 33, lateral views of oistodiform element, 32, UMC 1136 - 9 (C), ×80, 33, UMC 1136 - 10 (D), ×60.

PLATE 1

Cloud, P. E., JR., and Barnes, Y. E. 1948 : The Ellenburger Group of the central Texas. *Texas University Bureau of Economical Geology,* v. 4621, 473p.

Cross, C. W. 1894 : Description of the Pikes Peak sheet, Colorado. U. S. Geological Survey, Geologic Atlas, Pikes Peak Folio, v. 7, 5p. maps.

Druce, E. C., and Jones, P. J. 1971. Cambro - Ordovician conodont from the Burke River Structural Belt, Queensland. *Australia Bureau of Mineral Resources Bulletin,* v. 110, 167p.

Epstein, A. G., Epstein, J. B. and Harris, L. D. 1977 : Conodont Color Alteration : an index to organic metamorphism. *U. S. Geological Survey Professional Paper,* v. 995, 27p.

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

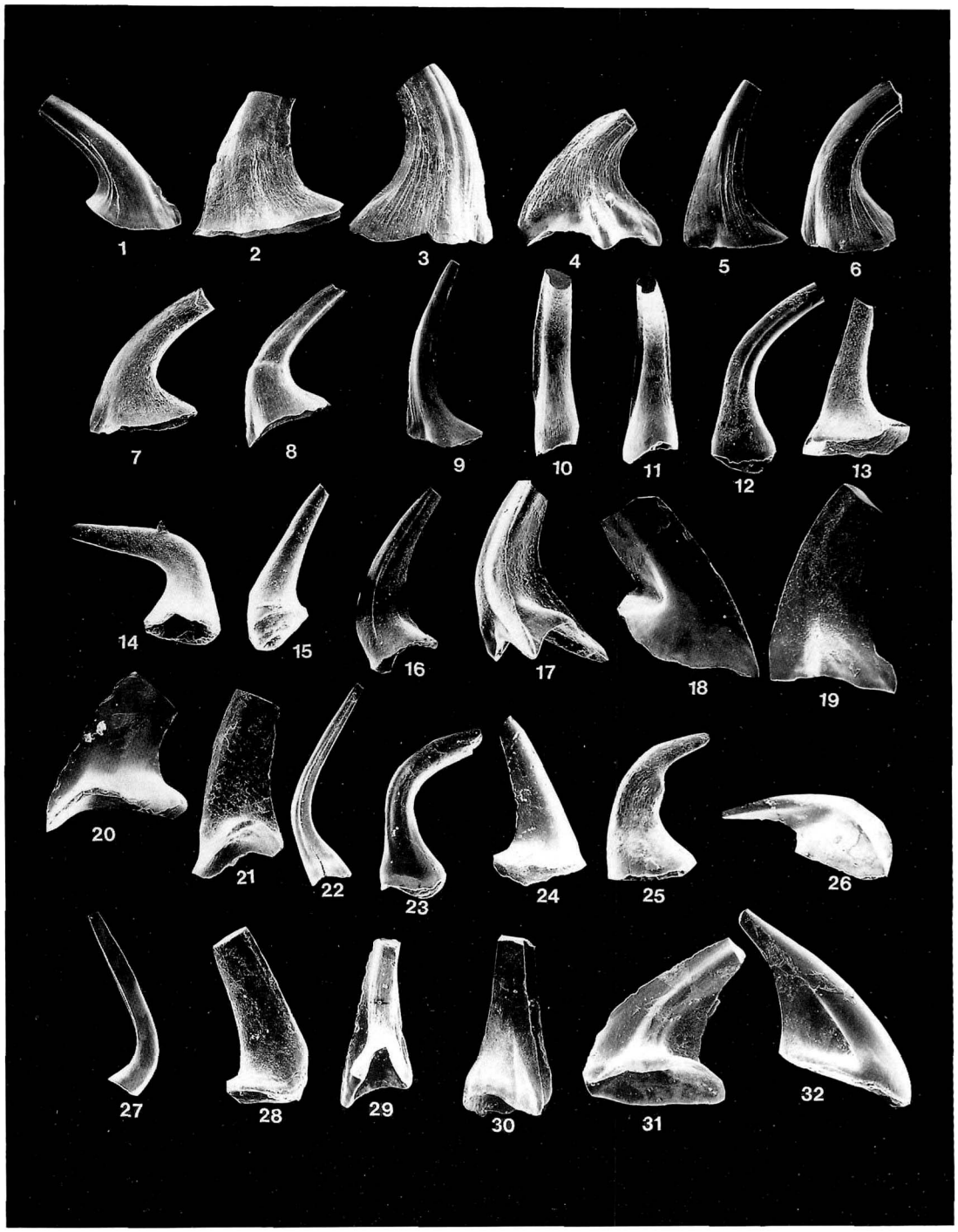
Ethington, R. L., and Clark, D. L. 1981 : Lower and Middle Ordovician Conodonts from the Ibex Area, western Millard County, Utah. *Brigham Young University Geology Studies,* v. 28, 127p.

Ethington, R. L., and Repetski, J. E. 1984 : Paleobiogeographic distribution of the early Ordo-

PLATE 2

Sample numbers from which the specimens were obstained are given in the parenthesis. 1 - 9, *Oistodus triangularis* (Furnish), 1, lateral view of oistodiform element, UMC 1136 - 11 (K), ×80, 2, 5, 9, outerlateral views of suberectiform element, 2, UMC 1136 - 12 (P), ×60, 5, UMC 1136 - 13 (R), ×80, 9, UMC 1136 - 14 (S), ×60, 3, 4, outerlateral views of acodiform element, 3, UMC 1136 - 15 (O), ×80, 4, UMC 1136 - 16 (M), ×70, 6 - 8, lateral views of drepanodiform element, 6, UMC 1136 - 17 (Q), ×80, 7, UMC 1136 - 18 (R), ×80, 8, UMC 1136 - 19 (R), ×60 ; 10 - 12, *Scolopodus longibasis* Seo, Lee and Ethington s. f., 10, posterolateral view of asymmetrical element, UMC 1136 - 20 (C), ×80, 11, posterolateral view of symmetrical element, UMC 1137 - 1 (C), ×80, 12, lateral view of symmetrical element, UMC 1137 - 2 (C), ×60 ; 13, *Oneotodus erectus* Druce and Jones s. f., lateral view, UMC 1137 - 3 (A), ×80 ; 14, *Teridontus nakamurai* (Nogami), lateral view, UMC 1137 - 4 (A), ×80 ; 15, *Oneotodus* sp., lateral view, UMC 1137 - 5 (A), ×80 ; 16, 22, *Variabiloconus bassleri* (Furnish), lateral views of both, 16, UMC 1137 - 6 (C), ×80, 22, UMC 1137 - 7 (C), ×60 ; 17 - 21, *Rossodus manitouensis,* Repetski and Ethington, 17, 21, lateral views of acontiodiform element, 17, UMC 1137 - 8 (J), ×80, 21, UMC 1137 - 9 (J), ×80, 18, lateral view of oistodiform element, UMC 1137 - 10 (K), ×80, 19, 20, lateral views of drepanodiform element, 19, UMC 1137 - 11 (M), 20, UMC 1137 - 12 (P), ×80 ; 23, *Scolopodus longibasis* Seo, Lee and Ethington s. f., lateral view of asymmetrical element, UMC 1137 - 13 (I), ×80 ; 24, *Drepanoistodus pervatus* Nowlan, lateral view of suberectiform element, UMC 1137 - 14 (O), ×80 ; 25, gen. et sp. indet. A, lateral view, UMC 1137 - 15 (D), ×80 ; 26, gen. et sp. indet. B, lateral view, UMC 1137 - 16 (J), ×70 ; 27, *Oneotodus simplx* (Furnish) s. f., lateral view, UMC 1137 - 17 (S), ×80 ; 28, *Scandodus furnishi* Lindström s. f., lateral view, UMC 1137 - 18 (H), ×60 ; 29, *Protopanderodus leei* Repetski, posterior view of acontiodiform element, UMC 1137 - 19 (H) ; 30, *Glyptoconus quadraplicatus* Furnish s. f., posterolateral view, UMC 1137 - 20 (J), ×80 ; 31, *Scandodus* sp., lateral view, UMC 1138 - 1 (F), ×80 ; 32, *Utahconus* sp., lateral view, UMC 1138 - 2 (E), ×80.

PLATE 2



vician conodonts in central and western United States. *Geological Society of America Special Paper,* v. 196, p. 89 - 101.

Furnish, W. M. 1938 : Conodonts from the Prairie du Chien Beds of the Upper Mississippi Valley. *Journal of Paleontology,* v. 12, p. 318-340.

Hintze, L. F., 1952 : Lower Ordovician trilobites from western *Utah and estern Nevada*|*Utah Geology and Mineralogical Survey, Bulletin* v. 48, 249p.

Lindström, M. 1976 : Conodont Paleogeography of the Ordovician, p. 501 - 522. *In* Bassett, M. G. (ed.), *The Ordovician System, Proceedings of a Paleontological Association Symposium Birmingham,* University of Wales Press and National Museum of wales. Cardiff.

Majer, J. C. 1950 : Detailed sections of Pre-Pennsylvanian rocks along the Front Range of Colorado. *U. S. Geological Survey Circular* v. 68, 20p. map.

Müller, K. J. 1964 : Conodonten aus dem unteren Ordovicium von Südkorea. *Neues Jahrbuch fur Geologie und Palaontologie* Abhandlungen, v. 119, p. 93 - 102.

Richardson, G. B. 1915 : Description of the Castle Rock quadrangle, Colorado. *U. S. Geological Survey, Geologic Atlas, Castle Rock Folio,* v. 198, 13p. maps.

Repetski, J. E. 1982. Conodonts from El Paso Group (Lower Ordovician) of westernmost Te-

PLATE 3

All specimens are produced from the Manitou Formation. Sample numbers from which the specimens were obstained are given in the parenthesis. 1, *Proconodontus posterocostatus* Miller s. f., lateral view, UMC 1138 - 3 (GL35), ×80, 2 - 3, 6, *Eoconodontus notchpeakensis* (Miller), lateral views of all, 2, UMC 1138 - 4 (GL35), ×80, 3, UMC 1138 - 5 (GL35), ×80, 6, UMC 1138 - 6 (GL35), ×80 ; 4, 7, *Prooneotodus rotundatus* (Müller), lateral views of both, 4, lateral view, UMC 1138 - 7 (GL39), ×80, 7, lateral view, UMC 1138 - 8 (GL39), ×80 ; 5, *Cambrooistodus minutus* (Miller), lateral view, UMC1138 - 9 (GL39) ; 8 - 9, *Cambrooistodus cambricus* Miller s. f., lateral views of both, UMC 1138 - 10 (GL39), ×90, 9, UMC 1138 - 11 (GL39), ×90 ; 10, 13, *Cordylodus proavus* (Müller) s. f., lateral views of both, 10, UMC 1138 - 12 (GL41), ×80, 13, UMC 1138 - 13 (GL41), ×60 ; 11 - 12, *Cordylodus rotundatus* Pander s. f., inner lateral views of both, 11, UMC 1138 - 14 (GL41), ×90, 12, UMC 1138 - 15 (GL41), ×80 ; 14, *Cordylodus intermedius* Furnish s. f., inner lateral view, UMC 1138 - 16 (GL41), ×80 ; 15, *Cordylodus prion* Lindström s. f., inner lateral view, UMC 1138 - 17 (GL41), ×80 ; 16 - 17, *Paltodus spurius* Ethington and Clark, s. f., inner lateral views of both, 16, UMC 1138 - 18 (GL41), ×60, 17, UMC 1138 - 19 (GL41), ×60 ; 18 - 20, *Rossodus utahensis* (Miller), 18, posterolateral view, UMC 1138 - 20 (GL41), ×80, 19, lateral view, UMC 1139 - 1 (GL41), ×60, 20, lateral view, UMC 1139 - 2 (GL41), ×60 ; 21, *Rossodus manitouensis* Repetski and Ethington, inner lateral view of acontiodiform element, UMC 1139 - 3 (GL49), ×80 ; 22, *Acontiodus iowensis* Furnish s. f., lateral view, UMC 1139 - 4 (GL49), ×80 ; 23, *Drepanoistodus* sp. lateral view, UMC 1139 - 5 (WC11), ×80 ; 24, *Macerodus dianae* Fåhraeus and Nowlan, lateral view, UMC 1139 - 6, (WC9) ×90 ; 25, *Scolopodus* sp., lateral view, UMC 1139 - 7 (WC13), ×80 ; 26, *Monocostodus sevierensis* (Miller) s. f., lateral view, UMC 1139 - 8 (WC11), ×80 ; 27, *Drepanodus arcuatus* Pander, posterior view, UMC 1139 - 9 (WC11), ×60 ; 28 - 29, *Histiodella donnae* Repetski s. f., posterior views of both, 28, UMC 1139 - 10 (WC9), ×80, 29, UMC 1139 - 11 (WC9), ×80.

PLATE 3

xas and southern New Mexico. *New Mexico Bureau of Mines and Mineral Resources Memoir,* v. 40, 120p.

Repetski, J. E., and Ethington, R. L. 1977 : Conodonts from graptolite facies in the Ouachita Mountains, Arkansas and Oklahoma : *Arkansas Geological Commission, Symposium on the Geology of the Ouchita Mountains,* v. i, p. 92 - 106.

Repetski, J. E., and Ethington, R. L. 1983 : *Rossodus manitouensis* (Conodonta), a new Early Ordovician index fossil. *Journal of Paleontology,* v. 57, p. 289 - 301.

Ross, R. J., JR. 1951 : Stratigraphy of the Garden City formation in northestern Utah and its trilobite faunas : *Yale Peabody Natural Historical Musium Bulletin* 6, 155p.

Ross, R. J., JR. 1976 : Ordovician paleogeography of western United States. *In* Bassett, M. G. (ed.), *The Ordovician System, Proceedings of a Paleontological Association Symposium* Birmingham, University of Wales Press and National Museum of wales, Cardiff. p. 73 - 105.

Scotese, C. R. 1990 : Atlas of the Phanerzoic Plate Tectonics Reconstructions International Lithospher Program (IUGG - IUGS). *Paleomap Project Technical* Report no. 10 - 90 - 1.

Seo, K. S. 1989 : Conodonts biostratigraphy of the Dumugol Formation (Lower Ordovician) in the Baegunsan Synclinal Zone, Yeongweol and Samcheog area, Kangweon - Do, korea (Ph. D dissertation). Yonsei University, 185p.

Simpson, G. G. 1960 : Notes on the measurement of faunal resemblance. *American Journal of Science,* v. 258, p. 300 - 311.