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中国奥陶纪牙形刺分区和生物地层*

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内 容 提 要

根据牙形刺动物群的性质和分布,中国奥陶纪牙形刺在 Tremadoc 以后可以明显区分为两大地理区,即华南区和华北区。华南区的牙形刺动物群几乎与北大西洋型的牙形刺动物群完全一致,属冷水型动物群。华北区的牙形刺动物群与北美中大陆区的牙形刺动物群较为接近,但有自己的地方型特征,属暖水动物群。总结了两个不同地理区的牙形刺生物地层,并较详细地进行了不同区的国内外对比。

关键词 奥陶纪 牙形刺 地理区 生物地层 中国

CONODONT PROVINCES AND BIOSTRATIGRAPHY IN ORDOVICIAN OF CHINA

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Summary

Although detailed conodont work in the Ordovician of China has been carried out for only a decade, much information is now available about the horizontal and vertical distribution of these fossils throughout the country. Ordovician rocks are widespread in China, some of the sections

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are among the finest known anywhere in the world, and the Ordovician conodont faunas are both diverse and abundant. Tremadocian conodont faunas do not exhibit notable provincial differentiation but younger Ordovician faunas are strikingly different in North and South China. This justifies the recognition of two conodont faunal provinces, the North China Province and the South China Province. The conodonts of the former province show affinity to those of the Midcontinent Faunal Region whereas the latter province shares a remarkably large number of species with the Atlantic Faunal Region. Each of these provinces has many species not recorded elsewhere and these apparent endemics give the Chinese faunas their distinctive character. The striking difference between these provincial faunas is attributed to regional environmental control; the North Chinese faunas are interpreted to have inhabited a low－latitude shallow tropical sea with possibly raised salinity, and the South Chinese faunas a mid－latitude, possibly deeper, sea having normal salinity.

Recent studies have shown that conodonts are extremely useful as index fossils in the Ordovician of China; indeed, they now rival the graptolites as the most important group for local and regional correlations. Because of the pronounced provincial differentiation, separate zonal schemes are used for the North and South Province respectively. By means of the North China provincial scheme of 12 zones, correlations can be made readily within that province but correlation to other areas, such as the North American Midcontinent, is difficult and uncertain in several stratigraphic intervals. The South China Province scheme of 18 zones and 4 subzones is closely similar to that used in the Atlantic Faunal Region, making it possible to establish surprisingly detailed long－range correlations with, in particular, the Baltoscandic region.

INTRODUCTION

Ordovician sediments representing a wide variety of marine depositional environments are well developed and widely distributed in China. In most areas they form a continuous sequence of richly fossiliferous limestones containing conodonts, trilobites, cephalopods, graptolites and brachiopods, which provide excellent opportunities for the study of Ordovician biostratigraphy and biogeographical provinces. The first report of Ordovician conodonts in China is that of An and Yang (1980). Our knowledge of Chinese Ordovician conodonts has rapidly increased during the last decade, especially by the publication of a monograph entitled "The Conodonts of North China and the Adjacent Regions," by An *et al*. (1983). Other important papers describing Ordovician conodonts of China include An (1981), Ni (1981), An and Ding (1982), Wang (1983), Dong (1985), Zhou *et al*. (1984), Wang (1984), An and Ding (1985), Jiang and An (1985), Chen *et al*. (1985), An *et al*. (1985), Wang and Lun (1984), Chen *et al*. (1986), and An (1987). These and other studies have resulted in a very large database particularly from key sections such as Dayangcha, Hunjiang City, Jilin Province; Zhaogezhuang, Tangshan City and Wushan, Lulong County, Hebei Province; Tianshifu, Benxi

City, Liaoning Province; Zhuozishan, Haibowan City, Inner Mongolia; Pingliang County, Gansu Province; Huanghuachang, Yichang City, Hubei Province; Tangshan, Nanjing City, Jiangsu Province; and Hexian County, Anhui Province.

Ordovician conodonts are extremely abundant and diversified both in North and South China. At the beginning of the Ordovician, the existence of conodont provincialism is doubtful in China. Most conodonts, such as *Cordylodus proavus*, *C. intermedius*, *C. prion*, *C. lindstromi*, *C. angulatus*, *C. rotundatus*, *Monocostodus sevierensis*, *Chosonodina herfurthi*, *Glyptoconus quadraplicatus*, *Utahconus utahensis* and most species of the genus *Proconodontus*, are widely distributed in both North and South China. After the time of deposition of the Yehli and Nantsinkuan Formations, conodont provincialism became apparent, and two conodont faunal provinces, the North and South China Provinces, can be recognized.

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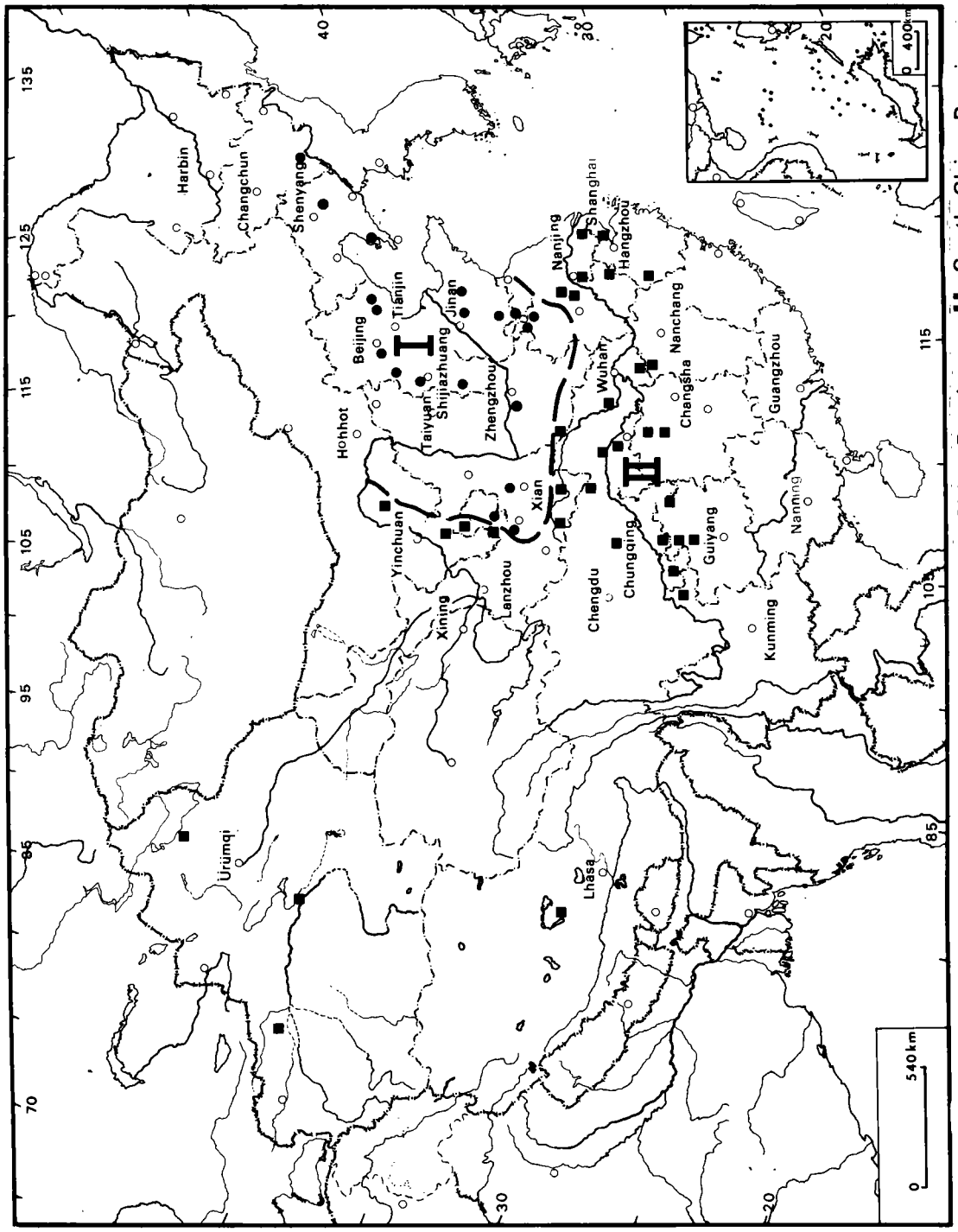
CONODONT PROVINCES IN CHINA

Based on the occurrence of different types of sediments and biofacies in the Ordovician, Mu (1983) subdivided China into six regions. They are: (1) North China, (2) Central China, (3) South China, (4) Northwest China, (5) Xizang-Yunnan, and (6) Junggar-Xing'an regions. These represent three ecostratigraphical types, and the conodonts found in these different regions represent two biogeographic units (Fig. 1): (1) the North China Province, which has faunas that are similar to those in the Midcontinent Faunal Region, and (2) the South China Province, which has faunas that are similar to those in the Atlantic Faunal Region. The Midcontinent Faunal Region is particularly well-known from the North American Midcontinent and Siberia, but has also been recognized in Australia and Korea (Bergström, 1973a; Fåhraeus, 1976). Sweet and Bergström (1984) and Bergström (1989) has subdivided the Midcontinent Faunal Region into several provinces. Barnes and Fåhraeus (1975) and Sweet and Bergström (1984) considered its faunas to have been adapted and largely restricted to low latitude epeiric seas characterized by raised temperature and salinity. As is the case in the Midcontinent Faunal Region, the Ordovician of North and Northeast China, including Jilin, Liaoning, Hebei, Shandong, Shanxi, Henan, and part of Anhui and Jiangsu Provinces, represents a restricted shallow low-latitude depositional environment characterized by raised temperature and salinity. The conodont faunas in this province are similar to those of the North American Midcontinent region, especially at the generic level. Some species are in common between these

area, for instance, *Glyptoconus quadraplicatus*, *Chosonodina herfurthi*, *Belodina compressa*, and *Microcoelodus symmetricus*. Other species, including *Serratognathus bilobatus*, *S. diversus*, *Tangshanodus tangshanensis*, *Paraserratognathus obesus*, *P. paltodiformis*, *P. problematicus*, "*Loxodus*" *dissectus*, *Aurilobodus leptosomatus*, *A. aurilobus*, *A. serratus*, *Plectodina onychodonta*, *Erraticondon tangshanensis*, *Rhipidognathus laiwuensis*, and *R. maggolensis*, which are characteristic species in the North China Province, are not recorded from the North American Midcontinent. In a numerical assessment of global Lower Paleozoic conodont provincialism, Bergström (1989) recognized a Chinese Province within the Midcontinent Faunal Region, and the present study provides further evidence of the provincial distinctiveness of the Ordovician conodont faunas from North China.

The faunas of the South China Province, which occur in the Yangtze River Region (including Gansu, Sichuan, Hubei, part of Anhui, Jiangxi and Jiangsu), Zhejiang, West Yunnan, the Zhuozishan area of Inner Mongolia, Tibet and Xinjiang, are, in general, similar to those of the Atlantic Faunal Region. The latter is considered to represent normal marine conditions with faunas containing some cosmopolitan elements that are present at low as well as high latitudes. The Yangtze River Region, separated from the North China Region by the Qinling－Huaiyang Suture Line, represented a normal outer shelf, deeper water environment of deposition during much of Ordovician time. The Yangtze River Region was within 30°—40° of the equator during the Ordovician, and its post-*Serratognathus* Zone conodont faunas are very similar to those of the Atlantic Faunal Region. Species in common include, among others, *Paltodus deltifer*, *Prioniodus elegans*, *Oepikodus evae*, *Baltoniodus triangularis*, *B. navis*, *Paroistodus originalis*, *Amorphognathus variabilis*, *Eoplacognathus suecicus*, *Pygodus serra*, *P. anserinus*, *Hamarodus europaeus*, and *Amorphognathus ordovicicus*. However, the post-Tremadocian portion of the Ordovician succession in South China contains a considerable number of species not recorded elsewhere in the North Atlantic Faunal Region such as *Serratognathus diversus*, *S. bilobatus*, *Belodella devonica*?, *Bergstroemognathus hubeiensis*, *Oepikodus communis*, *Oistodus meseaus*, *Amorphognathus antivariabilis*, *Yaoxianognathus yaoxianensis*, *Icriodella baotaensis*, *Columbodina perpusillus*, *Honghuayuangnathus ichangensis*, *Erraticodon hexianensis*, and *Nasusgnathus dolonus*. It should be pointed out that the Zhuozishan area, Inner Mongolia, and Pinglian County, Gansu Province were part of the North China Sea in Ordovician time, but conodont faunas from these areas belong to the South China Province. These areas were transitional between the North China Platform and the Qiliangshan Geosyncline, with greater water depth and presumably colder water temperatures than in the North China Region. This may explain why the conodont faunas in the Northwest China Region are similar to those of the North Atlantic Faunal Region, and different from those of the North China Province.

As mentioned above, Ordovician conodonts are extremely abundant and diversified in both North and South China. During earliest Ordovician time, there is no clear evidence of conodont



Text-fig. 1 Sketch-map showing location of collecting sites and the distribution of conodont faunal provinces in China

provincialism. During the deposition of the Fenghsiang Formation the *Paltodus deltifer* and *Paroistodus* faunas found in the Atlantic Faunal Region appeared in the South China Province. They are very different from the *Scalpellodus tersus* Fauna found in the North China Province at the base of the Liangchiashan Formation. However, during the deposition of the Honghuayuan and middle Liangchiashan Formations, some important index species, such as *Serratognathus bilobatus*, *S. diversus*, *Bergstroemognathus extensus*, and *B. hubeiensis*, occurred in both the South and North China Provinces. Of these, *Serratognathus* is unknown outside East Asia, *B. extensus* is previously known from South America and North America, and *B. hubeiensis* is recorded only from China. Some species, such as *Paroistodus proteus* and *Juanognathus variabilis*, occurred in China only in the South China Province. After the deposition of the Honghuayuan and Liangchiashan Formations, conodont provincialism became very apparent. Some important species characteristic of the Atlantic Faunal Region, such as *Oepikodus evae*, *Paroistodus originalis*, *Periodon aculeatus*, *Eoplacognathus elongatus*, *E. reclinatus*, *E. lindstroemi*, *E. foliaceus*, *Cahabagnathus sweeti*, *Pygodus serra*, *P. anserinus*, *P. anitae*, *Hamarodus europaeus*, and *Polonodus* – like elements, occur in the South China Province but have never been found in the North China Province. On the other hand, some important species, such as *Aurilobodus aurilobus*, *A. serratus*, "*Loxodus*" *dissectus*, *Microcoelodus asymmetricus*, *M. symmetricus*, *Paraserratognathus obesus*, *P. paltodiformis*, *Tangshanodus tangshanensis*, *Rhipidognathus laiwuensis* and *R. maggolensis*, which occur in the North China Province, have never been found in the South China Province.

The distribution of two provincial conodont faunas is shown on Text-fig. 1.

SOUTH CHINA PROVINCE CONODONT ZONES

A succession of 18 conodont zones and 4 subzones can be recognized in the Ordovician of the South China Province. This zonal sequence and its relationships with those of other fossil groups are discussed below. For a summary, see Table Ⅰ and Ⅱ.

1. *Cordylodus proavus* Zone

The lower and upper limits of this zone are marked by the first occurrences of *Cordylodus proavus* and *C. intermedius* or *Monocostodus sevierensis* respectively. The characteristic species is *Cordylodus proavus*. This zone has been found in the upper part of the Sanyoudong Formation at Huanghuachang, Yichang in Hubei, and in the upper part of the Upper Cambrian in Anhui, Hunan, and Guizhou.

2. *Cordylodus intermedius* Zone

This zone is characterized by the occurrence of *Cordylodus intermedius*, *C. lindstromi*, *C. prion*, *Hirsutodontus simplex*, *Monocostodus sevierensis*, *Utahconus utahensis*, and *Albiconus postcostatus*. The lower and upper limits of this zone are marked by the first occurrences of *Cordylodus intermedius* and *C. angulatus* respectively. This zone corresponds bro-

Tab. I Correlation of Lower Ordovician conodont, graptolite, and trilobite zones in the South China Province

Series	Formation	SOUTH CHINA PROVINCE	
		Conodont Zone	Graptolite and Trilobite Zone
Lower Ordovician	Kuniutan Fm.	*Eoplacognathus suecicus* Zone	*Amplexograptus confertus* Zone
		Amorphognathus variabilis Zone	
	Dawan Fm.	*Paroistodus originalis* Zone	*Undulograptus austrodentatus* Zone
		Baltoniodus navis Zone	*Oncograptus magnus* Zone
		Baltoniodus triangularis Zone	
		Oepikodus evae Zone	*Azygograptus suecicus* Zone *Didymograptus deflexus* Zone
	Honghuayuan Fm.	*Serratognathus* Zone	*Tetragraptus approximatus* Zone
	Fenghsiang Fm.	*Paltodus deltifer* Zone	*Acanthograptus sinensis* and *Tungtzuella* Zone
	Nantsinkuan Fm.	*Glyptoconus quadraplicatus* Zone	*Dactylocephalus dactyloides* - *Asaphellus inflatus* Zone
		Cordylodus angulatus Zone	
		Cordylodus intermedius Zone	*Rhabdinopora flabelliformis* Zone
	Sanyoudong Fm.	*Cordylodus proavus* Zone	

adly to the *Rhabdinopora* (formerly *Dictyonema*) *flabelliformis* Graptolite Zone and to the *Cordylodus intermedius* and *C. lindstromi* Zones of North China. It occupies an interval of 14.4m in the uppermost part of the Sanyoudong Formation at Huanghuachang, Yichang, Hubei and in the lowermost Ordovician in Anhui, Zhejiang, Jiangsu, Hunan, and Sichuan.

3. *Cordylodus angulatus* Zone

This zone is characterized by *Cordylodus angulatus*, *C. rotundatus*, *Chosonodina herfurthi*, *Rossodus manitouensis* and *Acanthodus costatus*. The lower and upper limits of this zone are marked by the first occurrences of *Cordylodus angulatus* and *Glyptoconus quadraplicatus* respectively. This zone, which corresponds to the *Cordylodus angulatus* Zone and the lower part of the *Glyptoconus quadraplicatus* – *Chosonodina herfurthi* Zone of North China, has been found in the lower part of the Nantsinkuan Formation. The unit consists of light-grey, grey biosparite and grey skeletal microsparite with dolomitic limestone. It is associated with the *Dactylocephalus dactyloides* – *Asaphellus inflatus* Fauna.

Tab. Ⅱ　Correlation of Middle and Upper Ordovician conodont, graptolite, and cephalopod zones in the South China Province

Series	Formation	SOUTH CHINA PROVINCE	
		Conodont Zone	Graptolite and Cephalopod Zone
Middle and Upper Ordovician	Wufeng Fm.	*Amorphognathus ordovicicus* Zone	*Diplograptus bohemicus* Zone
	Pagoda Fm.	*Protopanderodus insculptus* Zone	*Amplexograptus gansuensis* Zone
		Hamarodus europaeus Zone	*Sinoceras chinense* Zone
	Miaopo Fm.	*Prioniodus alobatus* Zone	*Nemagraptus gracilis* Zone
		Prioniodus variabilis Zone	
		Pygodus anserinus Zone	
	Kuniutan Fm.	*Pygodus serra* Zone	*Hustedograptus teretiusculus* Zone
		Eoplacognathus reclinatus Zone	*Didymograptus murchisoni* Zone
		Eoplacognathus foliaceus Zone	

4. *Glyptoconus quadraplicatus* Zone

The characteristic species of this zone is *Glyptoconus quadraplicatus*, the first occurrence of which marks the base of this zone. The zone is equivalent to the upper part of the *Glyptoconus quadraplicatus* – *Chosonodina herfurthi* Zone of North China. This interval was named by An *et al*. (1981) the *Scolopodus quadraplicatus* Zone and by Zeng *et al*. (1983) the *Paltodus deltifer pristinus* – *Glyptoconus quadraplicatus* Zone.

This zone occurs in the middle and upper parts of the Nantsinkuan Formation at the Huanghuachang Section, Yichang, Hubei Province. The formation is light-gray, medium to thick-bedded, intersparrudite, skeletal intraclastic limestone, and biolimestone.

5. *Paltodus deltifer* Zone

The entire Fenghsian Formation in the Yichang area, which is mainly a bioclastic limestone with yellowish-green shales, and the upper part of the Lunshan Formation in the Nanjing area, belong to the *Paltodus deltifer* Zone. Part of this zone is equivalent to the *Acanthograptus sinensis* and *Tungtzuella* Zones and part to the *Adelograptus* – *Kiaerograptus* Zone. The lower and upper limits of this zone are marked by the first occurrences of *Paltodus*

deltifer and *Serratognathus*, respectively.

6. *Serratognathus* Zone

The Honghuayuan Formation in the Yichang and Nanjing areas is referred to the *Paltoceras – Manchuroceras* and *Coreanoceras* Zones, and is characterized by *Serratognathus bilobatus*, *S. diversus*, *Paroistodus proteus*, *Triangulodus bicostatus*, *Bergstroemognathus hubeiensis*, and *B. extensus*. This unit is recognized as the *Serratognathus* Zone. Its lower and upper limits are marked by the first occurrences of *Serratognathus* and *Oepikodus evae* respectively. The upper part of this zone is equivalent to the *Prioniodus elegans* Zone in Zhejiang where it is associated with the *Didymograptus deflexus* Graptolite Fauna.

7. *Oepikodus evae* Zone

This interval, part of which corresponds to the lower part of the *Azygograptus suecicus* Graptolite Zone in the Dawan Formation at Yichang, Hubei Province and in the Nanjing, Zhejiang and South Anhui areas, is characterized by *Oepikodus evae*, *Protopanderodus gradatus*, *Juanognathus variabilis*, *Triangulodus brevibasis*, *Bergstroemognathus hubeiensis*, and *B. extensus*. The lower and upper boundaries of this zone are marked by the first occurrences of *Oepikodus evae* and *Baltoniodus triangularis* respectively. This zone is found in the North Atlantic area (Lindström, 1971; Bergström, 1988), North America (Ethington, 1972; Landing, 1976), South America (Serpagli, 1974), and Australia (Stewart, 1988).

8. *Baltoniodus triangularis* Zone

This zone has been found in the lower part of the Dawan Formation of the Eastern Yangtze Gorges and is characterized by the occurrence of *Baltoniodus triangularis*.

9. *Baltoniodus navis* Zone

This zone has been found in the lower to middle part of the Dawan Formation of the Eastern Yangtze Gorges and is characterized by the occurrence of *Baltoniodus navis*. This and the subjacent two zones are coeval with similarly named zones in Baltoscandia (Lindström, 1971), and correspond broadly to the *Oistodus multicorrugatus – Periodon flabellum* Zone erected by An *et al*. (1981). This interval is equivalent to the upper *Oncograptus magnus* Graptolite Zone in the Zhejiang area.

10. *Paroistodus originalis* Zone

This zone is characterized by *Paroistodus originalis*, *Baltoniodus navis*, *B. prevariabilis*, *Protopanderodus varicostatus* and *P. gradatus*. The lower and upper limits are marked by the first occurrences of *Paroistodus originalis* and *Amorphognathus variabilis* respectively. This zone includes the middle to upper part of the Dawan Formation in Yichang, Hubei Province and the Nanjing, South Anhui and Zhejiang areas, and the lower part of the Zhuozishan Formation in the Zhuozishan area, Inner Mongolia. It broadly corresponds to the *Protocycloceras deprati* Cephalopod Zone and the *Oelandograptus austrodentatus* Graptolite Zone.

11. *Amorphognathus variabilis* Zone

This zone contains *Amorphognathus variabilis*, *Periodon aculeatus*, *Baltoniodus prevariabilis*, *Protopanderodus varicostatus*, and *P. gradatus* and can be correlated with the *A. variabilis* Zone in Baltoscandia (Lindström, 1971). The lower and upper limits are marked by the first occurrences of *Amorphognathus variabilis* and *Eoplacognathus suecicus* respectively. This zone was found in the lower part of the Kuniutan Formation in Yichang, Hubei Province and in the South Anhui, Nanjing and Zhejiang areas. It is associated with the *Amplexograptus confertus* graptolite fauna in some sections.

12. *Eoplacognathus suecicus* Zone

This zone contains *Eoplacognathus suecicus*, *Polonodus clivosus*, *Protopanderodus gradatus*, *P. varicostatus*, and *Baltoniodus prevariabilis*. This assemblage is identical with that in the *E. suecicus* Zone in Baltoscandia (Lindström, 1971). It corresponds to the *Eoplacognathus pseudoplanus* Zone erected by An *et al.*, 1981. The lower and upper limits are marked by the first occurrences of *Eoplacognathus suecicus* and *E. foliaceus* respectively. This zone is represented in the upper part of the Kuniutan Formation in the Yichang area, Hubei Province and in the Nanjing and South Anhui areas, and the lower part of the Kelimoli Formation at Zhuozishan, Inner Mongolia. This interval also contains the *Amplexograptus confertus* Graptolite Fauna.

13. *Pygodus serra* Zone

The stratigraphical scope of this zone is the same as that advocated by Löfgren (1978) and Bergström (1983), that is, the lower and upper boundaries are marked by the appearances of *E. foliaceus* and *P. anserinus* respectively. In China, this zone can be subdivided into four subzones as follows:

(1) *Eoplacognathus foliaceus* Subzone

This subzone, which occurs in the upper part of the Kuniutan Formation in the Yichang area, Hubei Province and the Nanjing area, Jiangsu Province, is characterized by the occurrences of *Eoplacognathus foliaceus*, *Pygodus serra*, *Protopanderodus varicostatus*, *P. cooperi*, *Periodon aculeatus*, *Dapsilodus mutatus*, *Panderodus gracilis*, and *Baltoniodus prevariabilis*. It is equivalent to part of the *Pterograptus elegans* Graptolite Zone. The lower and upper limits are marked by the first occurrences of *Eoplacognathus foliaceus* and *E. reclinatus* respectively.

(2) *Eoplacognathus reclinatus* Subzone

This subzone, which is broadly equivalent to part of the *Pterograptus elegans* Zone, has been found in the upper part of the Kuniutan Formation in the Yichang area, Hubei Province and the Kelimoli Formation in the Haibowan area, Inner Mongolia. It is characterized by the occurrences of *Eoplacognathus reclinatus*, *Periodon aculeatus*, *Dapsilodus mutatus*, *Panderodus gracilis*, and *Protopanderodus varicostatus*. The lower and upper limits are marked by the first occurrences of *Eoplacognathus reclinatus* and *E. robustus* respectively.

(3) *Eoplacognathus robustus* Subzone

This subzone, which may be equivalent to part of the *Hustedograptus* (formerly *Glyptograptus*) *teretiusculus* Zone, has been found in the uppermost part of the Kuniutan Formation in the Yichang area, Hubei Province. It is characterized by the occurrences of *Eoplacognathus robustus*, *Periodon aculeatus*, *Panderodus gracilis*, and *Protopanderodus varicostatus*. The lower and upper limits are marked by the first occurrences of *Eoplacognathus robustus* and *E. protoramosus* respectively.

(4) *Eoplacognathus protoramosus* Subzone

This subzone, which may be equivalent to part of the *Hustedograptus teretiusculus* Zone, has been found in the uppermost part of the Kuniutan Formation and in the basal part of the Miaopo Formation in the Yichang area, Hubei Province. It also has been found in the lower part of the Datianba Formation in the Nanjing area, Jiangsu Province. It is characterized by the occurrences of *Eoplacognathus protoramosus*, *Pygodus serra*, and *Periodon aculeatus*. The lower and upper limits are marked by the first occurrences of *Eoplacognathus protoramosus* and *Pygodus anserinus* respectively. It is apparently broadly equivalent to the *E. lindstroemi* Subzone of the Baltic area (Bergström, 1971, 1983), which contains a species closely similar to *E. protoramosus* and *E. jianyeensis* (cf. Bergström, 1971, pl. 2, fig. 19).

14. *Pygodus anserinus* Zone

This zone is widely distributed in China. It has been found in the middle part of the Miaopo Formation of the Yichang area in Hubei Province, the middle part of the Datianba Formation in the Nanjing area, the Wuligezitake Formation in Weili, West Xinjiang, the Keerduo Formation in Xainza, Tibet, the Gongwusu Formation in the Zhuozishan area of Inner Mongolia, and the Pingliang Formation in Pingliang, Gansu Province. The zonal name－bearer, *Pygodus anserinus*, is locally associated with the *Nemagraptus gracilis* Graptolite Assemblage.

15. *Prioniodus variabilis* Zone

This zone has been found in the middle to upper part of the Datianba Formation of the Nanjing area in Jiangsu Province and in the Miaopo Formation of the Yichang area in Hubei Province. The characteristic species, *P. variabilis*, is associated with *Pygodus anserinus*, *Eoplacognathus jianyeensis* and *Scabardella altipes* in this zone. The lower and upper limits are marked by the first occurrences of *P. variabilis* and *P. alobatus* respectively.

16. *Prioniodus alobatus* Zone

This zone, which is characterized by the occurrence of *P. alobatus*, has been recognized in the uppermost part of the Miaopo Formation in the Yichang area of Hubei Province. *P. alobatus* is the name－bearing species of the *Prioniodus alobatus* Subzone of the *Amorphognathus tvaerensis* Zone in the North Atlantic area. In China this zone appears to be equivalent to part of the *Nemagraptus gracilis* Zone whereas it is coeval with a portion of the *Diplograptus multidens* Zone in Europe (Bergström 1971, 1986).

17. *Hamarodus europaeus* Zone

The major part of the Pagoda (Baota) Formation in South China yields *Sinoceras chinense*

and belongs to the *Hamarodus europaeus* Zone. This zone is characterized by *Hamarodus europaeus*, which is an important species in the *Amorphognathus superbus* Zone in the North Atlantic area.

18. *Protopanderodus insculptus* Zone

The upper part of the Pagoda Formation in South China, which contains *Richardsonoceras*, is referred to the *P. insculptus* Zone. This interval contains the graptolite *Amplexograptus gansuensis* in the Zhuozishan area, Inner Mongolia. *P. insculptus* is found in the *Amorphognathus ordovicicus* Zone in the North Atlantic Faunal Region.

19. *Amorphognathus ordovicicus* Zone

Amorphognathus ordovicicus, the zonal name－bearer, is well－known from the North Atlantic area, and has been found in the shales of the Wufeng Formation in the Yichang area, Hubei Province. There, it is associated with the *Diplograptus bohemicus* Graptolite Fauna.

NORTH CHINA PROVINCE CONODONT ZONES

Conodont faunas in this province are similar to those of the North American Midcontinent. As noted above, they are likely to have been adapted to warm temperatures and raised salinities. A conodont zonation of the North China Province has been established and its correlation with the graptolite and shelly sequences is reasonably well understood (Tables Ⅲ and Ⅳ). In the Cambrian－Ordovician boundary interval, the *Proconodonus*, *Eoconodontus*, *Cambrooistodus*, *Cordylodus proavus*, *C. intermedius*, *C. lindstromi* and *C. angulatus* Zones are present.

1. *Proconodontus* Zone

The lower and upper limits of this zone are marked by the first occurrences of *Proconodontus* and *Eoconodontus* respectively. This zone is widely distributed in the Upper Cambrian Fengshan Formation. In the Wushan Section, the interval from Bed 1 to Bed 8 (Zhou *et al.*, 1984), which corresponds to the *Ptychaspis*－*Tsinania* and *Quadraticephalus* Trilobite Assemblage Zone, is considered to represent the *Proconodontus* Zone. This is equivalent to the *Proconodontus tenuiserratus* Zone, and the *Procondontus posterocostatus* and *P. muelleri* Subzones of the *Proconodontus* Zone in North America (Miller, 1980, 1981, 1984, 1988).

2. *Eoconodontus* Zone

The lower and upper limits of this zone are indicated by the first occurrences of *Eoconodontus* and *Cambrooistodus* respectively. This zone has been found also in the Fengshan Formation in North and Northeast China. In the Wushan Section, the interval from Bed 9 to Bed 11 (Zhou *et al.*, 1984), which corresponds to the upper part of the *Wanwanaspis*－*Plethopeltella* Assemblage Zone, and *Changia* Assemblage Subzone, is referred to the *Eoconodontus* Zone. This unit is equivalent to most of the *Eoconodontus notchpeakensis* Subzone in North America (Miller, 1980, 1981, 1984, 1988).

Tab. Ⅲ Correlation of Upper Cambrian and Lower Ordovician conodont, trilobite, and graptolite zones in the North China Province

Series	Formation	NORTH CHINA PROVINCE		
		Trilobite Zone	Conodont Zone	Graptolite Zone
Lower Ordovician	Yehli Fm.	*Wanliangtingia* Zone	*Glyptoconus quadraplicatus* -*Chosonodina herfurthi* Zone	
			Cordylodus angulatus Zone	
		Yosimuraspis Zone	*Cordylodus lindstromi* Zone	*Rhabdinopora flabelliformis* -*Staurograptus dichotomus* Zone
			Cordylodus intermedius Zone	
Upper Cambrian		*Richardsonella*-*Platypeltoides* Zone	*Cordylodus proavus* Zone	
	Fengshan Fm.	*Mictosaukia*-*Fatocephalus* Zone	*Cambrooistodus* Zone	
		Wanwanaspis-*Plethopeltella* Zone	*Eoconodontus* Zone	
		Quadraticephalus Zone	*Proconodontus* Zone	
		Tsinania-*Ptychaspis* Zone		

3. *Cambrooistodus* Zone

The first occurrences of *Cambrooistodus* and *Cordylodus proavus* are proposed to mark the lower and upper limits of this zone respectively. It is equivalent to the upper part of the *Eoconodontus notchpeakensis* Subzone, and the *Cambrooistodus minutus* Subzone in North America (Miller, 1980, 1984, 1988; Miller *et al*., 1982). This zone lies in the upper part of the Fengshan Formation in North and Northeast China. It occurs in Bed 12 in the Wushan Section (Zhou *et al*., 1984) and in the interval from Bed 1 to Bed 6 in the Dayangcha Section (Chen *et al*., 1985). Both these intervals correspond to the *Mictosaukia* – *Fatocephalus* Trilobite Assemblage Zone.

4. *Cordylodus proavus* Zone

The base of this zone is at the first appearance of *Cordylodus proavus* and the top at the level of the lowest association of *Cordylodus intermedius*, *C. drucei*, *Monocostodus sevierensis*, *Utahconus utahensis* and *Albiconus postcostatus*. The *Cordylodus proavus* Zone, which corresponds to the *Richardsonella* – *Platypeltoides* Trilobite Assemblage Zone, can be subdivided into three parts. These parts are equivalent to the *Hirsutodontus hirsutus*, *Fryxellondontus inornatus*, and *Clavohamulus elongatus* Subzones in North America (Miller, 1980, 1981, 1984, 1988; Miller *et al*., 1982). The *Cordylodus proavus* Zone can be recognized in

Tab. Ⅳ　Correlation of Lower to Upper Ordovician conodont, cephalopod, and trilobite zones in the North China Province

Series	Formation	NORTH CHINA PROVINCE	
		Conodont Zone	Cephalopod and Trilobite Zone
U. Ord.	Beiguoshan Fm.	*Belodina confluens-Yaoxianognathus yaoxianensis* Zone	*Jiangshanoceras* Zone
Middle Ordovician	Longmendong Fm.	*Phragmodus undatus* Zone	
	Badou Fm.	*Belodina compressa-Microcoelodus symmetricus* Zone	*Gonioceras badouensis* Zone
	Gechuang Fm.	No conodont zone erected	
Lower Ordovician	Machiakou Fm.	*Aurilobodus serratus* Zone	*Tofangoceras pauciannulatus* Zone
		Eoplacognathus suecicus-Plectodina onychodonta Zone	*Stereoplasmoceras pseudoseptatum* Zone
	Beianzhuang Fm.	*Tangshanodus tangshanensis* Zone	*Polydesmia* Zone
		Paraserratognathus paltodiformis Zone	*Eoisotelus orientalis* Zone
	Liangchiashan Fm.	*Serratognathus bilobatus* Zone	*Manchuroceras-Coreanoceras* Zone
		Scalpellodus tersus-Scolopodus rex Zone	*Coreanoceras-Leptocyrtoceras* Zone

the uppermost part of the Fengshan Formation and at the base of the Yehli Formation in North and Northeast China. It corresponds to the interval from Bed 7 to the middle part of Bed 13 in the Dayangcha Section (Chen *et al.*, 1985), and to that of Beds 13 to 15 (Zhou *et al.*, 1984)

in the Wushan Section. In the Dayangcha Section, Bed 7 corresponds to the *Hirsutodontus hirsutus* Subzone based on the first occurrences of *Cordylodus proavus* or *Hirsutodontus hirsutus* and *Fryxellodontus inornatus*. Bed 8 corresponds to the *Fryxellondontus inornatus* Subzone based on the first occurrences of the zonal species *Fryxellodontus inornatus* and the characteristic species, *Semiacontiodus nogamii*. The *Clavohamulus elongatus* Subzone corresponds to the interval from Beds 9 to 12 (Chen *et al*., 1985) as indicated by the first occurrences of *Semiacontiodus nogamii*, and the association of *Cordylodus intermedius*, *C. drucei*, *Monocostodus sevierensis*, *Utahconus utahensis* and *Albiconus postcostatus* immediately above.

5. *Cordylodus intermedius* Zone

The upper limit of this zone is defined as the level of appearance of *Cordylodus lindstromi*, which has a worldwide distribution and is considered as one of the characteristic species of Fauna B in North America (Miller *et al*., 1982). This zone, which has been recognized at the base of the Yehli Formation, corresponds to the *Yusimuraspis* Trilobite Assemblage Zone (Zhou *et al*., 1984) or the lower part of the *Yusimuraspis* Assemblage Zone (Chen *et al*., 1985). It occurs between the middle part of Bed 13 and the upper part of Bed 17 in the Dayangcha Section (Chen *et al*., 1985) and in the interval from Beds 16 to 19 in the Wushan Section (Zhou *et al*., 1984). The *Cordylodus intermedius* Zone can be correlated with the *Hirsutodontus simplex* and *Clavohamulus hintzei* Subzones of the *Cordylodus intermedius* Zone in North America (Miller, 1980, 1981, 1984, 1988; Miller *et al*., 1982) based on the first occurrences of *Hirsutodontus simplex*, *Cordylodus intermedius*, *C. drucei*, *Monocostodus sevierensis*, *Utahconus utahensis*, *Albiconus postcostatus*, and *Cordylodus lindstromi* on both continents. It also corresponds to the *Oneotodus bicuspatus* – *Drepanodus simplex* Assemblage Zone and the *Cordylodus oklahomensis* Subzone in Australia (Druce and Jones, 1971). In the Wushan Section of Lulong, Hebei Province, a specimen of *Cordylodus intermedius* was found associated with *Fryxellodontus inornatus* and *Missisquoia perpetis* (Wang, 1983). On this basis, the base of the *Cordylodus intermedius* Zone was considered to correspond to that of the *Fryxellodontus inornatus* Subzone. In all other sections, however, the lowest occurrence of *Cordylodus intermedius* is the same as those of *Cordylodus drucei*, *Monocostodus sevierensis* and *Utahconus utahensis*. The presence of *Cordylodus intermedius* together with *Fryxellodontus inornatus* might be accounted for by laboratory contamination. The base of this zone is broadly equivalent to that of the *Rhabdinopora flabelliformis* Zone.

6. *Cordylodus lindstromi* Zone

The base and the top of this zone are marked by the first occurrences of *Cordylodus lindstromi* and *C. angulatus* respectively. This zone is distributed in the lower part of the Yehli Formation in North and Northeast China. It corresponds to the interval from the upper part of Bed 17 to the lower part of Bed 29 in the Dayangcha Section (Chen *et al*., 1985), to part of Bed 19 in the Wushan Section, and to the base of Bed 5 in the Doufanggou Section (Zhou *et*

al., 1984). In the lower part of this zone in the Dayangcha and Doufanggou Sections, the *Cordylodus lindstromi* Fauna is associated with the *Rhabdinopora flabelliformis* – *Staurograptus dichotomus* Fauna. The interval of the latter can be subdivided into the *R. praeparabola*, *R. flabelliformis parabola*, *R. f. sociale* and *Anisograptus richardsoni* Subzones in the interval from Beds 21 to 24 (Chen *et al*., 1985). The *Cordylodus lindstromi* Zone is equivalent to the lower part of the interval of Fauna B in North America (Miller, 1981, 1982, 1984, 1988) and to the *Cordylodus lindstromi*, *C. prion* and *C. caseyi* Subzones in Australia (Druce and Jones, 1971) based on the first occurrences of *Cordylodus lindstromi* and *C. angulatus*.

7. *Cordylodus angulatus* Zone

The lower and upper limits of this zone are drawn at the first occurrences of *Cordylodus angulatus* and *Chosonodina herfurthi* respectively. The characteristic species are *Cordylodus angulatus*, *C. rotundatus*, and *Utahconus*? *bassleri*, which are associated with the *Leistegium* (*Euleistegium*) *latilimbatum* Trilobite Fauna in the Changshangou, Wushan and Zhongzhuangpu Sections (Zhou *et al*., 1984). In North and Northeast China, where this zone is widely distributed, it approximately corresponds to the upper part of the *Wanliangtingia* Trilobite Zone and the *Rhabdinopora flabelliformis liaotungense* and *Dendrograptus lotolatzensis* Graptolite Zones. It also corresponds to the upper part of the interval of Faunas B—C in North America (Miller, 1981, 1982) and the *Cordylodus rotundatus* – *C. angulatus* Assemblage Zone in Australia (Druce and Jones, 1971).

8. *Glyptoconus quadraplicatus* – *Chosonodina herfurthi* Assemblage Zone

The characteristic species of this zone are *Chosonodina herfurthi*, *Acanthodus costatus*, and *Glyptoconus quadraplicatus*. The base is indicated by the first appearance of *Chosonodina herfurthi* and the top by those of *Scalpellodus tersus* and *Scolopodus rex*. The lower part of this assemblage zone is characterized by *Chosonodina herfurthi* and the upper part by *Glyptoconus quadraplicatus*. This assemblage zone has been found in the middle and upper parts of the Yehli Formation in North and Northeast China. It occurs in the interval from Beds 9 to 14 in the Changshangou Section (Zhou *et al*., 1983), and begins at Bed 22 in the Wushan Section, and the uppermost part of Bed 14 in the Tianshifu Section (Zhou *et al*., 1984). In the Changshangou Section, this zone corresponds approximately to the *Asaphellus trinodosus* Trilobite Zone, the *Endoaspis gulosa* Trilobite Zone, the *Callograptus taitzehoensis* – *Rhabdinopora flabelliformis orientale* Graptolite Assemblage Zone and the *Adelograptus* – *Clonograptus* Graptolite Assemblage Zone. Based on the occurrences of *Chosonodina herfurthi* and *Glyptoconus quadraplicatus*, this assemblage zone can be correlated with the *Loxodus bransoni* Interval (Fauna C) and the lower part of the *Glyptoconus quadraplicatus* – aff. *Scolopodus rex* Interval (Fauna D) in North America (Ethington and Clark, 1971, 1984) and with the *Chosonodina herfurthi* – *Acodus* Assemblage Zone in Australia (Druce and Jones, 1971).

9. *Scalpellodus tersus* – *Scolopodus rex* Assemblage Zone

The characteristic species of this zone are *Scalpellodus tersus*, *Scolopodus rex*, *Cornuodus longibasis*, *Paracordylodus* aff. *gracilis*, *Paraserratognathus incostatus*, and *Oistodus inaequalis*, which are associated with *Campendoceras amplum* in the Tangshan area. *Glyptoconus quadraplicatus* is still present in this zone. The lower and upper limits are marked by the first occurrences of *Scalpellodus tersus* and *Serratognathus bilobatus* respectively. This zone, which approximately corresponds to the lower part of the *Coreanoceras* Zone, has been found at the base of the Liangchiashan Formation in Tangshan, Hebei Province; Benxi, Liaoning Province, and in Hunjian Jilin Province.

10. *Serratognathus bilobatus* Zone

The characteristic species of this zone are *Serratognathus bilobatus*, *S. extensus*, *Bergstroemognathus extensus* and *B. hubeiensis*. The characteristic species of the subjacent zone, *Scalpellodus tersus* and *Scolopodus rex*, are still present. The lower and upper limits of this zone are at the first occurrences of *Serratognathus bilobatus* and *Paraserratognathus paltodiformis* respectively. This zone, which is widely distributed in the Liangchiashan Formation of North and Northeast China, broadly corresponds to the lower part of the *Manchuroceras* – *Coreanoceras* Cephalopod Zone. It may correspond to the upper part of the interval of Fauna D (*Acodus deltatus* – *Macerodus dianae* Interval) in North America (Ethington and Clark, 1971, 1981).

11. *Paraserratognathus paltodiformis* Zone

This zone, which occurs in the upper part of the Liangchiashan Formation and the lower part of the Beianzhuang Formation, corresponds to the upper part of the *Manchuroceras* Cephalopod Zone and is characterized by *Paraserratognathus paltodiformis*, *Scolopodus nogamii*, *S. flexilis*, *Rhipidognathus maggolensis*, *Bergstroemognathus hubeiensis* and *Baltoniodus approximatus*. The lower limit is marked by the first occurrence of *Paraserratognathus paltodiformis* and the upper limit by the appearance of *Tangshanodus tangshanensis*.

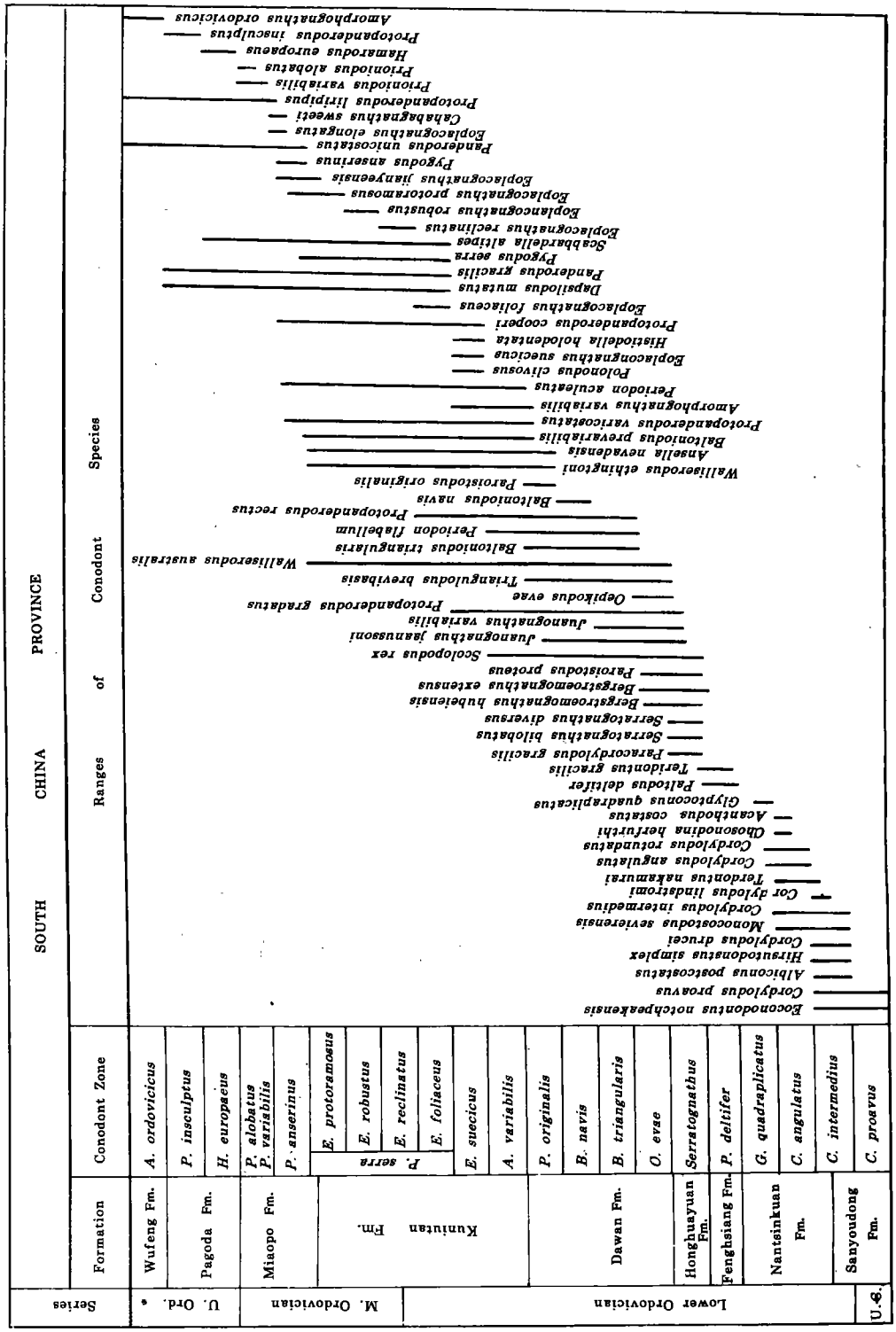
12. *Tangshanodus tangshanensis* Zone

The base of this zone is marked by the first occurrence of *Tangshanodus tangshanensis* and this species ranges through most of the Beianzhuang Formation in North China. In the lower part of the formation, the species is associated with *Polydesmia* and *Eoisotelus*. This zone broadly corresponds to the *Histiodella sinuosa* and *H. holodentata* Zones and the interval of Faunas 3—4 in North America (Sweet, 1984).

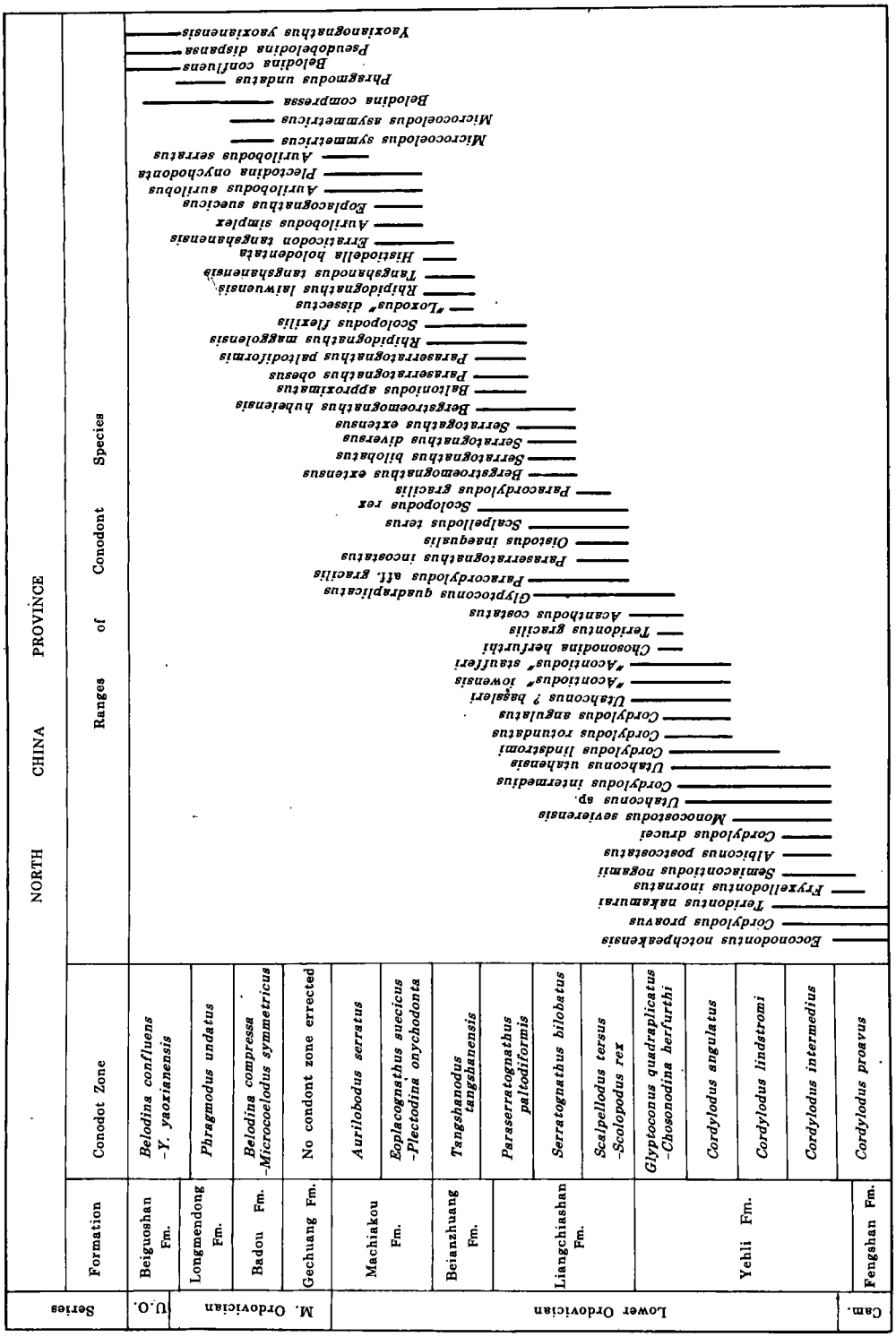
13. *Eoplacognathus suecicus* – *Plectodina onychodonta* Zone

The characteristic species of this zone are *Eoplacognathus suecicus*, *Plectodina onychodonta*, *Aurilobodus aurilobus*, *A. simplex*, *Erraticodon tangshanensis*, and *Eoplacognathus pseudoplanus*. The lower and upper limits are marked by the first occurrences of *Eoplacognathus suecicus* and *Aurilobodus serratus* respectively. The lower and middle parts of the Machiakou Formation in the Hubei and Shandong areas belong to this zone, which broadly cor-

Tab. V　Provincial range chart of selected conodont species in the South China Province



Tab. Ⅵ Provincial range chart of selected conodont species in the North China Province



responds to the *Stereoplasmoceras pseudoseptatum* Cephalopod Zone. This conodont zone is approximately coeval with the *Phragmodus polystrophos* (formerly *P.* "*pre* – *flexuosus*") Zone (part of Fauna **4**) in North America (Sweet and Bergström, **1976**; Sweet, **1984**) and with the *Eoplacognathus suecicus* Subzone in the North Atlantic area (Bergström, **1971**).

14. *Aurilobodus serratus* Zone

This zone occurs in the uppermost part of the Machiakou Formation in the Shandong area. The zonal species, *Aurilobodus serratus*, is associated with some other species such as *Aurilobodus aurilobus* and *Plectodina onychodonta*, which range from the subjacent *Eoplacognathus suecicus* – *Plectodina onychodonta* Zone.

15. *Belodina compressa* – *Microcoelodus symmetricus* Zone

In the Hebei and Shandong areas, the Badou Formation includes the *Gonioceras bodouense* Cephalopod Zone and the *Belodina compressa* – *Microcoelodus symmetricus* Zone. The latter zone is characterized by its name – bearing species, together with *Microcoelodus asymmetricus* and *Panderodus gracilis*; they are associated with the cephalopods *Gonioceras badouense* and *Vaginoceras badouense*. This zone broadly corresponds to the *Belodina compressa* Zone of Sweet (1984).

16. *Phragmodus undatus* Zone

This zone occurs in the Longmendong Formation of Longxian, Shaanxi Province. It broadly corresponds to the *Climacograptus peltifer* Graptolite Zone in this area. The characteristic species of this zone are *Phragmodus undatus*, *Belodina compressa*, and *Scabbardella altipes*.

17. *Belodina confluens* – *Yaoxianognathus yaoxianensis* Zone

This zone has been found in the upper part of the Longmendong Formation and in the Beiguoshan Formation in Longxian County, Shaanxi Province, corresponding to the *Climacograptus geniculatus* Graptolite Zone and the *Jiangshanoceras dephalopos* Zone, and characterized by the occurrences of *Belodina confluens*, *Yaoxianognathus yaoxianensis*, *Belodina compressa*, and *Pseudobelodina dispansa*.

The ranges of selected Upper Cambrian and Ordovician conodonts are shown in Tables Ⅴ and Ⅵ.

CORRELATION

1. Correlation Between The South and North China Provinces

Because of striking faunal differences caused by ecologic control, it is very difficult to achieve precise correlation between the conodont sequences in the South and North China Provinces in the part of the succession that is younger than the Honghuayuan and Liangchiashan Formations. On the other hand, the earliest Ordovician conodont sequences in both regions are very similar. Based on a comparison of the ranges the characteristic species in com-

mon, the *Cordylodus intermedius*, *C. angulatus*, and *Glyptoconus quadraplicatus* Zones of the South China Province, appear equivalent to the interval from the *Cordylodus intermedius* Zone to the *Glyptoconus quadraplicatus* – *Chosonodina herfurthi* Zone in the North China Province. Assuming that the first occurrence of *Serratognathus* is contemporaneous in both provinces,. the *Paltodus deltifer* Zone in the South China Province is broadly equivalent to the *Scapellodus tersus* – *Scolopodus rex* Zone in the North China Province. Based on the range of *Eoplacognathus suecicus* in both provinces, the *Eoplacognathus suecicus* Zone in the South China Province is correlated with the *Eoplacognathus suecicus* – *Plectodina onychodonta* Zone in the North China Province. The interval from the *Paraserratognathus paltodiformis* Zone to the *Tangshanodus tangshanensis* Zone in the North China Province may be equivalent to the interval from the *Oepikodus evae* Zone to the *Amorphognathus variabilis* Zone of the South China Province. Because *Belodina compressa* has been found below the *Hamarodus europaeus* Zone in Guizhou and Sichuan, the *Baltoniodus alobatus* Zone in South China may correspond approximately to the *Belodina compressa* – *Microcoelodus symmetricus* Zone in North China.

2. Correlation Between the South China Province and the North Atlantic Faunal Region

The standard conodont zone sequence in the Atlantic Faunal Region is recognized as follows (Lindström, 1971, Bergström 1971, 1983; cf. Table Ⅶ):

Amorphognathus ordovicicus Zone
Amorphognathus superbus Zone
Amorphognathus tvaerensis Zone
  Prioniodus alobatus Subzone
  Prioniodus gerdae Subzone
  Prioniodus variabilis Subzone
Pygodus anserinus Zone
  Amorphognathus inaequalis Subzone
  Amorphognathus kielcensis Subzone
Pygodus serra Zone
  Eoplacognathus lindstroemi Subzone
  Eoplacognathus robustus Subzone
  Eoplacognathus reclinatus Subzone
  Eoplacognathus foliaceus Subzone
Eoplacognathus suecicus Zone
Amorphognathus variabilis Zone
Microzarkodina parva Zone
Paroistodus originalis Zone
Baltoniodus navis Zone
Baltoniodus triangularis Zone
Oepikodus evae Zone

Tab. Ⅶ　Correlation between the South China Province and the North Atlantic Faunal Region

Series	SOUTH CHINA PROVINCE			ATLANTIC FAUNAL REGION	
	Formation	Conodont Zone	Graptolite and Cephalopod Zone	Conodont Zone (Lindström, 1971; Bergström, 1983)	
U. Ord.	Wufeng Fm.	*A. ordovicicus*	*D. bohemicus*	*A. ordovicicus*	Ashgill.
	Pagoda Fm.	*P. insculptus*		*A. superbus*	Caradocian
		H. europaeus	*Sinoceras chinense*		
M. Ordovician	Miaopo Fm.	*P. alobatus*		*A. tvaerensis*	
		P. variabilis	*N. gracilis*		
		P. anserinus		*P. anserinus*	Llan.
	Kuniutan Fm.	*Pygodus serra* *E. protoramosus*	*H. teretiusculus*	*Pygodus serra* *E. lindstroemi*	not named
		E. robustus		*E. robustus*	
		E. reclinatus		*E. reclinatus*	
		E. foliaceus	*P. elegans*	*E. foliaceus*	Llanvirnian
Lower Ordovician		*E. suecicus*	*A. confertus*	*E. suecicus*	
		A. variabilis		*A. variabilis*	
	Dawan Fm.	*P. originalis*	*O. austrodentatus*	*M. parva*	Arenigian
				P. originalis	
		B. navis	*C. amplus*	*B. navis*	
		B. triangularis	*Oncograptus*	*B. triangularis*	
		O. evae	*A. suecicus* *D. deflexus*	*O. evae*	
	Honghuayuan Fm.	*Serratognathus*	*D. filiformis- T. approximatus*	*P. elegans*	
				P. proteus	
	Fenghsiang Fm.	*P. deltifer*	*Adelogr. -Kiaerograptus*	*P. deltifer*	Tremadocian
	Nantsinkuan Fm.	*G. quadraplicatus*		*C. angulatus*	
		C. angulatus	*D. dactyloides-A. inflatus*		
	Sanyoudong Fm.	*C. intermedius*			
Cam.		*C. proavus*	*R.* ex gr. *flabelliformis*		

Prioniodus elegans Zone

Paroistodus proteus Zone

Paltodus deltifer Zone

Cordylodus angulatus Zone

This succession of conodont zones is very similar to that in South China. Most zones can be correlated directly between two regions based on characteristic species, such as *Cordylodus angulatus*, *Paltodus deltifer*, *Oepikodus evae*, *Baltoniodus triangularis*, *B. navis*, *Paroistodus originalis*, *Amorphognathus variabilis*, *Eoplacognathus suecicus*, *E. foliaceus*, *E. reclinatus*, *E. robustus*, *Pygodus anserinus*, *Prioniodus alobatus*, and *Amorphognathus ordovicicus*. The *Serratognathus* Zone in South China may be equivalent to the interval from the *Paroistodus proteus* Zone to the *Prioniodus elegans* Zone in the Atlantic Faunal Region. Based

on the occurrences of the characteristic species *Hamarodus europaeus*, *Amorphognathus superbus*, and *Protopanderodus insculptus*, the *Hamarodus europaeus* and *Protopanderodus insculptus* Zones of South China approximately correspond to the *Amorphognathus seperbus* Zone and the lower part of the *Amorphognathus ordovicicus* Zone in the Atlantic Faunal Region.

3. Correlation Between the North China Province and the North American Midcontinent Faunal Region

According to Ethington and Clark (1971, 1981), Sweet, Ethington and Barnes (1971), Miller (1988), and Sweet (1984) the conodont sequence in the North American Midcontinent Faunal Region can be summarized as follows (Table Ⅷ).

Aphelognathus shatzeri Zone (Fauna 13)
Aphelognathus divergens Zone (Faunas 13 and 12)
Aphelognathus grandis Zone (Fauna 12)
Oulodus robustus Zone (Fauna 12)
Oulodus velicuspis Zone (Faunas 12 and 11)
Belodina confluens Zone (Faunas 10 and 9)
Plectodina tenuis Zone (Fauna 9)
Phragmodus undatus Zone (Fauna 8)
Belodina compressa Zone (Fauna 7)
Erismodus quadridactylus Zone (Fauna 7)
Plectodina aculeata Zone (Fauna 7)
Cahabagnathus sweeti Zone (Fauna 6)
Cahabagnathus friendsvillensis Zone (Fauna 5)
Phragmodus polystrophos Zone (Fauna 4)
Histiodella holodentata Zone (Fauna 4)
Histiodella sinuosa Zone (Fauna 3)
Histiodella altifrons Zone (Fauna 2)
Microzarkodina flabellum – *Tripodus laevis* Interval (Fauna 1)
Protoprioniodus aranda – *Juanognathus jaanussoni* Interval (Fauna 1)
Jumodontus gamanda – ? *Reutterodus andinus* Interval (Fauna E)
Oepikodus communis – "*Micozarkodina*" *maratonensis* Interval (Fauna E)
Acodus deltatus – *Macerodus dianae* Interval (Fauna D)
Glyptoconus quadraplicatus – aff. *Scolopodus rex* Interval (Fauna D)
Loxodus bransoni Interval (Fauna C)
Cordylodus angulatus Zone (Fauna B)
Cordylodus lindstromi Zone (Fauna B)
Cordylodus intermedius Interval (Fauna B)
Clavohamulus hintzei Subzone
Hirsutodontus simplex Subzone

Tab. Ⅶ Correlation between the North China Province and the North American Midcontinent Faunal Region

Series	NORTH CHINA PROVINCE			NORTH AMERICAN MIDCONTINENT PROVINCE		
	Formation	Conodont Assemblage Zone	Cephalopod, Trilobite, and Graptolite Zone	Series	Conodont Fauna, Zone, and Interval: Ethington & Clark 1971; Sweet & Bergström 1973; Miller 1980, 1984	Ethington & Clark 1981; Sweet 1984; Miller 1988
U. Ord.	Beigoushan Fm.	*B. confluens–Y. yaoxianensis*	*Jiangshanoceras*	Cincinn.	Fauna 10	*B. confluens*
M. Ordovician	Longmendong Fm.	*P. undatus*	*C. geniculatus* *C. peltifer*	Mohawkian	Fauna 9 Fauna 8	*P. tenuis* *P. undatus*
	Badou Fm.	*B. compressa–M. symmetricus*	*Gonioceras badouensis*		Fauna 7	*B. compressa* *P. aculeata* *E. quadridactylus*
	Gechuang Fm.	no conodont zone erected	*Tofangoceras pauciannulatus*	Whiterockian	Fauna 6	*C. "sweeti"*
Lower Ordovician	Machiakou Fm.	*Aurilobodus serratus*			Fauna 5	*C. friendsvillensis*
		E. suecicus–P. onychodonta	*Stereoplasmoceras pseudoseptatum*		Fauna 4	*Phragmodus polystrophos* *H. holodentata*
	Beianzhu.	*Tangshanodus tangshanensis*	*Polydesmia*		Fauna 3	*H. sinuosa*
		Paras. paltodiformis	*Eoisotelus orientalis*		Fauna 2	*H. altifrons*
	Liangchiashan Fm.		*Manchuroceras–Coreanoceras*		Fauna 1	*M. flab.–T. laevis & P. aranda–J. jaanus.*
		Serratognathus bilobatus		?	Fauna E	*O. communis– "M." marathonensis*
		Scalpellodus tersus – Scolopodus rex	*Coreanoceras–Leptocyrtoceras*	Ibexian (Canadian)	Fauna D	*A. deltatus–M. dianae* *G. quadraplicatus–aff. S. rex*
	Yehli Fm.	*G. quadraplicatus – C. herfurthi*	*Wanliantingia*		Fauna C	*L. bransoni*
		C. angulatus			*C. angulatus*	*C. angulatus*
		C. lindstromi	*R. flabelliformis–S. dicht.*		*C. lindstromi*	*C. lindstromi*
		C. intermedius	*Richardsonella–Platypeltiodes*		*C. proavus*	*C. h.* *H. s.* *C. intermedius* *C. hintsei* *H. simplex*
Camb.	Fengshan Fm.	*C. proavus*				*C. e.* *F. i.* *C. proavus* *C. elong.* *F. inorn.* *H. n.* *H. hirs.*

Cordylodus proavus Zone (Fauna A)

Clavohamulus elongatus Subzone

Fryxellodontus inornatus Subzone

Hirsutodontus hirsutus Subzone

In the earliest Ordovician, there was considerable similarity between the conodont faunas of North China and Midcontinent. Many species, such as *Cordylodus proavus*, *C. intermedius*, *C. lindstromi*, *C. angulatus*, *C. rotundatus*, *Monocostodus sevierensis*, *Seminogamiconus nogamii*, *Glyptoconus quadraplicatus*, *Utahconus utahensis*, and *Hirsutodontus simplex*, are widely distributed in both North China and North American Midcontinent. Accordingly, it is relatively easy to correlate them between these regions on the basis of the occurrences of zonal and characteristic species. Based on the first occurrences of the key species just listed from both regions, the *Cordylodus intermedius*, *C. lindstromi*, and *C. angulatus* Zones in the North China Province correspond to the North American *Cordylodus intermedius* Interval or Zone (Fauna B), the *C. lindstromi* and *C. angulatus* Zones, and possibly part of the *Loxodus bransoni* Interval (Fauna C). The *Glyptoconus quadraplicatus* – *Chosonodina herfurthi* Zone in the North China Province can be correlated with the *Loxodus bransoni* Interval (Fauna C) and the lower part of the *Glyptoconus quadraplicatus* – aff. *Scolopodus rex* Interval based on the occurrences of *Glyptoconus quadraplicatus*, *Chosonodina herfurthi*, *Utahconus? bassleri*, *Rossodus manitouensis*, *Drepanodus suberectus*, *D. subarcuatus*, etc. in both regions. Apart from *G. quadraplicatus*, this species association is indicative of the *Loxodus bransoni* Interval (Ethington and Clark, 1981; Ethington *et al.*, 1987). The presence of *Histiodella holodentata* in the *Tangshanodus tangshanensis* Zone in the North China Province suggests that this zone is broadly equivalent to the *Histiodella holodentata* and *H. sinuosa* Zones of the North American Continent. Assuming that Sweet's (1984) correlation of the *Eoplacognathus suecicus* Zone with the lower part of the Midcontinent *Phragmodus polystrophos* Zone is essentially correct, the *Eoplacognathus suecicus* – *Plectodina onychodonta* Zone of the North China Province may be correlated with the latter Midcontinent zone. The *Belodina compressa* – *Microcoelodus symmetricus* Zone, which has been recognized in the Badou Formation of the North China Province, can be correlated with the *Belodina compressa* Zone of the Midcontinent based on the common occurrences of *Belodina compressa*, *Microcoelodus symmetricus*, and *M. asymmetricus*.

The *Phragmodus undatus* and *Belodina confluens* – *Yaoxianognathus yaoxianensis* Zones in the North China Province may be correlated with the interval of the *Phragmodus undatus* to *Belodina confluens* Zones (Faunas 8—10) respectively based on the occurrences of *Phragmodus undatus* and *Belodina confluens* in both regions.

4. Correlation Between the North China Province and the Siberian Platform

Recent work has made the Ordovician conodont faunas on the Siberian Platform reasonably well-known although many species need to be reclassified in terms of multielement taxonomy.

Tab. Ⅸ　Correlation between the North China Province and the Siberian Platform

Series	Formation	North China Province Conodont Zone	Stages	Siberian Platform Conodont Zone
U. Ord.	Beiguoshan Fm.	*Belodina confluens-Yaoxianognathus yaoxianensis* Zone	Dolborian	*Yaoxianognathus dolboricus* Zone
Middle Ordovician	Longmendong Fm.	*Phragmodus undatus* Zone		*Acanthocordylodus festus* Zone
	Badou Fm.	*Belodina compressa-Microcoelodus symmetricus* Zone	Baksian	*Belodina compressa - Columbodina mangazeica* Zone
	Gechuang Fm.	No conodont zone erected	Chertovskian	*Cahabagnathus sweeti - Phragmodus inflexus* Zone
Lower Ordovician	Machiakou Fm.	*Aurilobodus serratus* Zone	Kirenskian to Vihorevian	*Ptiloconus anomalis-B. lenaica* Zone *Phragmodus flexuosus* Zone *Cardiodella-Polyplacognathus* Zone *Coleodus mirabilis* Zone
		Eoplacognathus suecicus - Plectodina onychodonta Zone		?
	Beianzhuang Fm.	*Tangshanodus tangshanensis* Zone		
		Paraserratognathus paltodiformis Zone		
	Liangchiashan Fm.	*Serratognathus bilobatus* Zone	Kimaian	*Glyptoconus quadraplicatus - Histiodella angulata* Zone
		Scalpellodus tersus - Scolopodus rex Zone		
	(upper) Yehli Fm.	*Glyptoconus quadraplicatus - Chosonodina herfurthi* Zone	Ugor. Nyaian	*Acanthodus lineatus* Zone

The Siberian faunas exhibit a general similarity to other faunas of the Midcontinent Faunal Region, particularly at the generic level, but they are distinctive enough to justify separation of this area as an independent province, the Siberian Province (Bergström, 1989). It is difficult to compare the Siberian Ordovician conodont succession (for a summary, see Moskalenko, 1983) in detail with that of the North China Province because of provincial differences in the species associations, but a few biostratigraphically useful species are in common that permit a broad correlation. This is illustrated in Table Ⅸ and will be briefly discussed below.

The presences of *Acanthodus lineatus*, *Loxodus bransoni*, *Cordylodus angulatus*, and *C. rotundatus* below the level of appearance of *Glyptoconus quadraplicatus* in the Nyaian Stage of the Siberian Platform, an interval referred to the *Acanthodus lineatus* Zone by Moskalenko (1983), suggest correlation with the lower part of the *Glyptoconus quadraplicatus* – *Chosonodina herfurthi* Zone in the upper Yehli Formation of the North China Province. Rocks of the overlying Ugorian Stage in Siberia have not yet produced stratigraphically useful conodonts, but the superjacent Kimaian Stage has yielded diverse conodont faunas referred to the *Glyptoconus quadraplicatus* – *Histiodella*? *angulata* Zone (Moskalenko, 1983). Few of the species of this zone are useful for correlation with North China, but this interval is above the local range of *Acanthodus lineatus*, and based mainly on the range of *G. quadraplicatus* in the two provinces, the Siberian zone may correspond to the upper *G. quadraplicatus* – *C. herfurthi* Zone and the *Scalpellodus tersus* – *S. rex* and *Serratognathus bilobatus* Zones in the upper Yehli and lower Liangchiashan Formations in North China. Support for this correlation is also the fact that *Scolopodus rex* appears somewhat above the level of the appearance of *G. quadraplicatus* on the Siberian Platform (Abaimova, 1975) as it does in the basal *Scalpellodus tersus* – *S. rex* Zone in North China. For long – distance correlation it may also be significant that the range of *Jumognathus* (*Loxodus asiaticus* of Abaimova, 1975; cf. Ethington and Clark, 1981) overlaps the uppermost part of that of *G. quadraplicatus* in Siberia as it does in the upper part of the interval of Fauna E in North America (Ethington and Clark, 1981), which is here correlated with the *Serratognathus bilobatus* Zone in North China.

According to Moskalenko (1983) the boundary between the Kimaian and Vihorevian Stages is marked by conspicuous faunal turn-over with no conodont species in common between these units. Because the conodont fauna of the latter stage is comparable with Fauna 5 of Sweet *et al.* (1971) in North America, it appears that the Siberian succession has a gap corresponding to the interval of Faunas 1—4, that is, the lower Whiterockian of North American. In the North China Province, this stratigraphic gap is apparently filled by three conodont zones, the *Paraserratognathus paltodiformis*, *Tangshanodus tangshanensis*, and *Eoplacognathus suecicus* – *P. onychodonta* Zones, and the conodont succession shows no evidence of a prominent gap similar to that on the Siberian Platform.

The Chinese Machiakou and Gechuang Formations have not yet produced conodonts useful ,

for correlation with the Siberian Platform succession. The *Belodina compressa* – *Microcoelodus symmetricus* Zone in the Badou Formation in North China, which is located stratigraphically below the *Phragmodus undatus* Zone, is likely to be coeval with the lower part of the Siberian *Belodina compressa* – *Columbodina mangazeica* Zone (Baksian Stage). Finally, based on the presence of *Yaoxinognathus yaoxianensis*, the *Belodina confluens* – *Y. yaoxianensis* Zone of the Beiguoshan Formation is correlated with the "*S.*" *dolboricus* Zone of the upper Dolborian Stage on the Siberian Platform.

5. Correlation between the North China Province and Northwestern Australia

One of the outstanding Lower to Middle Ordovician successions in the world is in the Canning Basin, northwestern Australia. Some conodonts from this succession were described by McTavish (1973), and McTavish and Legg (1976) recorded, but did not describe, numerous species and established an informal zone succession. The lack of published descriptions and even illustrations of most Canning Basin conodonts precludes comparison between most of that succession and those in China. However, Watson (1988) recently described conodont faunas from two intervals, a lower one correlated with the *Histiodella holodentata* Zone (Lower part of the interval of Fauna 4), and an upper one considered coeval with the *Phragmodus polystrophos* Zone (upper part of the interval of Fauna 4) of the North American Midcontinent. As noted by Watson (1988), both Australian faunas have several stratigraphically significant species in common with North China faunas. Such species in the lower fauna include *Histiodella holodentata*, *Tangshanodus tangshanensis*, "*Loxodus*" *dissectus*, *Protopanderodus nogamii*, and *Erraticodon tangshanensis*. In terms of the North China Province conodont scheme used herein, the lower fauna corresponds to that of the *Tangshanodus tangshanensis* Zone. Apparently, the interval in the Goldwayer Formation of the Canning Basin that yielded this fauna is coeval with the Beianzhuang Formation of North China.

Watson's (1988) upper fauna shares *Ansella rigida*, *Dapsilodus compressus*, *Oistodus sthenus*, and *Eoplacognthus suecicus* with the fauna of the Machiakou Formation of North China. A correlation with the Chinese *Eoplacognathus suecicus* – *Plectodina onychodonta* Zone seems justified although it cannot be excluded that the Canning Basin fauna ranges into strata correlative with a portion of the *Aurilobodus serratus* Zone. Based on a variety of graptolite, trilobite, and conodont evidences both the Canning Basin faunas are considered as of early to middle Llanvirnian in age.

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EXPLANATION OF PLATES

All of the specimens are in the collection of Nanjing Institute of Geology and Palaeontology, Academia Sinica.

Plate I

1—6. *Periodon flabellum* (Lindström)

1. Lateral view of triconodelliform element, ×65, Haibowan, Inner Mongolia, Kelimoli Formation, Col. No. H 160－1, Cat. No. 65269. 2. Lateral view of prioniodiniform element, ×65, Haibowan, Inner Mongolia, Kelimoli Formation, Col. No. H 160－1, Cat. No. 62270. 3. Lateral view of cordylodiform element, ×65, Haibowan, Inner Mongolia, Kelimoli Formation, Col. No. H 160－1, Cat. No. 65271. 4. Lateral view of cladognathiform element, ×65, Haibowan, Inner Mongolia, Kelimoli Formation, Col. No. H 160－1, Cat. No. 65275. 5. Lateral view of oistodiform element, ×65, Haibowan, Inner Mongolia, Kelimoli Formation, Col. No. H 160－1, Cat. No. 65274. 6. Lateral view of prioniodiniform element, ×65, Haibowan, Inner Mongolia, Kelimoli Formation, Col. No. H 160－1, Cat. No. 65276.

7—11. *Eoplacognathus elongatus* (Bergström)

7, 8. Lower and upper views of one specimen, ×65, Pingliang County, Gansu Province, Pingliang Formation, Col. No. Pg 5－1, Cat. No. 65333－1. 9, 10. Upper and lower views of one specimen, ×65, Pingliang County, Gansu Province, Pingliang Formation, Col. No. Pg 5－1, Cat. No. 65334. 11. Upper view, ×65, Pingliang County, Gansu Province, Pingliang Formation, Col. No. Pg 5－1, Cat. No. 65333－2.

12, 13. *Histiodella holodentata* (Ethington and Clark)

12. Lateal view, ×60, Haibowan, Inner Mongolia, Kelimoli Formation, Col. No. H 1100, Cat. No. 78104. 13. Lateal view, ×65, Haibowan, Inner Mongolia, Kelimoli Formation, Col. No. H 145－2, Cat. No. 65300.

14. *Pygodus serra* (Hadding)

Upper view, ×60, Haibowan, Inner Mongolia, Kelimoli Formation, Col. No. H 1, 168－1, Cat. No. 52202.

15. *Walliserodus ethingtoni* (Fåhraeus)

Lateral view, ×65, Haibowan, Inner Mongolia, Kelimoli Formation, Col. No. H 154－2, Cat. No. 65178.

16. *Belodella nevadensis* (Ethington and Schumacher)

Lateral view, ×65, Haibowan, Inner Mongolia, Kelimoli Formation, Col. No. H 160－1, Cat. No. 65297.

17. *Protopanderodus varicostatus* (Sweet and Bergström)

Lateral view, ×65, Haibowan, Inner Mongolia, Kelimoli Formation, Col. No. H 157－1, Cat. No. 65221.

18. *Scabbardella altipes* (Henningsmoen)

Lateal view, ×65, Haibowan, Inner Mongolia, Gongwusu Formation, Col. No. H 1q－3(4), Cat. No. 65167.

19—21, 25. *Acontiodus staufferi* Furnish

19. Posterior view, ×60, Zhaogezhuang in Tangshan, Hebei Province, Yehli Formation, Col. No. Cc 12－5, Cat. No. 78024. 20. Lateral view, ×65, Tiangshifu in Benxi, Liaoning Province, Yehli Formation, Col. No. Xty 1－12, Cat. No. 77908. 21. Latero－posterior view, ×60, Taishifu in Benxi, Liaoning Province, Yehli Formation, Col. No. Xty 1－12, Cat. No. 77907. 25. Latero－upper view, ×60, Tiashifu in Benxi, Liaoning Province, Yehli Formation, Col. No. Xty 1－12, Cat. No. 77904.

22, 23. *Protopanderodus cooperi* (Sweet and Bergström)

22. Lateral view, ×45, Pingliang County, Gansu Province, Pingliang Formation, Col. No. Pg 6, Cat. No. 65322. 23. Lateral view, ×65, Pingliang County, Gansu Province, Pingliang Formation, Col. No. Pg 5－1, Cat. No. 65226.

24, 27. *Cahabagnathus sweeti* (Bergström)

24. Upper view, ×65, Longxian County, Shaanxi Province, "Sandaogou Formation," Col. No. Ln 55, Cat. No. 65335. 27. Upper view, ×65, Longxian County, Shaanxi Province, "Sandaogou Formation," Col. No. Ln 55, Cat. No. 65331.

26. *Glyptoconus quadraplicatus* (Branson and Mehl)

Posterior view, ×65, Tianshifu in Benxi, Liaoning Province, Yehli Formation, Col. No. Xty 1－12, Cat. No. 77902.

Plate Ⅱ

1—7, 9. *Serratognathus bilobatus* Lee

1, 2. Upper and lower views of one specimen, ×50, Tianshifu in Benxi, Liaoning Province, Liangchiashan Formation, Col. No. Xt 15－5, Cat. No. 105930a. 3, 4. Upper and lower views of one specimen, ×80, Tianshifu in Benxi, Liaoning Province, Liangchiashan Formation, Col. No. Xt 15－5, Cat. No. 105930b. 5, 9. Upper and lower views of one specimen, ×60, Dayangcha in Hunjing, Jilin Province, Liangchiashan Formation, Col. No. Hx 12, Cat. No. 105931. 6, 7. Lower and upper views of one specimen, ×60, Zhaogezhuang in Tangshan, Hebei Province, Liangchiashan Formation, Col. No. Cc 23－1, Cat. No. 105932.

8, 13—15. *Bergstroemognathus extensus* (Graves and Ellison)

8. Lateral view of prioniodiform element, ×50, Dayangcha in Hunjiang, Jilin Province, Liangchiashan Formation, Col. No. Hx 12, Cat. No. 105935a. 13. Lateral view of prioniodiform element, ×50, Dayangcha in Hunjiang, Jilin Province, Liangchiashan Formation, Col. No. Hx 12, Cat. No. 105935b. 14. Lateal view of falodontiform element, ×50, Tianshifu in Benxi, Liaoning Province, Liangchiashan Formation, Col. No. Xt 15－7, Cat. No. 105936. 15. Lateral view of falodiform element, ×50, Jurong County, Jiangsu Province, Hunghuayuan Formation, Col. No. Lg 59, Cat. No. 105937.

10—12. *Serratognathus diversus* An

10. Upper view, ×106, Jurog County, Jiangsu Province, Hunghuayuan Formation, Col. No. Lg 74, Cat. No. 105933a. 11. Upper view, ×86, Jurong County, Jiangsu Province, Hunghuayuan Formation, Col. No. Lg 78, Cat. No. 105934. 12. Upper view, ×100, Jurong County, Jiangsu Province, Hunghuayuan Formation, Col. No. Lg 74, Cat. No. 105933b.

16, 17. *Paraserratognathus obesus* Yang

Lateral and anterior views of one specimen, ×40, Tianshifu in Benxi, Liaoning Province, Liangchiashan Formation, Col. No. Xt 16－1, Cat. No. 105938.

18, 19. *Scolopodus rex* Lindström

18. Lateral view, ×50, Dayangcha in Hunjiang, Jilin Province, Liangchiashan Formation, Col. No. Hx 12, Cat. No. 105939a. 19. Lateral view, ×50, Dayangcha in Hunjiang, Jilin Province, Liangchiashan Formation, Col. No. Hx 12, Cat. No. 105939b.

20, 21. "*Lexodus*" *dissectus* An

20. Lateral view, ×50, Zhaogezhuang in Tangshan, Hebei Province, Beianzhuang Formation, Col. No. Cc 33－3, Cat.

No. 105940a. 21. Lateral view, ×50, Zhaogezhuang in Tangshan, Hebei Province, Beianzhuang Formation, Col. No. Cc 33－3, Cat. No. 105940a.

Plate Ⅲ

1—11. *Tangshanodus tangshanensis* An

1. Lateral view of cordylodiform element, ×60, Zhaogezhuang in Tangshan, Hebei Province, Beianzhuang Formation, Col. No. Cc 35－1, Cat. No. 105941. 2. Lateral view of cordylodiform element, ×60, Zhaogezhuang in Tangshan, Hebei Province, Beianzhuang Formation, Col. No. Cc 35－1, Cat. No. 105942. 3. Lateral view of gothodiform element, ×60, Zhaogezhuang in Tangshan, Hebei Province, Beianzhuang Formation, Col. No. Cc 35－1, Cat. No. 105944. 4. Lateral view of cordylodiform element, ×60, Zhaogezhuang in Tangshan, Hebei Province, Beianzhuang Formation, Col. No. Cc 36－1, Cat. No. 105948. 5. Lateral view of cordylodiform element, ×60, Zhaogezhuang in Tangshan, Hebei Province, Beianzhuang Formation, Col. No. Cc 36－1, Cat. No. 105943. 6. Lateral view of gothodiform element, ×60, Zhaogezhuang in Tangshan, Hebei Province, Beianzhuang Formation, Col. No. Cc 36－1, Cat. No. 105949. 7. Lateral view of cordylodiform element, ×60, Zhaogezhuang in Tangshan, Hebei Province, Beianzhuang Formation, Col. No. Cc 36－1, Cat. No. 105950. 8. Lateral view of cordylodiform element, ×60, Zhaogezhuang in Tangshan, Hebei Province, Beianzhuang Formation, Col. No. Cc 35－1, Cat. No. 105951. 9. Lateral view of gothodiform element, ×60, Zhaogezhuang in Tangshan, Hebei Province, Beianzhuang Formation, Col. No. Cc 35－1, Cat. No. 105945. 10. Lateral view of gothodiform element, ×60, Zhaogezhuang in Tangshan, Hebei Province, Beianzhuang Formation, Col. No. Cc 35－1, Cat. No. 105946. 11. Lateral view of gothodiform element, ×60, Zhaogezhuang in Tangshan, Hebei Province, Beianzhuang Formation, Col. No. Cc 35－1, Cat. No. 105947.

12, 13. *Erraticodon* sp.

12. Lateral view, ×50, Tianshifu in Benxi, Liaoning Province, Machiakou Formation, Col. No TK 44－1, Cat. No. 105952. 13. Lateral view, ×50, Tianshifu in Benxi, Liaoning Province, Machiakou Formation, Col. No TK 5－10, Cat. No. 105953.

14. *Microcoelodus symmetricus* Branson and Mehl

Posterior view, ×65, Fengfeng County, Hebei Province, Fengfeng Formation, Col. No. Ff 1, Cat. No. 105954.

15—17. *Eoplacognathus suecicus* Bergström

15. Upper view, ×60, Doufanggou in Benxi, Liaoning Province, Machiagou Formation Col. No. Bdm 6, Cat. No. 105955. 16, 17. Upper and lower views of one specimen, ×60, Zhaogezhuang in Tangshan, Hebei Province, Machiakou Formation, Col. No. Cc 47－7, Cat. No. 105956.

Plate Ⅳ

1, 2. *Amorphognathus ordovicicus* (Branson and Mehl)

Aboral and oral views, ×40, ×50, Wangjiawan of Yichang area, Hubei, Wufeng Formation, Col. No Yo 12, in the collection of the Yichang Inst. Geol. and Min. Res., Chinese Acad. Sci.

3—5. *Eoplacognathus foliaceus* (Fahraeus)

3. Lateral view of polyplacognathiform element, ×50, Nanjing area of Jiangsu, Tatianba Formation, Col. No. WC 11, Cat. No. 82102, in the collection of the Dept. of Geology, Nanjing Univ. 4. Oral view of polyplacognathiform element, ×50, Nanjing area of Jiangsu, Tatianba Formation, Col. No. WC 11, Cat. No. 82101, in the collection of Dept. of Geology, Nanjing Univ. 5. Oral view of ambalodiform element, ×50, Nanjing area of Jiangsu, Tatianba Formation, Col. No. WC 11, Cat. No. 82103, in the collection of Dept. of Geology, Nanjing Univ.

6. *Eoplacognathus pseudoplanus* (Viira)

Oral view of ambalodiform element, ×60, West Xinjiang, Qiulitake Formation, Col. No. Nj 294, Cat. No. 105971.

7. *Prioniodus variabilis* Bergström

Oral view of amorphognathiform element, ×45, Nanjing area of Jiangsu, Tatianba Formation, Col. No. F－20, Cat.

No. 105973.

8, 18. *Hamarodus europaeus* Serpagli

8. Lateral view, ×45, Nanjing area of Jiangsu, Pagoda Formation, Col. No. F－21, Cat. No. 105974. 18. Lateral view, ×45, Nanjing area of Jiangsu, Pagoda Formation, Col. No. F－21. Cat. No. 105975.

9, 10. *Phragmodus undatus* Branson and Mehl

9. Lateral view, ×65, Longxian of Shaanxi, Longmendong Formation, Col. No. Lip－2, Cat. No. 65236. 10. Lateral view, ×65, Longxian of Shaanxi, Longmendong Formation, Col. No. Lip－2, Cat. No. 65237.

11. *Cahabagnathus sweeti* (Bergström)

Oral view of polyplacognathiform element, ×60, West Xinjiang, Kanling Formation, Col. No. NJ 384, Cat. No. 105976.

12, 13. *Belodina compressa* (Branson and Mehl)

12. Lateral view, ×65, Longxian of Shaanxi, Beiguoshan Formation, Col. No. Leb 16－2, Cat. No. 65239. 13. Lateral view, ×65, Longxian of Shaanxi, Beiguoshan Formation, Col. No. Leb 4－1, Cat. No. 65336.

14—16. *Belodina confluens* Sweet

14. Lateral view, ×60, Longxian of Shaanxi, Beiguoshan Formation, Col. No. B 80, Cat. No. 842, in the collection of No. 3 Petroleum Exploration and Prospecting Team, Ministry of Geology and Mineral Resources. 15. Lateral view, ×60, Longxian of Shaanxi, Beiguoshan Formation, Col. No. B 80, Cat. No. 846, in the collection of No. 3 Petroleum Exploration and Prospecting Team, Ministry of Geology and Mineral Resouces. 16. Lateral view, ×60, Longxian of Shaanxi, Beiguoshan Formation, Col. No. B 88, Cat. No. 8437, in the collection of No. 3 Petroleum Exploration and Prospecting Team, Ministry of Geology and Mineral Resouces.

17. *Amorphognathus variabilis* (Sergeeva)

Latero－oral view, ×60, West Xinjiang, Qiulitake Formation, Col. No. NJ 294, Cat. No. 105972.